Research Highlights

Invasive plants and animals research 2022-23

Department of Agriculture and Fisheries

Queensland Government

Cover photo: Chital deer traversing fence, Spyglass Research Station, Basalt. Photo credit: Mohit Deolankar, James Cook University.

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Contents

Introduction

This document summarises the 2022–23 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 four centres across the state:

• Ecosciences Precinct, Dutton Park

• 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. biological control and herbicides), as well as improved knowledge of pest species' biology and assessment of pest impact.

Notable activities of the research program for 2022–23 are outlined below.

Invasive plant research

- Our weed biological control program has been supported by external funding bodies that are detailed at the end on this report. AgriFutures and the Australian Government have funded overseas surveys and host testing for biological control agents for prickly acacia, Navua sedge, giant rat's tail grass and Koster's curse since 2020. These projects were completed in early 2023.
- Approval was granted from the Australian Government to release the prickly acacia gall thrips. The agent has been released at numerous sites in north Queensland with early signs of establishment and impact. A new agent, a gall mite, is planned for host testing in South Africa and Australia but cannot start until the agent can be safely collected from Ethiopia which continues to experience civil unrest.
- Following on from the AgriFutures work, two promising agents for giant rat's tail grass need host testing in Australia. For this weed, a naturalised leaf smut pathogen was also discovered and is proving damaging. It is being assessed for active spread in Australia as a control agent. Endemic pathogens have also been identified that could be used as mycoherbicides or augmentative biological control for giant rat's tail grass.
- Two pathogens are showing promise as biological control agents for Navua sedge. Host testing is being completed and a release application for at least one should be drafted by mid-2024.

- Unfortunately, the agent being tested for *Miconia crenata* (Koster's curse) is not proving sufficiently host specific. Alternative agents are available and, given the high potential impact of Koster's curse, we will test one of these for host specificity.
- We are currently releasing a leaf-mining moth to control bellyache bush. This follows release of a previous agent during 2003-7 that failed to establish. Another insect agent has been identified and host testing will be undertaken initially in Argentina. Other weeds with current biological control projects include cat's claw creeper, lantana, parthenium, bellyache bush, chinee apple, sicklepod, *Urena lobata*, Singapore daisy, African tulip tree, harrisia and opuntioid cacti. We are hoping to submit applications to release pathogen agents for lantana, cat's claw creeper and bellyache bush with the Australian Government in 2023-24.
- We continue to mass-rear and release biological control agents to control Siam weed, parkinsonia and *Cylindropuntia* cacti. We are monitoring the releases of previously released biological control agents (e.g. cat's claw creeper and parthenium) to determine their establishment, spread and impact. This will help decide when releases can cease, the need for other agents or control methods, and to evaluate the benefit of biological control. A new project is compiling locations of agents released in Queensland. This will allow redistribution of agents by land managers without reliance on laboratory colonies.
- We are also optimising the use of wick wipers to selectively apply herbicides to giant rat's tail grass. A new project is working with land managers to identify and control or eradicate strategic outlier infestations of gamba grass, grader grass and giant rat's tail grass. The results will be documented as a set of case studies.
- Projects continue to support state and national eradication programs for numerous weeds, including red witchweed, miconia, mikania, limnocharis. We carry out ecological studies to determine seed bank persistence and age to maturity, developing control methods and techniques to monitor eradication progress. Properties infested with red witchweed (an obligate parasite of sugarcane, corn and other grasses) are being treated and progress towards eradication is being determined by monitoring depletion of the soil seedbank.
- Herbicide trials are being conducted for several weeds including Siam weed, sicklepod, gamba grass, Aleman grass, bogmoss and weedy shrubs and trees. A new project has started on the ecology and management of sticky florestina. Further trials have found that flumioxazin (Clipper®) and florpyrauxifen-benzyl (ProcellaCOR®) provide excellent control of many aquatic weeds including cabomba, water lettuce and Amazon frogbit, with low risk to native aquatic flora.
- We are studying the ecology of several weeds to assist management. Weed seed longevity and age at maturity is needed to determine the timing and duration of treatment at a site. Collaborative research with the Northern Territory on Siam weed ecology and control with herbicide and fire has been completed. The results will be incorporated into a best practice management manual.
- We have assessed over half of 200 emerging weed species in Queensland to determine their priority for management. Ideally, limited resources should be directed now before the weeds are widespread and abundant. Problematic weeds have common traits and are likely to be predictable.

- Drones are now being widely used to detect weeds in broadacre crops and spot spray. We are working to extend this capability to particular rangeland weeds such as parthenium, chinee apple and Navua sedge.

Pest animal research

- The Centre for Invasive Species Solutions (CISS) has supported several pest animal and some weed projects through both funding and collaboration. These projects have been completed with reports available on the CISS website (https://invasives.com.au/our-publications). Future funding for new projects is unclear, but a portfolio of projects has been developed and adjusted to meet stakeholder demand.
- For wild dogs, we are continuing to monitor the response of wildlife to the removal of wild dogs inside cluster fences in western Queensland. We are trialling video-GPS collars on wild dogs to determine encounter rates with canid pest ejectors and cameras. We will also be assessing the ability of dogs to detect the odours of 1080 and possibly PAPP (para-aminopropiophenone) with ramifications to bait uptake.
- We continue to assess and develop surveillance methods for two high-risk pest animals, red-eared slider turtles and Asian black-spined toads. Current survey methods need modification if incursions are going to be detected sufficiently early and with an adequate degree of confidence.
- Best practice guidelines for peri-urban wild dog management are now available on the PestSmart website (https://pestsmart.org.au/). A glovebox guide for deer management is in press and will also be available on the PestSmart website. Workshops on best practice management of wild deer were delivered to pest managers in north Queensland in early 2023.
- We have continued our collaboration with NSW Department of Primary Industries on aspects of cost-effective management of deer in peri-urban, agricultural and conservation settings. A special issue of *Wildlife Research* is in publication, with 14 research articles on the ecology, impacts and management of wild deer in Australia. In north Queensland the collaboration includes James Cook University where a long-term project on chital deer ecology and management is moving into its final year of Australian Research Council funding.
- Southern Queensland rabbit abundance is currently relatively low due largely to biological control and removal of productive rabbit breeding sites (warrens, log piles). The productivity of other breeding sites is being assessed to help determine best strategies for minimising rates of population recovery.
- For rangeland populations of feral deer and pigs, we are evaluating control effectiveness at several demonstration sites. Following successes in temperate Australia, we hope to assess thermal-assisted shooting and monitoring.
- We are working with Southern Queensland Landscapes and CSIRO to better understand feral pig movements and habitat use. This will help design control and monitoring strategies and support modelling the spread of exotic diseases within feral pig populations.

Pesticide permits

- We obtain minor-use permits from the Australian Pesticides and Veterinary Medicines Authority as required for certain weed and pest animal species, pesticides, application methods and situations or environments. Sixteen minor-use or emergency-use permits were obtained in 2022-23.

Funding, collaboration and research priorities

In the 2022–23 financial year, Biosecurity Queensland's Invasive Plants and Animals research program received funding from several sources. Expenditure from Queensland Government base funds was $1.7 million; expenditure from the Land Protection Fund amounted to $2.2 million; and expenditure under contracts with external partners totalled $2.2 million (see 'External funding', page 85-86). 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. The Queensland Government also provided approximately $9.2 million in indirect costs that included facilities, equipment and support services.

Our research program for 2022–23 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 Queensland local governments, AgForce, the Queensland Farmers' Federation, the Queensland Conservation Council and NRM Regions Queensland. The committee critically reviews proposed and current projects and allocated investments and makes recommendations on strategic priorities.

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 87-88). 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. Integrated control of aquatic weeds

Project dates

July 2012 – June 2023

Project team

Tobias Bickel, Christine Perrett and Bahar Farahani

Project summary

Management of aquatic weeds is often challenging and there are limited control tools available. Site specific situations often limit the use and efficacy of control tools. Therefore, integration of multiple tools is often necessary for efficient control of aquatic weeds.

Clipper (flumioxazin) was registered as an aquatic herbicide with the Australian Pesticides and Veterinary Medicines Authority in 2020 and in 2021 CSIRO obtained a release permit for a biocontrol weevil, *Hydrotimetes natans*, to control cabomba in Australia. The CSIRO and DAF aquatic weed teams collaborate on research to integrate the herbicide and the biocontrol agent to achieve better control of cabomba in Queensland and Australia wide.

This year the aquatic weed management team conducted field trials with flumioxazin to control cabomba in a range of water bodies coupled with simultaneous releases of the biocontrol agent by CSIRO. The long-term management goal is for the biocontrol agent to reduce the overall cabomba population in release sites while the herbicide is used to remove cabomba from strategic locations (e.g. boat ramps) to prevent further spread of this weed. Field experiments were also conducted to test the control efficacy of the clipper effervescent tablet and how it is best employed for cabomba management. Lastly, research was carried out to quantify the regeneration of native aquatic plants after herbicide treatment from the soil seed bank to help managers restore wetlands after removal of invasive aquatic plants.

The work carried out this year shows that flumioxazin is a great operational tool for cabomba management under different scenarios and that it can be effectively integrated with the biological control agent.

Collaborators

- CSIRO
- Nguyen Nguyen and Junfeng Xu (University of Queensland)
- Department of Environment and Science
- Seqwater
- Townsville City Council
- Moreton Bay Regional Council

- NIWA New Zealand
- Macspred
- Sumitomo

Key publications

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

Kumaran, N. & **Bickel**, **T**.**O**. (2023). New tools for Integrated Management of Cabomba in Australia, *Management Guide (SEQwater, NRM managers)*, CSIRO, Brisbane, 23pp.

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

2. Water weed management research – new aquatic weed management tools

Project dates

January 2021 – June 2023

Project team

Tobias Bickel, Christine Perrett and Bahar Farahani

Project summary

Invasive aquatic weeds cause significant impacts to Queensland's freshwater resources. Most of these weeds are difficult to manage due to a lack of suitable control tools. In 2021, flumioxazin (Clipper herbicide) was registered by the Australian Pesticides and Veterinary Medicines Authority for control of a wide range of aquatic weeds. The team also conducted experiments to assess a new aquatic herbicide, florpyrauxifen-benzyl (ProcellaCOR).

We carried out laboratory and field trials with flumioxazin and florpyrauxifen benzyl in a wide range of water bodies infested with different aquatic weeds to gauge control efficacy in different situations and different targets while also monitoring non-target effects.

Flumioxazin provided excellent control of Amazon frogbit, kidney-leaved mudplantain, hairy water hyssop (*Bacopa lanigera*), Mexican water lily and water lettuce in the field. It also gave good control of sagittaria, both submerged and emergent. Florpyrauxifen-benzyl efficiently controlled parrots feather, *Rotala rotundifolia* and sagittaria. Experiments also demonstrated that flumioxazin and florpyrauxifen-benzyl cause limited to no damage to many native aquatic plants, especially valuable emergent plants along the shoreline.

This project generated data for the registration of ProcellaCOR in Australia. Together, these two new herbicides will greatly aid the efficient management of many aquatic weeds in Queensland and all over Australia. The team is currently preparing a manual for best practice management of aquatic weeds with these two new herbicides.

Collaborators

- Mathew McVay (University of Queensland)
- Marie Bigot (CSIRO)
- Department of Environment and Science
- SePro, USA
- Macspred
- Sunwater
- Logan City Council
- Moreton Bay Regional Council
- Gold Coast City Council
- Brisbane City Council
- NIWA, New Zealand
- Victorian Department of Jobs, Precincts and Regions
- NSW Department of Primary Industries

Key publications

Bickel, **T.O.**, **Perret**, **C.**, **Farahani**, **B**. & Oudyn, F. (2021). Control of invasive aquatic plants with Procellacor (florpyrauxifen-benzyl) in Australia. *Report (submitted to SePro, USA & APVMA)*, DAF, Brisbane, 25pp.

Bickel, **T.O.**, **Farahani**, **B.S.**, **Perrett**, **C.**, Xu, J. & **Vitelli**, **J**. (2022). *Control of the emerging aquatic weed Amazon frogbit with flumioxazin*, in Proceedings of the 22nd Australasian Weeds Conference, Eds. Brodie, C., Emms, J., Feuerherdt, L., Ivory, S., Melland, R., Potter, S., Weed Management Society of South Australia, Adelaide, 25 – 29 September.

3. Research supporting the management of nationally significant tropical weeds

Project dates

July 2008 – June 2024

Project team

Simon Brooks and Kirsty Gough

Project summary

The project develops and refines metrics to monitor progress towards eradication of several tropical weeds under the National Tropical Weeds Eradication Program. These need to be spatially and temporally consistent.

The project quantifies aspects of the life history of weeds targeted for eradication that influence the timing and location of field control operations. These include seed-bank persistence, age to maturity and dispersal potential. Effective control measures are also investigated.

Field and glasshouse trials investigating seed persistence of *Limnocharis flava*, *Miconia calvescens*, *M. racemosa, M. nervosa* and *Mikania micrantha* have been running for 7-13 years, with all species showing persistent seed banks. Bulk or depth field soil seed bank samples were collected from *L. flava, M. micrantha* and *M. racemosa* infestations. Field crew data and observations on the growth to maturity and reproductive seasonality of invasive melastomes are being used to refine guidelines for identifying and preventing seed producing plants. A habitat suitability model will be used to design surveys to detect and remove *M. calvescens*.

Collaborators

- Kim Erbacher, John Edwards, Alex Diczbalis, Michael Graham and Moya Calvert (Biosecurity Queensland)
- Tom Price, Nigel Weston and Bert Lukitsch, (Department of Environment, Parks and Water Security NT)
- Jacob Maher and Phil Cassey (University of Adelaide).

Key publications

Brooks, **S**. **& Jeffery**, **M**. (2018). *Progress in the eradication of* Mikania micrantha *from Australia*. In; Proceedings of the 21st Australasian Weeds Conference, eds. S. Johnson, L. Weston, H. Wu and B. Auld. The Weed Society of New South Wales. 9-13 September. pp. 350-3.

Brooks, **S**., **Erbacher**, **K**. & Maher, J. (2022). *Progress towards the eradication of* Limnocharis flava *from Australia*. In: Proceedings of the 22nd Australasian Weeds Conference. Eds. Brodie, C., Emms, J., Feuerherdt, L., Ivory, S., Melland, R., Potter, S., Weed Management Society of South Australia Inc., Adelaide, South Australia. pp. 262-5.

Brooks, **S**. & **Erbacher**, **K**. (2022). *Progress in the eradication of* Miconia calvescens *from Australia*. In: Proceedings of the 22nd Australasian Weeds Conference. Eds. Brodie, C., Emms, J., Feuerherdt, L., Ivory, S., Melland, R., Potter, S., Weed Management Society of South Australia Inc., Adelaide, South Australia. pp. 63-6.

4. Weed seed dynamics

Project dates

August 2007 – June 2030

Project team

Simon Brooks, Danielle Brazier and Clare Warren

Project summary

Seed longevity is an important determinant of the duration of weed control. This project investigates the seed longevity of priority weeds by burying seeds enclosed in bags in different soil types, under grassed and bare conditions and at various depths. Completed trials have shown that neem and yellow bells have relatively transient soil seed banks that are exhausted after 1 year. The seed packets of yellow oleander, stevia, gamba grass, chinee apple, calotrope and mesquite were exhausted in <5 years. Trials of lantana and parthenium showed small numbers of seeds retained viability for up to 10 years, while viable prickly acacia seed was retrieved after 13 years. Tropical soda apple has been added to this trial, which still contains prickly acacia, Harissa cactus and immersed sagittaria. Seeds of some species germinated in packets at depth, and a glasshouse pot trial has commenced to investigate the effect of seed burial depth on seedling emergence.

In field enclosures, we are also monitoring the emergence of seedlings of neem, leucaena, prickly acacia, chinee apple and mesquite. Neem tree seedling emergence concluded in less than a year, while prickly acacia, mesquite and leucaena emergence reflects weeds with long-lived seed banks. Elephant ear vine fruit and parkinsonia pods have been added to the field emergence trial.

A series of experiments have continued which compare the data from buried seed packet trials to a laboratory test of relative longevity, the Controlled Ageing Test (CAT). Correlating results from the CAT and packet trials will help to classify seeds of weeds into broad seed longevity categories over a shorter time frame.

Figure 1 Emergent parkinsonia plant

Figure 2 Tropical soda apple seeds buried in pipes as part of seed burial trials

Collaborators

- Shane Campbell and Bagirath Chauhan (University of Queensland)
- Geoff Swan, Matthew Ryan and Ashley Blokland (Biosecurity Queensland)
- Faiz Bebawi

Key publications

Long, R.L., Panetta, F.D., Steadman, K.J., Probert R., Bekker, R.M., **Brooks**, **S.J. &** Adkins, S.W. (2008). Seed persistence in the field may be predicted by laboratory-controlled ageing. *Weed Science* 56: 523-8.

5. Best practice management and remote detection of *Chromolaena odorata* in the Northern Territory

Project dates

June 2021 to June 2023.

Project team

Simon Brooks, Clare Warren, Dannielle Brazier and Kelli Murree

Project summary

The Northern Territory Government received Commonwealth funding for the project 'Advancing the detection, control and management of Siam weed in northern Australia'. As collaborators, Biosecurity Queensland receives funding from the Northern Territory to assist with the remote detection of *Chromolaena odorata* and provides information for inclusion in a best practice manual. Both aspects of the project are beneficial to Queensland, with the consolidation of best practice information requested by local stakeholders.

This project investigated the timing of seed maturity relative to flower head morphology, to determine when herbicide and fire treatments should be applied to prevent development of mature seed. Trials in 2021 and 2022 retrieved viable seed from contained potted specimens from late July onwards, despite flower structures being present and fortnightly treatments with a fluroxypyr herbicide. Field observations also showed seed development was prevented by fires in June and early July. We identified a shorter window to implement control measures to prevent viable seed production, after the weed is detectible from the air in late June.

This project is also investigating the efficacy of low volume foliar herbicides applied to potted specimens via a ground-based boom. Pot trials have identified appropriate rates, active ingredients and number passes. As a result, Northern Territory staff have been applying double passes of a fluroxypyr herbicide which has improved control outcomes.

Figure 3 Experimental treatment of chromolaena with fire in the Northern Territory

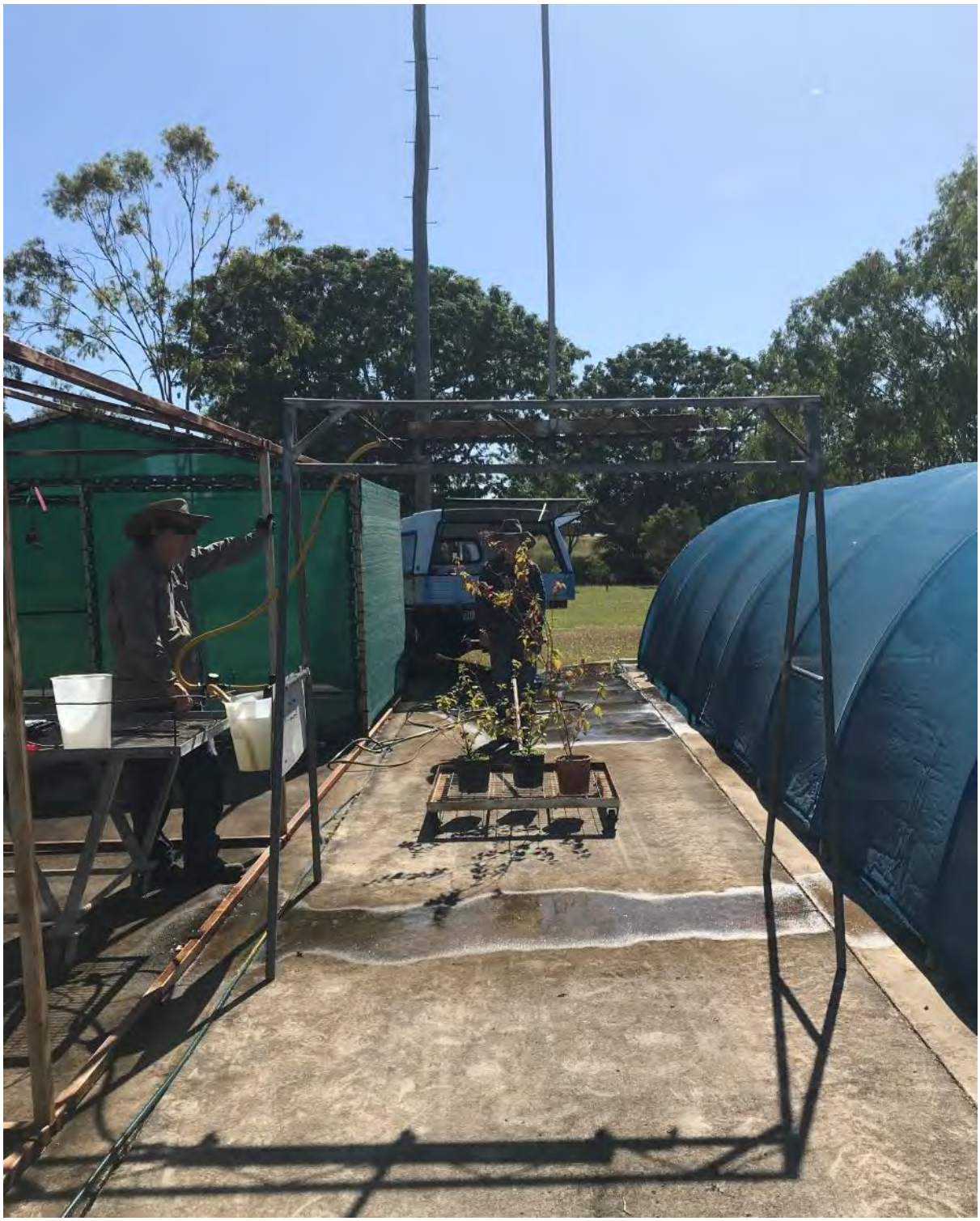

Figure 4 Herbicide treatment of chromolaena using a ground-based boom

Figure 5 Chromolaena plants before treatment

Figure 6 Chromolaena plants after treatment

Figure 7 Aerial view of plot after different treatments

Collaborators

- Tom Price, Shelley Inglis, Nigel Weston, Joshua Maeer and Louis Elliot (Department of Environment, Parks and Water Security NT)
- Deepak Guatam (RMIT)
- David Green, Ashley Blokland and Rob Cobon (Biosecurity Queensland)

6. Encapsulated herbicide control of woody weeds

Project dates

January 2021- June 2025

Project team

Simon Brooks, Dannielle Brazier and Clare Warren

Project summary

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

A successful trial on rubber vine has concluded with several active ingredients (metsulfuron-methyl, metsulfuron + aminopyralid and picloram) found to be highly effective. After 18 months aminopyralid + metsulfuron, picloram and clopyralid stem-injected capsules controlled over 92% of leucaena plants. Encapsulated herbicide is also promising for the control of African tulip trees and pond apple. Trials on neem trees have also recently been established. Subject to trial results and research gaps, the project will continue to refine rates and investigate active ingredients suited to stem injection as either dry or liquid formulations. This project has also assisted a PhD candidate from the University of Queensland establish encapsulated herbicide trials on chinee apple.

Figure 8 Establishing encapsulated herbicide trials on neem tree

Figure 9 Site infested with neem trees

Figure 10 Pond apple trial setup

Figure 11 Pond apple trial assessment

Collaborators

- Vic Galea (University of Queensland and Bioherbicides Australia)
- Shane Campbell and Ciara O'Brien (University of Queensland)
- Matt Buckman (Hinchinbrook Shire Council)
- Chris Roach (Queensland Parks and Wildlife Service)
- David Green (Biosecurity Queensland)
- Melissa Hayes (Whitsunday Regional Council)

Key publications

Goulter, K.C. Galea V.J. & Riikonen, P. (2018). *Encapsulated dry herbicides: A novel approach for control of trees*. Proceedings of the 21st Australasian Weeds Conference 2018. Edited by Stephen Johnson, Leslie Weston, Hanwen Wu and Bruce Auld. pp. 247-250. (The Weed Society of New South Wales Inc. Sydney).

McKenzie, J., **Brazier D**., Owen A., **Vitelli J**. & Mayer, B. (2010). *Stem injection: a control technique often overlooked for exotic woody weeds*. Proceedings of the 17th Australasian Weeds Conference, ed. S.M. Zydenbos, pp. 459-61. (New Zealand Plant Protection Society, Christchurch).

7. Biological control of Koster's curse (*Miconia crenata)*

Project dates

April 2020 – June 2023

Project team

Jason Callander and David Comben

Project summary

Miconia crenata (syn. *Clidemia hirta;* Koster's curse) is a fast growing weed of grazing, plantations, cropping and natural ecosystems in many countries across the world. When found in north Queensland, this weed was made a target of a national cost-share eradication program. As more infestations of the weed were discovered in Queensland, far outside the exclusion zone, eradication was deemed improbable, and the species was transitioned to "management". Currently two isolated populations exist, but if left uncontrolled, Koster's curse has the potential to spread south along the Queensland coast, as far as Hervey Bay. Prospects for biological control of Koster's curse are good, with a half a dozen agents historically tested and released in Hawai'i and two new prospective agents identified in Brazil in the last decade.

A biological control project was initiated with funding from the Australian Government. This project initially assessed *Liothrips urichi* Karny (Thysanoptera: Phlaeothripidae), reported to be effective against the weed in numerous countries where it has been released and established. Detailed host specificity testing of the prospective agent, undertaken in the quarantine facility at Ecosciences Precinct, encountered off-target feeding and development

on a few native Melastomataceae species. The scope of host testing was reduced to focus on these native taxa and comprehensively assess the level of risk this prospective agent might pose. Data were applied to an Australian biological control risk model developed recently by Agriculture Victoria. The model indicated that although the thrips is highly unlikely to fully utilise any of the non-target plant species as hosts, there is a moderate risk of potential spill-over damage. While there are no published reports or field observations of off-target impacts by *Liothrips urichi* in its native or introduced ranges, further work on *Liothrips urichi* has been suspended. Future research will focus on *Colletotrichum gloeosporioides* f. sp. c*lidemiae* (leaf spot pathogen), *Allorhogas clidemiae* (fruit galling wasp) and *Mompha trithalama* (fruit feeding moth).

Collaborators

- Aradhana Deesh and Takala Talacakau (Ministry of Agriculture, Fiji)
- Tracy Johnson (USDA, Institute of Pacific Islands Forestry, Hawaii)
- Local governments
- Barbara Waterhouse (Northern Australia Quarantine Strategy)
- Kim Erbacher and Kim Badcock (Four Tropical Weeds Eradication Program, South Johnstone)
- Peter Green (Senior Biosecurity Officer, Cairns)
- Sid Clayton (Kuranda City Council, Kuranda)
- Garry Sankowsky (Cairns)

Key publications

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

8. Biological control of cactus species

Project dates

July 2021 – June 2023

Project team

Jason Callander and Zachary Shortland

Project summary

Invasive opuntioid cacti are found within most Australian states and territories, with a great potential for increased distribution from the regions where they are currently established. Chemical control can be effective for some species, but in some regions the costs of chemical control exceed the value of the land, highlighting the importance of finding

alternative novel, cost effective approaches to control invasive cacti in Australia. Biocontrol of some invasive cacti in Australia has been highly successful in many areas. However, for other species, no biocontrol agents have been deliberately released, and in most cases, differences in biotic and abiotic conditions influencing their efficacy have not been identified. This project seeks to 1) contribute to the reduction of impact and spread of invasive cacti in Queensland using host-specific and damaging biological control agents, 2) identify additional control options for landholders to make best use of biocontrol agents available to them for management of tree form cacti, and 3) maintain *Dactylopius* and *Cactoblastis* colonies to supply starter colonies of biocontrol agents to Biosecurity Officers and local governments as required.

Collaborators

- Jeffery Newton (Longreach Regional Council)
- Duncan Swan, Tex Hayward and Stephen Downey (Biosecurity Officers, BQ)
- Mark Oswald, Pest Management Officer (Mackay Regional Council)
- Matt Tucker, Ranger Sunshine Coast (Department of Environment and Science)
- Kirstin Beasley, Ranger (Department of Environment and Science)
- Lucas Mackie, Project Officer (Southern Queensland Landscapes)
- Andrew McConnachie (NSW Department of Primary Industries)
- Department of Agriculture, Forestry and Fisheries
- Iain Paterson (Rhodes University, South Africa)
- Dr Helmuth Zimmermann, consultant (South Africa)

Key publications

Jones, P.K., **Day**, **M**.**D**., McConnachie, A.J., Holtkamp, R.H., **Conroy**, **J**., **Pidgeon**, **G**., Clark, E., Clark, P., Fletcher, A. & Savage, M. (2023). The successful biological control of *Cylindropuntia fulgida* var. *mamillata* (A. Schott ex Engelm.) Backeb. (Cactaceae) (coral or boxing glove cactus) at two field sites in Queensland, Australia, *Biological Control*, *182*. doi: https://doi.org/10.1016/j.biocontrol.2023.105235

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

9. Weed management in the Pacific

Project dates

July 2020 – June 2023

Project team

Jason Callander, David Comben and Zachary Shortland

Project summary

Biosecurity Queensland is working in collaboration with, and with funding from, Landcare Research New Zealand Limited Manaaki Whenua to tackle invasive weed species of significance to Pacific Island countries and the State of Queensland. This explores options for biological control against weeds that have either not previously been targeted in Australia, or are novel targets globally. African tulip tree (*Spathodea campanulata*) and Singapore daisy (*Sphagneticola trilobata*) are two such species targeted by this project, both viewed as serious weeds in many Pacific Island countries, and are restricted weeds in Queensland. *Spathodea campanulata* has been successfully nominated as a candidate for biological control in Australia, while an application to nominate *Sphagneticola trilobata* as a candidate for biological control is being reviewed by the Environment and Invasives Committee. Two biological control agents have been tested for host specificity, and field released against *S. campanulata* in the Cook Islands. One of these prospective agents, a galling mite species *Colomerus spathodeae* (Eriophyidae), has been prioritised and imported into quarantine at the Ecosciences Precinct for host specificity testing. A collaborator in Mexico is currently undertaking native range exploration to seek potential agents for *S. trilobata*. To date, half a dozen insects and pathogens have been shortlisted for further investigation.

Collaborators

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

Key publications

Comben, **D**.**F**. & **Callander**, **J**. (2022). Nomination of a candidate weed for biological control; *Sphagneticola trilobata* L. (Pruski) (Asteraceae). Technical Report (submitted to Environment and Invasives Committee). State of Queensland, Brisbane.

Comben, **D**.**F**., **Callander**, **J**., **Day**, **M**.**D**. & **Pople**, **T**. (2022). *Nomination of a candidate weed for biological control; Spathodea campanulata P. Beauv. (Bignoniaceae)*. Technical Report (submitted to Environment and Invasives Committee). State of Queensland, Brisbane.

10. Biological control of lantana

Project dates

April 2021 – June 2023

Project team

Jason Callander and Zachary Shortland

Project summary

Complexities in lantana varieties have hampered biocontrol efforts to date, demonstrating a need for matching of biocontrol agents to specific lantana varieties. Biosecurity Queensland is collaborating on a project “Weed genomics to improve Lantana biocontrol” that is funded by the Australian Government and led by NSW Royal Botanic Gardens. The project revealed that invasive lantana consists of several diverged sub-lineages, with limited gene flow among them (Lu-Irving *et al*. 2022). These findings provide a framework to re-evaluate previous attempts to classify the invasive *L. camara* complex, with about half of the populations of lantana in Australia identified as being from two sub-lineages, corresponding broadly with the “common pink” and the "common pink-edged red” varieties. This project also sought to add to the biological control toolbox against lantana. Two prospective agents are being pursued. The rust pathogen *Puccinia lantanae*, has been tested by CABI under contract from Biosecurity Queensland and an import release application has been prepared and submitted to Australian regulators. The second agent, the lantana gall fly *Eutreta xanthochaeta*, has been imported into quarantine and host specificity testing has commenced.

Collaborators

- CABI-UK
- Plant Protection Research Institute, South Africa
- Tracy Johnson (USDA, Institute of Pacific Islands Forestry, Hawaii)
- NSW Royal Botanic Gardens
- Queensland Parks and Wildlife Service
- Local governments in coastal and subcoastal Qld
- Seqwater
- University of Queensland

Key publications

Lu-Irving, P., Encinas-Viso, F., **Callander**, **J**., **Day**, **M**.**D**. & Le Roux, J. (2022). *New insights from population genomics into the invasive Lantana camara L species complex*. Proceedings of the 22nd Australasian Weeds Conference. Eds. Brodie, C., Emms, J., Feuerherdt, L., Ivory, S., Melland, R., Potter, S., Weed Management Society of South Australia Inc., Adelaide. pp. 45-47.

Lu-Irving, P., Encinas-Viso, F., **Callander**, **J**., **Day**, **M**.**D**. & Le Roux, J. (2023). *Population genomics of invasive lantana: implications for improved biocontrol*, 4th International Congress on Biological Invasions, New Zealand, Christchurch, 3 May.

Thomas, S.E., Evans, H.C., Cortat, G., Koutsidou, C., **Day**, **M**.**D**. & Ellison, C.A. (2021). Assessment of the microcyclic rust *Puccinia lantanae* as a classical biological control agent

of the pantropical weed *Lantana camara*. *Biological control: theory and applications in pest management 160*:104688

11. Biological control of parthenium (*Parthenium hysterophorus*)

Project dates

January 2007 - June 2024

Project team

K. Dhileepan and Boyang Shi

Project summary

Parthenium weed (*Parthenium hysterophorus* L.), a noxious weed of grazing areas in Queensland, is a Weed of National Significance in Australia. Parthenium also causes severe human and animal health problems. Eleven biological control agents (nine insects and two rust pathogens) have been released against parthenium in Australia. Most of these agents have become established and have proven effective against the weed in central Queensland (CQ). Parthenium is spreading into south Queensland (SQ) and southeast Queensland (SEQ), where many of the widespread and effective biological control agents in CQ are not present. Hence, the seed-feeding weevil (*Smicronyx lutulentus*), the stem-boring weevil (*Listronotus setosipennis*), the root-boring moth (*Carmenta ithacae*), the summer rust (*Puccinia xanthii* var. *parthenii-hysterophorae*) and the winter rust (*Puccinia abrupta* var. *partheniicola*) have been redistributed from CQ into SQ and SEQ. Monitoring the establishment and spread of parthenium biological control agents is continuing.

Collaborators

- Chris Hoffmann and Steven Moore (Lockyer Valley Regional Council, Gatton)
- Lachlan Grundon (Balonne Shire Council, St George)
- Melinda Clarke (Burnett Catchment Care Association, Monto)
- Prof Steve Adkins (University of Queensland, Gatton)
- Dr Asad Shabbir (NSW Department of Primary Industries)
- Ken Woodall (RAPID Workforce, Mitchell)
- Tom Garrett and Holly Hosie (Southern Queensland NRM)
- 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**. (2009). Managing *Parthenium hysterophorus* across landscapes: limitations and prospects, pp. 227-260. In: *Management of Invasive Weeds* (ed. Inderjit, S.), Invading Nature – Springer Series in Invasion Ecology Vol. 5, Springer Science.

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

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

Dhileepan K., **Callander J**., **Shi**, **B**. & **Osunkoya**, **O**.**O**. (2018). Biological control of parthenium (*Parthenium hysterophorus*): the Australian experience. *Biocontrol Science and Technology 28*(10):970−988.

12. Biological control of cat's claw creeper (*Dolichandra unguis-cati*)

Project dates

January 2007 - June 2024

Project team

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

Project summary

Cat's claw creeper (*Dolichandra unguis-cati*) is a Weed of National Significance in Australia. Biocontrol is considered the most desirable option to manage the weed. So far, a leaf-sucking tingid (*Carvalhotingis visenda*), a leaf-tying moth (*Hypocosmia pyrochroma*) and a leaf-mining beetle (*Hedwigiella jureceki*) have been released in the field. The tingid has become established widely and is causing visible damage in the field. Field establishment of the leaf-tying moth has been noticed only in a few of the release sites and it is spreading very slowly. The leaf-mining beetle has established well in all release sites and is spreading widely. Since cat's claw creeper is a perennial vine with abundant subterranean tuber reserves, additional agents are needed to complement the existing agents. Surveys in Brazil and Paraguay have identified three fungal pathogens as prospective biocontrol agents: a leaf-spot pathogen *Neoramulariopsis unguis-cati* (Speg.) Raghv. Singh & Kushwaha (syn: *Cercosporella unguis-cati* Speg.), a galling rust (*Uropyxis rickiana*) and a leaf-rust (*Prospodium macfadyenae*). The *N. unguis-cati* leaf-spot is already present in South Africa where it is causing widespread defoliation of cat's claw creeper. Preliminary research into the biology and infection parameters of the leaf-spot pathogen and the galling rust has been completed. Based on the results, the leaf-spot pathogen was prioritized for detailed host-

range testing which has been completed by CABI (UK). Host-range testing of 35 non-target species showed that the leaf-spot pathogen exhibits a high level of host specificity, sporulating only on cat's claw creeper, its natural host. An application seeking approval for release of this agent will be submitted to the Australian regulatory authorities. Full host-specificity assessment of the galling rust will be pursed in the future.

Figure 12 Leaf-spot on cat's claw creeper at CABI in the UK

Figure 13 Leaf spot on cat's claw creeper at CABI in the UK

Figure 14 Leaf spot on cat's claw creeper plants ex-Paraguay

Collaborators

- Seqwater
- Marion Seier and Kate Pollard (CABI, UK)
- Anthony King (Plant Protection Research Institute, Pretoria, South Africa)
- Robert Barreto (Universidade Federal de Viscosa, Brazil)
- Adans Colman (National University of Asunción, Paraguay)
- Anibal Carvalho (Instituto de Pesquisas Jardim Botanico do Rio de Janeiro, Brazil)
- Kevin Jackson (Gympie, Qld)
- Melinda Clarke (Burnett Catchment Care Association, Monto)
- NSW biocontrol taskforce

Key publications

Colmán, A.A., Pollard, K.M., Seier, M.K., & Barreto, R.W. (2020). *Cercosporella unguis-cati*, the causal agent of the leaf spot of *Dolichandra unguis-cati*, reported from Paraguay. *New Disease Reports 42*(1), 18-18.

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

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* 52: 175-181.

Dhileepan, **K**., **Snow**, **E**., **Shi**, **B**., **Gray**, **B**., Jackson, K. & Senaratne, K.A.D.W. (2021). Establishment of the biological control agent *Hypocosmia pyrochroma* for *Dolichandra unguis-cati* (Bignoniaceae) is limited by microclimate. *Journal of Applied Entomology* 145(9):890−899.

13. Biological control of bellyache bush (*Jatropha gossypiifolia*)

Project dates

January 2007 - June 2024

Project team

K. Dhileepan, Di Taylor and Md Mahbubur Rahman

Project summary

Bellyache bush (*Jatropha gossypiifolia*), a Weed of National Significance, is a serious weed of rangelands and riparian zones in northern Australia. Bellyache bush has been a target for biological control since 1997 with limited success to date. A leaf rust (*Phakopsora jatrophicola*) from Trinidad, a leaf-miner (*Stomphastis thraustica*) from Peru and a gall midge (*Prodiplosis hirsutus*) from Paraguay have been identified as prospective biological control agents. Host specificity tests for the leaf rust and the leaf-miner have been completed. Approval to release the leaf-miner was received in October 2022, and field releases commenced in October 2022 in partnership with local governments and NRM groups. So far 31 field releases, totally more than 14,000 individuals, have been made across 22 sites covering central, north, and northwest Queensland.

A release application for the leaf rust is being prepared. Preliminary host specificity tests for the gall midge (*P. hirsutus*) confirmed that the midge has a restricted host range, limited to a few closely-related Jatropha species that are not present in Australia. There are no Jatropha species native to Australia. Future research will focus on either continuing the host specificity testing at FuEDEI (Fundación Para El Estudio De Especies Invasivas) in Buenos Aires, Argentina or importing the gall midge from Paraguay into the quarantine facility in Brisbane for detailed host specificity testing.

Figure 15 Di Taylor releasing Stomphastis with a local government pest officer

Collaborators

- Marion Seier and Kate Pollard (CABI, UK)
- Guillermo Cabrera Walsh, Marina Oleiro and Carolina Mengoni (Fundación Para El Estudio De Especies Invasivas, Buenos Aires, Argentina)
- Peter Kolesik (South Australian Museum, Adelaide)
- Kumaran Nagalingam (CSIRO, Brisbane)
- Jurate De Prins (Royal Museum of Central Africa, Belgium)
- Geoff Penton and Charles Curry (Southern Gulf NRM, Mt Isa)
- Jo Menneke (Charters Towers Regional Council)
- John Fisher (Barcaldine Regional Council)
- Susan Waters (Central Highlands Regional Council, Springsure).

- Melissa Hayes (Whitsunday Regional Council, Proserpine)
- Megan Davies (Burdekin Regional Council)
- Russell Jack (Department of Resources, Townsville)
- Geoff Swan (Biosecurity Queensland, Emerald)
- Bradley Drinkwater (Townsville City Council)
- Graham Wienert (Mareeba Regional Council)
- Loukas Elgey (Ethridge Regional Council)

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, pp. 5−10. In: Impson F.A.C., Kleinjan, C.A. & Hoffmann, J.H. (eds), *Proceedings of the XIV International Symposium on Biological Control of Weed*, Kruger National Park, South Africa, 2-7 March 2014.

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

Kolesik, P., Kumaran, N., Oleiro, M., Gonalons, C.M., Brookes, D., Walsh, G.C. & **Dhileepan K**. (2022). *Prodiplosis hirsuta*, a new species of gall midge (Diptera: Cecidomyiidae) feeding on shoot tips of *Jatropha* (Euphorbiaceae) in South America. *Austral Entomology* 61(1): 37−48.

14. Biological control of Navua sedge (*Cyperus aromaticus*)

Project dates

January 2007 - June 2024

Project team

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

Project summary

Navua sedge (*Cyperus aromaticus*) is an extremely aggressive perennial sedge affecting the beef and dairy industries in the Queensland wet tropics. The sedge is unpalatable, and can form dense stands, replacing palatable tropical pasture species. Current management options are mechanical and chemical, which are expensive and offer only short-term relief. Biocontrol is the most cost effective and long-term management option. Navua sedge has been approved as a target for biocontrol in Australia, and a list of test plants for host specificity testing was compiled. Surveys in Africa identified a smut fungus (*Cintractia kyllingae*) attacking flower heads and seeds in Tanzania, Kenya and Nigeria, a rust fungus (*Uredo kyllingae-erectae*) attacking leaves and stems in Nigeria, Tanzania and Madagascar, and potentially an as yet undescribed new species attacking leaves and stems in Madagascar as promising biological control agents. These pathogens have been exported to

CABI-UK. Research on the biology and host specificity of the flower smut pathogen from Tanzania and the rust pathogen and the new species from Madagascar are in progress in quarantine in CABI-UK.

No native pathogens have been identified as prospective mycoherbicides in Australia. Evaluation of various herbicides for the management of Navua sedge in the glasshouse and field by the Federation University of Australia is in progress. Student research projects in collaboration with universities in Australia are in progress to fill research gaps in the biology, ecology, and management of Navua sedge.

Figure 16 Rust infection in Navua sedge in Madagascar

Figure 17 Navua sedge researchers in Madagascar

Collaborators

- Prof Roger Shivas (University of Southern Queensland)
- Dr Marion Seier and Dr Daisuke Kurose (CABI-UK)
- Prof Florentine Singarayer, Dr Aakansha Chadha and Bhagya Ranasinghe Hathamune Gamage (Federation University, Ballarat)
- Dr Yu Pei Tan (Queensland Plant Pathology Herbarium)
- Melissa Setter and Stephen Setter (CWTA, South Johnston)
- Dr Shane Campbell (University of Queensland, Gatton, Qld)
- Dr Mutuku Musili and Frederick Munyao Mutie (East African Herbarium, Kenya)
- Dr John Elia Ntandu (National Herbarium of Tanzania)
- Emmanuel. C. Chukwuma (Forest Research Institute, Ibadan, Nigeria)
- Ocholi T Edogbanya (Kogi State University, Anyigba, Nigeria).
- Dr Isabel Larridon (Kew gardens, UK)
- Dr Julia Kruse (Natural History Museum, Germany)
- Dr James Hereward (University of Queensland, St Lucia)
- Dr Emilie Fillols (Sugar Research Australia, Gordonvale)
- Rajaonera Tahina Ernest (University of Antananarivo, Madagascar)

- Bernie English (Agri-Science Queensland, Mareeba)
- Rob Pagano (Beef grazier, Tarazali)
- John McKenna (Beef grazier, Malanda)
- Lawrence Di Bella and Richard Hobs, Herbert Cane Productivity Services Limited (Ingham)
- Lance Rodman (sugarcane farmer, Gordonvale)
- 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)
- Darryn Higgins (Cook Shire Council)
- Michael Zitha (Biosecurity Queensland, Thursday Island)

Key publications

Chadha, A., Florentine, S.K., **Dhileepan**, **K**., Turville, C. & Dowling, K. (2022). Efficacy of halosulfuron-methyl in the management of Navua sedge (*Cyperus aromaticus*): differential responses of plants with and without established rhizomes. *Weed Technology* 36(3):397−402.

Chadha, A., **Osunkoya**, **O**.**O**., **Shi**, **B**., Florentine, S.K. & **Dhileepan**, **K**. (2022). Soil seed bank dynamics of pastures invaded by Navua sedge (*Cyperus aromaticus*) in tropical north Queensland. *Frontiers in Agronomy*, May 2022, doi:10.3389/fagro.2022.897417.

Dhileepan, **K**., Musili, P.M., Ntandu, J.E., Chukwuma, E., Kurose, D., Seier, M.K., Ellison, C.A. & Shivas, R.G. (2022). Fungal pathogens of Navua sedge (*Cyperus aromaticus*) in equatorial Africa as prospective weed biological control agents. *Biocontrol Science and Technology* 32(1):114−120.

Shi, **B**., **Osunkoya**, **O**.**O**., Chadha, A., Florentine, S.K. & **Dhileepan**, **K**. (2021). Biology, Ecology and Management of Invasive Navua sedge (*Cyperus aromaticus*) – A Global Review. *Plants* 10(9), 1851, doi.org/10.3390/plants10091851.

15. Biological control of prickly acacia (*Vachellia nilotica* ssp. *indica*)

Project dates

January 2007 - June 2025

Project team

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

Project summary

Prickly acacia (*Vachellia nilotica* subsp. *indica*) is a Weed of National Significance and a target for biological control, albeit with limited success to date. Native range surveys for prospective biological control agents were conducted in Ethiopia and Senegal based on plant phenotype and climate matching. During the native range surveys, priority was given to gall-inducing agents, in view of their host specificity. Based on field host range, geographic range and damage potential, a gall thrips (*Acaciothrips ebneri*) inducing shoot-tip rosette galls, a gall mite (*Aceria* sp.) deforming leaflets, rachides, and shoot-tips in Ethiopia, and a gall fly (*Notomma mutilum*) inducing stem-galls in Senegal were prioritised for further studies. The gall thrips from Ethiopia and the gall fly from Senegal were imported into quarantine in Brisbane. Host specificity tests for gall thrips have been completed and an application seeking approval to release the gall thrips in Australia was submitted. The gall thrips was approved for field release in November 2022 and field releases commenced in January 2023 in partnership with NRM groups and local government agencies. To date, field releases have been made in 24 sites covering coastal, central highlands and western inland regions in Queensland. For the gall fly, in view of the potential non-target risk, no-choice and choice tests were discontinued. Host specificity testing of the gall mite has been delayed due to difficulties with importing the gall mite from Ethiopia. Host specificity testing of the gall mite will commence when it is safer to conduct field visits to Ethiopia to collect and import the gall mites.

Collaborators

- Anthony King, (Agricultural Research Council - Plant Protection Research Institute, Pretoria, South Africa)
- Nathalie Diagne (Senegalese Institute of Agricultural Research, Centre National de Researches Agronomique, Bambey, Senegal)
- Mindaye Teshome (Forestry Research Centre, Addis Ababa, Ethiopia)
- James Hereward (School of Biological Sciences, University of Queensland, St Lucia).
- Geoff Penton and Charles Curry (Southern Gulf NRM, Mt Isa)
- Susan Walters (Central Highlands Regional Council, Springsure)
- Melissa Hays (Whitsundays Regional Council, Proserpine)
- Brooke Payne (Burdekin Regional Council, Ayr)
- Simon Wiggins and Doug Allpass (Desert Channels Group)
- David Lawrence (Rockhampton Regional Council, Rockhampton)
- Andries van Jaarsveld (Isaac Regional Council, Moranbah)
- Geoffrey Swan (Biosecurity Queensland, Emerald)
- Winton Shire Council
- Richmond Shire Council
- McKinlay Shire Council
- Flinders Shire Council

Figure 18 Dr Boyang Shi releasing Acaciothrips onto prickly acacia

Figure 19 Dr Boyang Shi and Acaciothrips galls established on prickly acacia

Key publications

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

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

16. Biological control and ecology of chinee apple (*Ziziphus mauritiana*)

Project dates

July 2021- June 2025

Project team

Olusegun Osunkoya, Kunjithapatham Dhileepan, Di Taylor, Boyang Shi and Christine Perrett

Project summary

Ziziphus mauritiana Lamarck (Rhamnaceae), commonly known as Indian jujube or Chinee apple is a major pasture and environmental weed in northern Australia, where its impenetrable thickets hinder stock and affect pasture production. Current management options are mechanical and chemical control which are expensive. Despite its long-term presence (since 1880) in Queensland, little information is available on the extent of its distribution or on economic loss and environmental impacts it causes. Prospects for its management using biological control are also lacking. This project addresses these knowledge gaps. The research focus is on (i) the assessment of the current/potential spread, (ii) economic loss, (iii) ecological changes (below and above ground) induced by the weed, (iv) genetic diversity and introduction history in Australia, as well as (v) developing computer simulation models to gauge efficacy of prospective biocontrol agents (using Climex) and spread potential including range shifts (using MaxEnt) of the weed in view of climate change. Currently surveys for insects and pathogens associated with *Z. mauritiana* are in progress in Pakistan, in collaboration with the University of Punjab, Lahore. So far, 23 phytophagous insects and five pathogens have been collected on *Z. mauritiana* in Pakistan. Many of the agents are yet to be identified. Further native range research will be pursued if adequate funding is sourced.

Collaborators

- Wayne Vogler and Kelli Pukallus (Tropical Weeds Research Centre, Charters Towers)

- Bradley Gray and Moya Calvert (Prevention & Preparedness, Biosecurity Queensland)
- Scott Hardy (Whitsundays Regional Council)
- NQ Dry Tropics NRM
- Roger Shivas (University of Southern Queensland)
- Shane Campbell (The University of Queensland, Gatton)
- Asad Shabbir (Department of Primary Industries, NSW, Orange)
- Mubarak Ali (University of Punjab, Lahore, Pakistan)
- Md Mahbubur Rahman (Bangladesh Agricultural University, Mymensingh, Bangladesh)
- Peter Trotter (Aspect Imaging, Sunshine Coast, Qld)
- Nanjappa Aswath and Naina Islam (Institute for Future Farming Systems, Centre for Intelligent Systems, Central Queensland University, Rockhampton Qld)

Key publications

Bebawi F.F., Campbell S.D. & Mayer R.J. (2016). Seed bank persistence and germination of Chinee apple (*Ziziphus mauritiana* Lam.). *Rangeland Journal*, 38, 17–25.

Dhileepan, **K**. (2017). "Biological control of *Ziziphus mauritiana* (Rhamnaceae): feasibility, prospective agents and research gaps." *Annals of Applied Biology 170*(3): 287-300.

Grice A.C. (1996). Seed production, dispersal and germination in *Cryptostegia grandiflora* and *Ziziphus mauritiana*, two invasive shrubs in tropical woodlands of northern Australia. *Australian Journal of Ecology,21*, 324–331.

Grice A.C. (2002). The Biology of Australian Weeds. 39. *Ziziphus mauritiana* Lam. *Plant Protection Quarterly,17*, 2–11.

17. Impact and management of Navua sedge

Project dates

July 2020 – June 2025

Project team

Olusegun Osunkoya, Christine Perrett, Kunjithapatham Dhileepan and Boyang Shi

Project summary

There are few quantitative data on the ecology and economic cost of Navua sedge. In far north Queensland, numerous grazing and cropping (mainly sugar cane) sites that are infested with Navua sedge have been identified, and we have established research plots on many of them. Within these experimental plots, we continue to carry out surveys, identify high, medium and low infestation subplots, quantify pasture diversity, soil seed bank composition and soil chemistry. In 2022-2023 within the identified infestation plots, we

imposed various herbicide treatments, and are again surveying the plots to quantify changes in above-ground abundance of desirable pasture plants, pasture yield loss/gain, soil seed bank composition, and soil chemistry. Due to low stakeholder response rate in previous years, we again contacted cropping farmers and graziers to estimate their economic losses. These stakeholders ranged from coastal to inland and highland areas and spanned a wide range of environments from Townsville to Cape Tribulation. We are also trialling drone imagery and artificial intelligence to automate identification of Navua sedge and its growth stages, especially in grazing and sugar cane farms.

Figure 20 Drone surveying a Navua sedge infestation in a grazing land in Malanda, Far North Queensland undergoing herbicide trials.

Collaborators

- Prof. Florentine Singarayer (Federation University, Ballarat Victoria)
- 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)
- Bernie English (Agri-Science Queensland, Mareeba)

- 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)
- Herbert Cane Productivity Services Limited (Ingham)
- Marcus Bulstrode (Sustainable Farming Systems Agri-Science Queensland, Department of Agriculture & Fisheries, South Johnstone Qld)

Key publications

Chadha, A., **Osunkoya**, **O**.**O**., **Shi B**., Florentine, S.K. & **Dhileepan**, **K**. (2022). Soil Seed Bank Dynamics of Pastures Invaded by Navua Sedge (Cyperus aromaticus) in Tropical North Queensland. *Frontiers in Agronomy.* 4:897417. doi: 10.3389/fagro.2022.897417

Shi, **B**., **Osunkoya**, **O**.**O**., Chadha, A., Florentine, S.K. & **Dhileepan**, **K**. (2021). Biology, Ecology and Management of the Invasive Navua Sedge (*Cyperus aromaticus*)—A Global Review. *Plants* 10, 1–16. doi: 10.3390/ plants1009185

Shi, **B**., **Osunkoya**, **O**.**O**., Soni, A., Campbell, S. & **Dhileepan**, **K**. (2023). Growth of the invasive Navua sedge (*Cyperus aromaticus*) under competitive interaction with pasture species and simulated grazing conditions: Implication for management. *Ecological Research*, 38(2), 331-346. https://doi.org/10.1111/1440-1703.12369

Vitelli, **J**. **S**., Madigan, B.A. & van Haaren, P.E. (2010). Control techniques and management strategies for the problematic Navua sedge (*Cyperus aromaticus*) (2010). *Invasive Plant Science and Management*, v.3, p.315- 326

18. Risk assessment for new and emerging weeds

Project dates

July 2021 - June 2024

Project team

Olusegun Osunkoya and Christine Perrett

Project summary

Local government (LG) pest officers and other on-the-ground pest managers are often the best source of information on emerging and recently arrived invasive alien species, some of which may be undergoing significant changes in abundance and distribution in a given landscape. Hence it is important to interact with these groups and other stakeholders to capture information on local spread and changing abundance of many pest plants (both established pests and new incursions). Reporting and collating these data enables proactive management, especially of the new pests. Our aims in this project are to (i) assess the risk of

more than 200 emerging (horizon) weed species using the grey and published literature and field experience of LG pest officers and other land managers; (ii) evaluate the drivers of invasiveness for these horizon weeds, including the influences of biotic (e.g. species traits) and abiotic characteristics (e.g. invasion pathways [nursery, internet mail], climate change, global native vs invaded ranges, and propagule pressure [including trade]), and (iii) rank the emerging species for feasible management actions such as population suppression or even eradication given their stage of invasion. Since the inception of the project, more than 100 horizon weeds have been assessed, and this exercise is ongoing.

Collaborators

- Moya Calvert and Brad Gray (Biosecurity Queensland)
- Josh Dyke (Local Government Association of Queensland)
- Queensland Herbarium
- All Queensland local governments
- NRM groups
- Jens Froese and Sam Nicol (CSIRO Brisbane)
- DAF Biosecurity Officers
- Jamie Camac (Centre for Biosecurity Risk Analysis Group, University of Melbourne, Victoria)
- Farzin Shabani (Qatar University, Qatar)

Key publications

Osunkoya, **O**.**O**., Froese, J.G., Nicol, S., **Perrett**, **C**., Moore, K., **Callander**, **J**. & Campbell S. (2019a). A risk-based inventory of invasive plant species of Queensland, Australia: Regional, ecological and floristic insights. *Austral Ecology* 44, 1123-38.

Osunkoya, **O**.**O**., Froese, J.G. & Nicol, S. (2019b). Management feasibility of established invasive plant species in Queensland, Australia: a stakeholders' perspective. *Journal of Environmental Management* 246, 484–495.

Osunkoya, **O**.**O**., Lock, C.B., **Dhileepan**, **K**. & Buru, J.C. (2021). Lag times and invasion dynamics of established and emerging weeds: insights from herbarium records of Queensland, Australia. *Biological Invasions*, 23 (11), 3383- 3408.

Osunkoya, **O**.**O**., **Perrett**, **C**., **Calvert**, **M**. & **Csurhes**, **S**. (2022). Horizon scan for incoming weeds into Queensland, Australia. *Proceedings, 22nd conference of the Australasian Weeds Society*, Adelaide, South Australia, 9: 67-70.

19. Real-time, drone-based weed identification for improved pasture management

Project dates

July 2022 - June 2024

Project team

Olusegun Osunkoya, Kunjithapatham Dhileepan and Boyang Shi

Project summary

In any landscape, one key challenge prior to weed control is weed identification. Drones (unmanned aerial vehicles) have been used for object identification however real time object identification in managed and natural systems is limited to a handful of cases. This project will develop the hardware and software required to facilitate the real time detection of weeds, a first step in the real time spraying of weeds or delivery of biocontrol agents. This project focuses on researching and trialling real time object identification by working initially on autonomously identifying parthenium (a Weed of National Significance) using drones and artificial intelligence. Once perfected, the ultimate goal is to extend the technique, to other weeds of importance in Queensland. We have carried out trials on chinee apple and Navua sedge and had some successes with both weeds. Thus, our results will have broader application for real time identification of an object from a drone including identifying animal pests. Our work and results will also have economic benefits for the mapping and hence management of other high priority weeds (e.g. lantana, cat's claw creeper, Chilean needle grass, gorse, mesquite and gamba grass).

Collaborators

- Peter Trotter (Aspect Imaging, Sunshine Coast, Queensland)
- Felipe Gonzalez (Centre for Robotic Engineering, Queensland University of Technology)
- Biosecurity Officers
- Local government pest officers
- Nanjappa Aswath and Naina Islam (Institute for Future Farming Systems, Centre for Intelligent Systems, Central Queensland University, Rockhampton QLD)
- Marcus Bulstrode (Sustainable Farming Systems Agri-Science Queensland, Department of Agriculture & Fisheries, South Johnstone Qld)

Key publications

Costello, B., **Osunkoya**, **O**.**O**., Sandino, J., Marinic, W., Trotter P., **Shi B**., Gonzalez F. & **Dhileepan**, **K**. (2022). Detection of parthenium weed (*Parthenium hysterophorus* L.) and its growth stages using artificial intelligence. *Agriculture*, 12, 1838. https://doi.org/10.3390/agriculture12111838

Islam, N., Rashid, M.M., Pasandideh, F., Ray, B., Moore. S. & Kadel, R. (2021). A review of applications and communication technologies for internet of things (IoT) and unmanned aerial vehicle (UAV) based sustainable smart farming. *Sustainability*, 13, 1821. https://doi.org/10.3390/su13041821

Lambert, J.P.T., Hicks, H.L., Childs, D.Z. & Freckleton, R.P. (2018). Evaluating the potential of unmanned aerial systems for mapping weeds at field scales: a case study with *Alopecurus myosuroides*. *Weed Research* 58 35–45.

Figure 21 Drone surveying a chinee apple infestation (in the background) on a grazing property in Bowen, Central Queensland

20. Weed biological control agent rear and release

Project dates

July 2019 – July 2024

Project team

Kelli Pukallus and Mary Butler

Project summary

This project mass rears biological control agents for releases in northern Queensland for the control of tropical weeds. Sites where agents are released are monitored to determine establishment and spread.

Australia's first biological control agent for Siam weed (*Chromolaena odorata),* the stem-galling fly (*Cecidochares connexa),* was approved for release in late 2018. Mass-rearing and release commenced in late 2019 at the Tropical Weeds Research Centre in Charters Towers. Adult flies or galled stems have been released within nine Queensland local government areas (LGAs) to date. Galls have been detected at and spreading from release sites in all LGAs, with significant impact on flowering in some regions this season. Biosecurity Queensland is also working with the Northern Territory Government to assist with their *C. connexa* release program. In addition to releases, pre- and post-establishment damage assessments have been conducted at various northern Queensland sites over a four-year period and fungal pathogens and insects associated with *Chromolaena odorata* within Australia are being catalogued.

The monitoring of establishment, spread and impact of previously released biological control agents is important to determine when releases can cease, the need for other agents or control methods and to evaluate the biological control program's benefit. Yearly and monthly surveys are conducted on a variety of weeds and collections of associated agents and other natural enemies (arthropods and pathogens) are compiled. Greater spread of previously released agents is also achieved through collection and redistribution of agents for invasive weed species such as parthenium and lantana to landholders and local governments.

Figure 22 Galls of Cecidochares connexa *on Chromolaena*

Figure 23 Mary Butler releasing insects onto Chromolaena odorata

Collaborators

- Charters Towers Regional Council
- Townsville City Council
- Hinchinbrook Shire Council
- Douglas Shire Council
- Cassowary Coast Regional Council
- Queensland Department of Environment and Science
- NQ Dry Tropics

- Bush Heritage Australia
- Tablelands Regional Council
- Queensland Department Resources
- Queensland Department of Transport and Main Roads
- Northern Territory Government - Department of Environment and Natural Resources
- Defence Australia
- Ergon Energy
- Queensland Corrective Services, Townsville
- Burdekin Shire Council
- Central Highlands Regional Council
- Isaac Regional Council
- Cairns Regional Council
- NQ Plantations
- Mareeba Shire Council
- Plant Biosecurity Laboratories – Biosecurity Queensland

Key publications

Pukallus, **K**., **Kronk**, **A**. & Franklin, M. (2022). *First release and establishment of the biological control agent* Cecidochares connexa *for the management of* Chromolaena odorata *(L.) R.M. King & H. Rob (chromolaena) in Australia.* In: Proceedings of the 22nd Australasian Weeds Conference. Eds. Brodie, C., Emms, J., Feuerherdt, L., Ivory, S., Melland, R., Potter, S., Weed Management Society of South Australia Inc., Adelaide, South Australia. pp. 238-241.

21. Biological control compendium

Project dates

July 2022 – July 2024

Project team

Kelli Pukallus

Project summary

The project is creating a readily available, easy-to-read record of biological control agents released in Queensland for the management of weeds. Each compendium record will include information about the agent's biology, agent locations and release procedure shared on open digital platforms. This information is important as once an agent release program is complete the Invasive Plants and Animals program does not maintain colonies of agents to supply the general public. The compendium will enable land managers, local government officers and the general public to collect and redistribute the agents they require to increase agent numbers and impact.

The compendium will be updated over time and will also include links to fact sheets on agents.

22. Biological control of parkinsonia (*Parkinsonia aculeata*) with *Eueupithecia vollonoides (*UU2)

Project dates

February 2020 – July 2023

Project team

Kelli Pukallus, Mary Butler and Kirsty Gough

Project summary

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

This project continued and expanded the mass-rearing and release of a second biological control agent for parkinsonia, UU2 (*Eueupithecia vollonoides*), throughout northern Australia. The project aimed to establish UU2 where it had not previously been released or established. At least 222,000 pupae were released at 75 sites within Queensland, Northern Territory and Western Australia. The project also assisted with studies on monitoring and pheromone trapping of *Eueupithecia species* within several locations across northern Queensland.

This project was conducted with funding from MLA and CSIRO.

Collaborators

- CSIRO (Brisbane)
- Meat and Livestock Australia
- Mount Isa City Council
- Central Highlands Regional Council
- Flinders Shire Council
- Richmond Shire Council
- Cloncurry Shire Council
- Isaac Regional Council
- Barcaldine Regional Council
- Charters Towers Regional Council
- Barcoo Shire Council
- Livingstone Regional Council

- Longreach Regional Council
- Mount Isa Water Board
- Northern Territory Department of Environment, Parks and Water Security
- Malak Malak Lands Trust
- Western Australian Department of Primary Industries and Regional Development
- Kimberley Rangelands Biosecurity Association
- Biosecurity Officers
- Fitzroy Basin Association
- McKinlay Shire Council

Key publications

Murray, C., Walter, G. & Rafter, M. (2022). *Pheromone trapping for monitoring the establishment and spread of* Eueupithecia cisplatensis *and* E. vollonoides*, biological control agents for* Parkinsonia aculeata. In: Proceedings of the 22nd Australasian Weeds Conference. Eds. Brodie, C., Emms, J., Feuerherdt, L., Ivory, S., Melland, R., Potter, S., Weed Management Society of South Australia Inc., Adelaide, South Australia, p237.

Rafter, M. A., **Pukallus**, **K**., Wenting, S., Walter, G. H. & White, A. (2022). *Parkinsonia biological control: Establishment, spread and impact of UU1 and UU2 across northern Australia*. In: Proceedings of the 22nd Australasian Weeds Conference. Eds. Brodie, C., Emms, J., Feuerherdt, L., Ivory, S., Melland, R., Potter, S., Weed Management Society of South Australia Inc., Adelaide, South Australia, p236.

Rafter, M., McKay, F., Parisi, M., Sosa, A., Heard, T., White, A., Fichera, G., Brookes, D., Nagalingam, K., Kaye, L. & Sathyamurthy, R. (2022). Biology, host specificity and DNA barcoding of cryptic *Eueupithecia species* (Lepidoptera: Geometridae), and implications for biological control of *Parkinsonia aculeata* (Fabaceae) in Australia. *Austral Entomology*, 61(1):8.

23. Sicklepod ecology and control

Project dates

January 2016 – June 2027

Project team

Melissa Setter and Stephen Setter

Project summary

Sicklepod (*Senna obtusifolia*) is a serious weed of northern Queensland from Cape York to Mackay. It occurs in pastures, crops, and corridors such as road and powerline clearings and creek and riverbanks. This project aims to determine the longevity and production of sicklepod seed, including the seasonality of seed production. Seeds are persisting for at least 48 months after burial, with testing continuing.

The project is also investigating the use of pre-emergent herbicides to suppress seedlings in strategic areas and the potential for the use of low-volume, high-concentration herbicides. The efficacy of sixteen different herbicides for suppressing seedling emergence and establishment was tested in pots with herbicides containing picloram, including Conqueror®, Grazon Extra®, Stuka flexi®, Tordon 75-D® and Tordon Regrowth Master® found to be effective.

The effective herbicides from the pot trial were tested in field conditions in the dry topics of north Queensland at the Morehead and West Normanby Rivers and Oaky Creek near Cooktown. The most effective and suitable herbicides were Conqueror®, Grazon Extra®, and Tordon 75-D®, all of which contain picloram. A demonstration site has been established in conjunction with Cook Shire Council, to showcase the effectiveness of these herbicides.

Following the success of the pre-emergent herbicides in the dry areas of north Queensland, they are now being tested in wetter tropical areas, including Mossman, Innisfail, Ingham, and Mackay. The use of low-volume, high-concentration herbicide control options are yet to be tested.

Collaborators

- DAF Biosecurity Officers
- Local governments in northern Queensland (e.g. Cook Shire Council, Douglas Shire Council, Cassowary Coast Regional Council, Hinchinbrook Shire Council, Mackay Regional Council)
- Queensland Parks and Wildlife Service
- Landowners and pastoralists
- Cape York Weeds and Feral Animals Inc.

Key publications

Dunlop, E. A. (2007). Mapping and modelling the invasion dynamics of *Senna obtusifolia* at different levels of scale in Australia. PhD thesis, Queensland University of Technology.

Mackey, A.P., Miller, E.N. & Palmer, W.A. (1997). Sicklepod (*Senna obtusifolia*) in Queensland, Pest Status Review Series – Land Protection, Department of Natural Resources and Mines, Qld.

Neldner, V.J., Fensham, R.J., Clarkson, J.R. & Stanton, J.P. (1997). The natural grasslands of Cape York Peninsula. Description, distribution and conservation status. *Biological Conservation* 81: 121-136.

Setter, **M.J.**, **Setter**, **S.D.**, 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, Ed. T. Sydes, (Weed Society of Queensland Pty. Ltd.), Gold Coast, May 2019. (Oral Presentation)

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

Project dates

January 2020 – June 2023

Project team

Melissa Setter, Stephen Setter and Clare Warren

Project summary

Aleman grass is a deliberately introduced, promoted and planted ponded pasture species which has become weedy in unmanaged agricultural and environmental aquatic systems in Queensland. Field-based herbicide trials were conducted in the lower Herbert River basin with in-kind support from north Queensland local governments, Agri-science Queensland and canegrowers.

The first component of the trial was to investigate effective herbicides and wetter rates for the control of Aleman grass in land-based field situations. NEMO® wetter, several herbicides including Haloxyfop (Verdict®), Imazapyr (Poacherl®), Glyphosate (Weedmaster Duo®) and application rates of each were identified as being effective. Success was quantified using both traditional ground-based manual methods and aerial imagery from unmanned aerial vehicles (UAVs). A direct comparison of assessment methods resulted in confirmation of UAV image capture as a reliable tool for assessments in this situation.

The next component utilised UAVs to map, apply and assess the efficacy of the effective treatments identified in the initial land-based trial. Once again, the treatments and assessments mirrored the results from the land-based trial.

The results of the trials identified herbicides and application rates plus NEMO® that provide effective control of Aleman grass. These results will be used to seek a minor use permit for Aleman grass control from the Australia Pesticides and Veterinary Medicines Authority. In addition, the trial found UAVs to be a useful tool not only for herbicide application but also assessing efficacy of treatment.

Collaborators

- Biosecurity Officers
- Far North Queensland Regional Organisation of Councils
- Terrain NRM
- Cassowary Coast Regional Council
- Hinchinbrook Shire Council
- Marcus Bulstrode, Senior Development Officer - Sustainable Farming Systems RD&E (Agri-Science Queensland, Department of Agriculture and Fisheries)

Key publications

Abbott, B.N., Wallace, J., Nicholas, D.M., Karim, F. & Waltham, N.J. (2020). Bund removal to re-establish tidal flow, remove aquatic weeds and restore coastal wetland services — North Queensland, Australia, *PLoS ONE* 15(1): e0217531.

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

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

25. Aquatic weeds of northern Australia—ecology and control

Project dates

January 2015 – June 2026

Project team

Melissa Setter and Stephen Setter

Project summary

Aquatic weeds are a burgeoning problem with the increasing commercial trade in aquatic plants, particularly via the internet. Several escaped aquarium plants are particularly problematic in the Wet Tropics, but with potential distributions across large parts of northern Australia. These include hygrophila (*Hygrophila costata*), bog moss (*Myacca fluviatilis*) and Amazon frogbit (*Limnobium laevigatum*). Escaped ponded pasture species such as Aleman grass (*Echinochloa polystachya*) are also problematic, and under investigation. This project proposes to answer specific ecological questions to improve management of current infestations and predict further infestations. Control options will also be investigated for selected species.

Specific research includes:

Bog moss - Glasshouse research on herbicide control has recently concluded, with several successful treatments identified, notably ProcellaCOR® and Reglone®.

Hygrophila – We have assessed seed and vegetative reproduction abilities in regional populations. We found negligible viable seed production, and conclude vegetative reproduction is the main dispersal mode in north Queensland. Stem sections can float and survive for 3 weeks in fresh or brackish water and 2 weeks in salt water.

Amazon frogbit - Seed viability and longevity has been assessed in regional populations. Seed was produced in north Queensland during October – December. Each fruit averaged 70 seeds, with approximately 80-90% germination success.

Aleman grass - Seed viability and longevity has also been assessed in regional populations. No viability has been detected in local populations. This is consistent with the literature which suggests low viability.

Collaborators

- DAF Biosecurity Officers

- Far North Queensland Regional Organisation of Councils
- Terrain NRM
- Cairns Regional Council
- Cassowary Coast Regional Council
- Hinchinbrook Shire Council

Key publications

Setter, **S**.**D**. & **Setter**, **M**.**J**. (2019). *Adapting autonomous underwater vehicles (AUV) for aquatic weed control*. Proceedings of the Queensland Pest Animal and Weeds (PAWS) Symposium, Gold Coast, Queensland.

26. *Harrisia martinii* biological control and integrated management

Project dates

July 2020 – June 2023

Project team

Tamara Taylor, Lauren Kelk and Kelli Murree

Project summary

Native to Argentina, *Harrisia martinii* is a spiny cactus species that can form dense infestations, choking out pasture species and native vegetation. Infestations can cause injuries to livestock and wildlife and inhibit their movement. A biological control agent, *Hypogeococcus pungens* (Harrisia mealybug), was released in the 1970s and provided early control of *H. martinii* at release locations in central Queensland. However, due to environmental conditions limiting development and dispersal, the mealy bug is not providing adequate control in south Queensland. Infestations also appear to be increasing again in central Queensland. Field and laboratory studies by University of Queensland PhD candidate, Angela Ezeh, are examining the thermal tolerance of the mealybug and the impact of the biocontrol agent under different environmental conditions.

Additional field trials include an investigation of the impact of sheep grazing on *Harrisia* density at a property in Goondiwindi. As part of this study, since January 2023 seven sheep have been collared for GPS tracking to determine whether using sheep as a management tool is limited by geographic features within the landscape. Glasshouse experiments comparing the number and viability of *H. martinii* seed in the soil from locations with different *Harrisia* control history have been completed and an analysis of the number of viable seeds in different animal scats collected from infested areas has commenced.

After extensive searches for a previously released biological control agent (a stem-boring beetle, *Nealcidion cereicola*) in central Queensland, we now agree with previous reports that this beetle has died out. A re-importation of the beetle from Argentina is due to arrive by December 2023. Additionally, a collaborator in Argentina is studying a potential new biological control agent, a stem-feeding fly (*Dasiops bourquini*), to determine if laboratory rearing methods can be established for host testing in Australia.

Figure 24 Using radio telemetry to track sheep at Goondiwindi during trials on Harrisia cactus control

Collaborators

- Michael Day (Brisbane)
- John Conroy, Biosecurity Officer (Goondiwindi)
- Angela Ezeh (University of Queensland)
- CONICET – CECOAL – Universidad Nacional del Nordeste (UNNE), Argentina
- Goondiwindi Regional Council
- Harrisia Cactus Working Group
- Northern Slopes Landcare Association
- Macintyre Ag Alliance
- NSW Department of Primary Industries

- Horizon Ecological Consulting

Figure 25 Sheep wearing GPS tracking collars as part of trials on controlling Harissia cactus

Key publications

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

Novoa, A., Brundu, G., Day, M., Deltoro, V., Essl, F., Foxcroft, L., Fried, G., Kaplan, H., Kumschick, S., Lloyd, S., Marchante, E., Marchante, H., Paterson, I., Pyšek, P., Richardson, D., Witt, A., Zimmermann, H. & Wilson, J. (2019). Global Actions for Managing Cactus Invasions, *Plants*, 8(10), p421.

Tomley, A. (2001). A report on the status of a biological control program for Harrisia cactus in Queensland, Queensland Government, Natural Resources and Mines, Alan Fletcher Research Station, Sherwood.

27. Biological control of pasture weeds in Vanuatu and Queensland

Project dates

October 2018 – June 2023

Project team

Tamara Taylor and Lauren Kelk

Project summary

Biosecurity Queensland is collaborating with Landcare Research NZ on a 5-year weed biological control project based in Vanuatu, funded by the NZ Ministry of Foreign Affairs and Trade. Three pasture weeds targeted under this project are *Senna tora* (one of three sicklepods which are restricted weeds in Queensland), *Solanum torvum* (a weed declared by some local governments in Queensland) and *Urena lobata* (a widespread environmental weed in Queensland). Potential biological control candidates for *S. tora* will be brought into the quarantine at the Ecosciences Precinct in Brisbane for host testing, while those for *S. torvum* and *U. lobata* are being studied in New Zealand. Landcare Research NZ has recently applied for approval to release an agent for *S. torvum* in Vanuatu. However, it is unlikely that importation and testing in Australia will occur, due to potential impacts on a broader range of hosts present in this country. Molecular analysis of sicklepod (*S. tora* and *S. obtusifolia*) provenances collected from Australia, Vanuatu, Tonga, Malaysia, China, Brazil, French Guiana, the Dominican Republic, Puerto Rico, Mexico, Costa Rica, Venezuela, Colombia, Guadeloupe and Nicaragua has been completed by Landcare Research NZ.

Sicklepod in Vanuatu and Australia has been determined to be more closely related to populations in central America and the Caribbean, rather than Malaysian populations as previously proposed. In December 2022 a trip to the Dominican Republic was conducted to survey for potential biological control agents for *S. obtusifolia*. A moth (*Anabasis ochrodesma*) with stem feeding larvae was observed to be damaging to sicklepod, but not to other species of *Senna* nearby. Arrangements are underway to obtain permits to import *A. ochrodesma* into quarantine in Brisbane for host specificity testing. Additionally, a stem-galling weevil (*Conotrachelus* sp.) from Mexico will be imported for host testing in late 2023. This weevil was originally proposed as a biological control agent and exported from Mexico into quarantine in October 1998 and August 1999. Host specificity testing commenced after the 1999 import. Data from preliminary tests indicate that five species of *Senna* were unable to support *Conotrachelus* sp. development, while successful development occurred on *S. obtusifolia*. However, the laboratory culture died out within a few months. The project ended at this time, with no further imports of the insect. We consider that this agent is worth pursuing for re-importation and continued host testing.

Collaborators

- Michael Day (Brisbane)
- Manaaki Whenua Landcare Research NZ
- Ministry of Foreign Affairs and Trade, NZ
- Biosecurity Vanuatu
- Department of Environment, Vanuatu
- Malaysian Agricultural Research and Development Institute
- Ricardo Segura (Mexico)

Figure 26 Biocontrol researcher, Chris McGrannachan from Manaaki Whenua - Landcare Research NZ, sweeping for insects in a paddock of Senna obtusifolia in the Dominican Republic.

Figure 27 Staff from the Botanical Garden of Santiago, Dominican Republic assisting with the search for potential biological control agents for Senna obtusifolia.

Key publications

Cock, M.J.W. & Evans, H.C. (1984). Possibilities for biological control of *Cassia tora* and *C. obtusifolia*. *Tropical Pest Management*, 30: 339-350.

Palmer, W.A. & Pullen, K.R. (2001). The phytophagous arthropods associated with *Senna obtusifolia* (Caesalpiniaceae) in Mexico and Honduras and their prospects for utilization for biological control. *Biological Control* 20: 76–83.

Palmer, W.A., Heard, T.A. & Sheppard, A.W. (2010), A review of Australian classical biological control of weeds programs and research activities over the past 12 years. *Biological Control*, Volume 52 (3): 271-287.

28. Giant rat's tail grass classic biological control

Project dates

July 2022 – June 2024

Project team

Tamara Taylor, Lauren Kelk, David Comben and Wayne Vogler

Project summary

Giant rat's tail grass (GRT) is the common name of two species, *Sporobolus pyramidalis* and *S. natalensis*, native to Africa. Current control efforts for these weedy *Sporobolus* grasses in Australia rely on the use of chemicals, mechanical control, plant competition and pasture management. However, conventional control can be difficult and expensive and GRT continues to rapidly spread into new areas. Biosecurity Queensland subcontracted Rhodes University in South Africa from 2016 to 2022 to survey for potential biological control agents for GRT in their native range and conduct preliminary host specificity testing. This research was funded by the Australian Government's Rural R&D for Profit Program through AgriFutures Australia. Rhodes University found two species of wasps with stem feeding larvae from the *Tetramesa* genus that were damaging to GRT. Host testing concluded that neither wasp species was able to complete development on any of the 24 grass species tested other than on GRT. Both wasp species appear to be suitable for further host testing of native Australian grasses.

Two importations of *Tetramesa* sp. A and B have been received in Ecosciences Precinct quarantine facility in Brisbane. The first import of 800 field-collected GRT stems arrived in September 2022. These were hand delivered by the Rhodes University researcher who conducted the study in South Africa, and also provided Biosecurity Queensland staff with valuable training to rear the wasps. A total of 25 *Tetramesa* sp. B (11 female and 14 male) and 6 *Tetramesa* sp. B (4 female and 2 male) emerged from the imported stems. A total of 21 parasitic wasps also emerged. Asynchronous emergence of the wasps limited the potential for mating once they were introduced to plants for rearing, given that adults only live for 4 – 7 days. Only one next generation wasp was produced from this import, which is not enough to establish a culture. A further import transported by a visiting researcher from South Africa to Sydney was collected by Biosecurity Queensland staff from Sydney. One hundred and forty-nine GRT stems were imported, from which 5 *Tetramesa* sp. A (2 female

and 3 male) and 3 *Tetramesa* sp. B (all male) emerged. This import also failed to produce a laboratory culture of the wasps. Rhodes University have committed to provide Biosecurity Queensland with a further supply of GRT stems from new laboratory cultures of *Tetramesa* produced without parasitism, an additional problem with earlier imports. Arrangements have been made for these to be collected in November 2023.

Figure 28 Imported giant rat's tail grass stems containing Tetramesa *sp. awaiting emergence in quarantine.*

Collaborators

- Rhodes University, South Africa
- AgriFutures Australia
- Australian Department of Agriculture, Fisheries and Forestry

Key publications

Sutton, G.F, Canavan, K., **Day, M.D**., den Breeyen, A., Goolsby, J.A., Cristofaro, M., McConnachie, A. & Paterson, I.D. (2019). Grasses as suitable targets for classical weed biological control, *BioControl*, 64: 605–622.

Sutton, G.F. (2021). Prioritising biological control agents for release against *Sporobolus pyramidalis* and *Sporobolus natalensis* (Poaceae) in Australia. Doctoral dissertation, Rhodes University.

Sutton, G.F., Canavan, K., **Day**, **M**.**D**. & Paterson, I.D. (2021). Field-based ecological studies to assess prospective biological control agents for invasive alien plants: an example from giant rat's tail grass, *Journal of Applied Ecology*. 58(5): 1043-1054.

29. Chemical registration - providing tools for weed control

Project dates

July 2012 – June 2024

Project team

Joe 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.

Eighteen weed and pest animal (see project 39 below) permits were issued to Biosecurity Queensland during 2022–23 by the Australian Pesticides and Veterinary Medicines Authority (APVMA). Fifteen permits related to weeds — parthenium, cacti, pimelea, bellyache bush, alligator weed, water primrose, Amazon frogbit and salvinia. One permit was for insecticide control.

Control recommendations are provided in pest fact sheets (https://www.daf.qld.gov.au/business-priorities/biosecurity/invasive-plants-animals/fact-sheets) that are regularly updated.

Collaborators

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

Key publications

APVMA (2022) PER10892: Permit to allow minor use of glyphosate and Nemo aquatic surfactant for use in aquatic areas to control salvinia. Issued 17 August 2022.

APVMA (2022) PER92459: Permit to allow minor use of amitrole, ammonium thiocyanate, aminopyralid, triclopyr and other products for the control of Cactaceae in various situations. Issued 31 August 2022.

APVMA (2022) PER14361 Permit to allow minor use and supply of an unregistered agvet chemical product (ethylene) for control of red witchweed in infected premises. Issued 02 September 2022.

APVMA (2022) PER13707: Permit to allow minor use of metsulfuron-methyl for the control of bellyache bush in native pastures, rights-of-way, commercial and industrial areas. Issued 7 September 2022.

APVMA (2022) PER91744 Permit to allow minor use of a flumioxazin and glyphosate with Bonus or Nemo surfactants for control of Amazon frogbit in non-potable and offline potable waterways associated with Wappa dam. Issued 29 September 2022.

APVMA (2022) PER13549: Permit to allow minor use of glyphosate and 2,4-DB for the control of pimelea in fallow and pastures. Issued 3 November 2022.

APVMA (2022) PER13812: Permit to allow minor use of triclopyr and picloram for the control of coral cactus in pastures, rights of way, commercial and industrial areas. Issued 3 November 2022.

APVMA (2022) PER92465: Permit to allow minor use of picloram, triclopyr, metsulfuron-methyl and imazapyr for the control of Cactaceae in various situations. Issued 7 November 2022.

APVMA (2022) PER92475: Permit to allow minor use of aminopyralid, picloram, triclopyr, metsulfuron-methyl and glyphosate for the control of Cactaceae in various situations. Issued 8 November 2022.

APVMA (2022) PER93074: Permit to allow minor use of various products (Roundup, Vigilant II) for control of water primrose in North Pine Reservoir Reserve. Issued 1 December 2022.

APVMA (2022) PER10221: Permit to allow minor use of metsulfuron-methyl in non-potable waterways for control of alligator weed. Issued 30 December 2022.

APVMA (2023) PER13706: Permit to allow minor use of imidacloprid insecticide to control the lantana stemsucking leafhopper on fiddlewood trees. Issued 9 March 2023.

APVMA (2023) PER89268: Permit to allow minor use of Nemo aquatic surfactant for use in specified aquatic and ripairian situations. Issued 16 June 2023.

APVMA (2023) PER81236: Permit to allow minor use of Nufarm Bonus adjuvant/surfactant for use in aquatic, riparian or adjacent areas. Issued 20 June 2023.

APVMA (2023) PER10367: Permit to allow minor use of metsulfuron-methyl in pastures and non-crop situations for control of parthenium weed by aerial application in inaccessible areas. Issued 26 June 2023.

30. Treatments and strategies for red witchweed eradication

Project dates

July 2014 - June 2025

Project team

Joseph Vitelli, Bahar Farahani, Melissa Brien and Anna Williams

Project summary

In a sugarcane-growing area near Mackay, we have been investigating how best to deplete the red witchweed (RWW) seed bank and prevent further seed production over a ten-year period. A large trial showed that after five annual applications of either ethylene gas, dazomet, ethephon, sorghum, corn or soybean, the RWW soil seedbank viability was reduced to 0%, irrespective of seed burial depth.

Properties infested with RWW are being treated and progress towards eradication is being determined by monitoring the RWW soil seedbank on infested properties. Sachets of RWW seeds have been buried at depths of 100, 300 and 500 mm across 25 sites on infested properties covering the active eradication management zone for RWW. The 25 sites vary in soil type and topography.

After four years, the viability of retrieved seeds had declined dramatically, irrespective of treatment combination used. However, the decline in viability of seeds varies across sites, burial depth and time. Sachets of seeds are removed at regular intervals and seed viability determined to allow paddocks to be released from quarantine. A seed trial is continuing at the Ecosciences Precinct to fine tune treatments to accelerate depletion of the RWW seed bank. The trial assesses the use of soybean as a false host and fumigation by injecting ethylene gas or applying the granular fumigant dazomet.

Collaborators

- Local governments
- Michelle Smith, Matt Birch and Tom Bowditch (Biosecurity Queensland)
- University of Queensland

Key publications

Epée, M., Paul,T. (2018). Comparative analysis on the management of the parasitic weed *Striga* in the USA, Australia and Kenya. Available at SSRN: https://ssrn.com/abstract=3231805 or http://dx.doi.org/10.2139/ssrn.3231805

Eplee, R.E. (1992). Witchweed (*Striga asiatica*): An overview of management strategies in the USA. *Crop Protection* 11, 3-7. doi: https://doi.org/10.1016/0261-2194(92)90071-C.

Williams, A.M., Riding, N. & **Vitelli**, **J**.**S**. (2022). Monitoring *Striga asiatica* (Orobanchaceae) seedbank for eradication success, 22nd Australian Weeds Conference, Adelaide, pp158-161.

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

Project dates

February 2019– June 2023

Project team

Joseph Vitelli, David Holdom, Tess James, Dipika Roy and Bahar Farahani

Project summary

This project has been assessing the suitability of endemic and naturalised fungal pathogens to control giant rat's tail grass. It was supported by funding from the Australian Government, AgriFutures Australia, and cash and in-kind from several collaborators.

Seventy endemic pathogens were isolated from giant rat's tail grass (GRT) throughout its Australian invasive range. A series of experiments prioritised candidates, with eight isolates killing 50-100% of GRT seedings. Three fungi showed promise by infecting GRT but were not target host specific, infecting one native grass species, African lovegrass and Callide Rhodes grass. Testing will continue to determine the extent of non-target damage and the suitability of the other five isolates. Suitable fungal pathogens could be developed as a mycoherbicide or simply as augmentative biological control for the management of GRT. A naturalised leaf smut pathogen, *Ustilago sporoboli-indici*, damaging to GRT, was discovered in the field surveys. The smut has minor impacts on some native *Sporobolus* and other weedy *Sporobolus* species in the laboratory. A PhD program will continue to investigate its suitability as a control agent for GRT.

Collaborators

- Australian Department of Agriculture, Fisheries and Forestry
- AgriFutures Australia
- New South Wales Environmental Trust
- NSW Biocontrol Taskforce
- Bundaberg Regional Council (including Eric Dyke and James Anderson)
- Gympie Regional Council
- HQ Plantations Pty Ltd
- AgForce Queensland
- Brooke Johnstone, Shane Campbell (The University of Queensland, School of Agriculture & Food Sciences)
- Tracey Steinrucken (CSIRO)
- Roger Shivas (University of Southern Queensland)
- Kaylene Bransgrove, Yu Pei Tan (DAF Plant Biosecurity and Product Integrity)
- David Officer (NSW Department of Primary Industries)

Key publications

Steinrucken, T.V. & **Vitelli**, **J**.**S**. (2023). Biocontrol of weedy *Sporobolus* grasses in Australia using fungal pathogens. *BioControl*, 68 (4): 341-361 https://doi.org/10.1007/s10526-023-10195-5

32. Management of giant rat's tail grass using wick wipers

Project dates

February 2017– June 2023

Project team

Joseph Vitelli, David Holdom, Tess James, Dipika Roy and Bahar Farahani

Project summary

Giant rat's tail grass (GRT) and the other introduced weedy *Sporobolus* grasses are unpalatable, perennial, tussock-forming grasses of serious concern to the grazing industry across eastern Australia. GRT reduces carrying capacity and productivity of more than 450,000 ha of pastoral land in eastern Queensland, New South Wales and areas of Victoria and is a high-risk fodder contaminant.

There is an increase in the use of wick wipers among landholders but a limited understanding on how to use both glyphosate and flupropanate herbicides in the presence of endemic and naturalised pathogens to effectively manage GRT. This project aims to optimise the use of two herbicides (glyphosate and flupropanate) to control and suppress seed production of GRT plants growing in pastures and along roadsides using weed wipers.

Slashing removes rank and dead growth from the previous season, crash grazing provides the height difference between the desirable pasture and GRT in readiness for herbicide (glyphosate or flupropanate or both) application. Wick wiping then targets individual GRT tussocks on a broad-acre scale. At one trial site, the GRT leaf smut is rendering GRT flower-heads sterile. An integrated control approach has reduced populations of GRT by almost 40% in three years at a trial site at Conondale. With additional treatment, this decline in GRT could be greater.

An integrated trial will test the combination of four fertiliser (0, 50, 100 and 200 kg N ha^{-1}) and two herbicide applications using a wick wiper under grazed conditions. A pot trial will refine herbicide rates.

Collaborators

- Tom Cowan and Shane Campbell (University of Queensland)
- Peter Thompson (property manager, Elgin, Conondale)

Figure 29 Wick wiper application

Figure 30 Giant rat's tail grass following wick wiper treatment

33. Management of sticky florestina

Project dates

July 2022 – June 2025

Project team

Wayne Vogler and Clare Warren

Project summary

Sticky florestina (*Florestina tripteris*) is an annual plant from semi-arid North America that was introduced to central-western Queensland anecdotally in the 1960s and reported as a pest in the late 1980s. Local governments are reporting a current profusion of the weed along roadsides. There is considerable scope for further spread of the weed as seeds are readily spread by livestock, wildlife, machinery and along waterways. Much of central, western and southern Queensland is highly suitable for sticky florestina and improved management options are needed to reduce future potential negative impacts to pasture production and the environment. The project aims to improve the control and management options for sticky florestina in central west Queensland by improving knowledge about the ecology and biology of sticky florestina and improving herbicide and integrated management options for sticky florestina along roadsides, pasture and environmental areas in central west Queensland.

Laboratory work has focused on developing an effective repeatable seed gemination protocol. This has largely been achieved although it continues to be refined. Seeds have been buried in a trial established at Longreach to determine the length of time seed remains viable. A more rapid Controlled Ageing test is assessing seed longevity in the laboratory in Charters Towers. An indication of the dispersal distance of sticky florestina in water is being determined by a seed floatation study in both still and agitated water.

Glasshouse investigations of time to reproductive maturity, effect of herbicide application on seed viability, and time to reproductive maturity following cutting are being developed and will commence in late 2023. This will provide the information to develop and test effective control regimes on roadsides and around infrastructure. The effect of dry heat on seed viability will also be determined to give an indication whether heat from planned burning can kill seed.

Collaborators

- Longreach Regional Council, Central West Regional Pest Management Group

Figure 31 Field trial determining seed longevity in sticky florestina at Longreach

Key publications

McKenzie, J., Brazier, D., Campbell, S., Vitelli, J, Anderson, A & Mayer, R. (2014). Foliar herbicide control of sticky florestina (*Florestina tripteris* DC.), *The Rangeland Journal*, 36: 259-265.

Soto-Trejo, F., Schilling, E.E., Oyama, K, Lira, R. & Davila, P. (2016). A taxonomic revision of the genus *Florestina* (Asteraceae, Bahieae), *Phytotaxa*, 268 (2): 91-109.

34. Strategic invasive grass control to reduce risk of further invasion in northern Queensland

Project dates

July 2022 – June 2025

Project team

Wayne Vogler and Clare Warren

Project summary

Gamba grass, grader grass and giant rat's tail grass are serious invasive weeds in northern Australia resulting in large scale environmental damage and economic loss to graziers. These high priority grasses are in northern and eastern areas of Queensland and are spreading from small early invasion infestations. The particular hotspots being targeted are in Cape York, Atherton Tablelands, Yeppoon, Mackay, Whitsunday and Burdekin regions. The project is engaging a range of land managers through their local governments to identify and control or eradicate strategic outlier infestations of these grass species on both private and publicly owned land. The project is providing a hands-on demonstration of the latest control strategies, safe herbicide application techniques, how to monitor management progress and improving the capacity of land managers to effectively manage incursions of these grasses.

Strategic infestations have been identified within the boundaries of the six local government collaborators. On ground activities have been defined for each grass species relevant to their situation and have commenced in five local government areas. Control activities will commence in the final local government area in the second half of 2023. Case studies will be developed for each control activity and grass species and published at the end of the project.

Collaborators

- Burdekin, Cook, Livingstone, Mackay, Tablelands and Whitsunday Regional Councils.

Figure 32 Immature gamba grass in the Cook shire

Figure 33 Grader grass in the Burdekin region

Figure 34 Treated gamba grass

Figure 35 Wayne Vogler discussing grader grass identification at the Woolooga grass masterclass

Figure 36 Wayne Vogler discussing management of giant rat's tail grass at the Gatton grass masterclass

Part 2: Pest animal management

35. Refining management of feral deer in Queensland

Project dates

July 2020 – June 2024

Project team

Matt Amos, Michael Brennan and Tony Pople

Project summary

Wild deer are widely distributed and increasing in eastern Australia. The expansion of the deer population increases the risk of negative impacts to both rural and urban communities, agriculture and the environment. Control and monitoring tools are limited and the best tools are situation-dependent, varying with factors such as landform, vegetation, human habitation, and target deer species. Both need thorough evaluation to support the development of best practice management guidelines for land managers planning control operations in Queensland.

This project is assessing the cost-effectiveness and feasibility of deer control and monitoring methods at five study sites: Brisbane, North Pine Dam, Sunshine Coast, Yeppoon and Wild Duck Island. Faecal pellet counts in southwestern Brisbane suggest a reduction in the deer population from 2018 to 2021 where ground control by both shooting and trapping is undertaken. Camera grid density estimates of rusa deer at North Pine Dam and Wild Duck Island have been undertaken annually since 2019, whilst rusa deer at Yeppoon were monitored in 2019 and 2020. The deer numbers have fluctuated at North Pine Dam where deer are being removed by ground shooting. The Wild Duck Island deer population has been greatly reduced from aerial culling operations. Results from thermal vehicle surveys at the Sunshine Coast suggest that deer numbers have been reduced to low levels by ground shooting.

Two workshops on best practice management of wild deer were held in 2022-23 for local governments and other land managers – one in central Queensland (Yeppoon) and one in north Queensland (Ingham). A range of topics were covered, including control options, monitoring techniques, deer identification and community engagement. Local government pest managers also presented results and recommendations of deer management programs from various locations in Queensland including Brisbane and the Sunshine Coast.

Collaborators

- Dave Forsyth, Sebastien Comte and Andrew Bengsen (New South Wales Department of Primary Industries)
- Steve Burke (Marine Parks, Department of Environment and Science)
- Mark Kimber, Tony Cathcart and Jesse Wojtala (Sunshine Coast Regional Council)
- Jess Doman and Perry Ward (Seqwater)

- Bill Manners, Dan Franks and Robyn Jones (Brisbane City Council)
- Darren Sheil (Moreton Bay Regional Council)
- Leise Childs, Dave Mitchell and John Wyland (Livingstone Shire Council)

Key publications

Amos, **M**., **Brennan**, **M**., **Pople**, **T**., Cathcart, T., Kimber, M., Wojtala, J., Doman, J., Manners, B., Franks, D., Jones, R., Childs, L., Mitchell, D. & Wyland, J. (2021). Broadscale monitoring of feral deer population trends and control effort in Queensland peri-urban environs, *18th Australasian Vertebrate Pest Conference*, Virtual, 25-27 May.

Amos, **M**., **Pople**, **T**., **Brennan**, **M**., Sheil, D., Kimber, M. & Cathcart, A. (2022). Home ranges of rusa deer (*Cervus timorensis*) in a subtropical peri-urban environment in South East Queensland, *Australian Mammalogy*, In Press.

Forsyth, D., **Pople**, **T**., Page, B., Moriarty, A., Ramsey, D., Parkes, J., Wiebkin, A. & Lane, C. (eds) (2017). 2016 National Wild Deer Management Workshop Proceedings, Adelaide, 17-18 November 2016, Invasive Animals Cooperative Research Centre, Canberra, Australia.

36. Evaluating breeding success of wild rabbits in various harbour types

Project dates

July 2021 – June 2024

Project team

Peter Elsworth

Project summary

The European rabbit is a significant pest to agriculture and the environment. As a result of biocontrol activity (RHDV1, K5, RHDV2 and myxomatosis) and concerted harbour removal projects in south-east Queensland, rabbit numbers in the state are the lowest they have been for decades. The harbour removal efforts have focused on “key breeding” locations, primarily large warren systems and long-standing log piles. Removing the key breeding sites is considered a good strategy for rabbit control, based on the belief that control in other areas is unnecessary given these contribute little to population size or recovery. As stakeholders look to maximise benefit for lowest cost, this method is gaining momentum. However, it is necessary to determine if “lower importance” breeding sites are sufficiently productive to allow rabbit populations to be self-sustaining or recover following control of key breeding sites.

Motion-sensitive cameras were deployed on lower importance breeding sites to monitor the output and survival of young, along with interactions with predators. Across two breeding seasons, rabbit populations remained static or declined despite high numbers of kittens

being born. Natural mortality was very high with predators and weather conditions preventing young rabbits reaching breeding age to allow population recovery.

Collaborators

- Nathan Ring (Darling Downs and Moreton Rabbit Board)
- Southern Downs Regional Council
- Highfields Pioneer Village

Key publications

Berman, D., **Brennan**, **M**. & **Elsworth**, **P**. (2011). How can warren destruction by ripping control European wild rabbits (*Oryctolagus cuniculus*) on large properties in the Australian arid zone? *Wildlife Research*, 38: 77-88.

Cox, T.E., Ramsey, D.S.L., 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*, 9(1), 1–11.

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.

37. Testing management strategies for feral pigs

Project dates

June 2021 – June 2024

Project team

Matthew Gentle, Lana Harriott, Cameron Wilson, Peter Elsworth, James Speed, Catherine Kelly and Tony Pople

Project summary

This project is monitoring feral pig population size on two sites (Westmar in southern Queensland, and Collinsville in northern Queensland) in response to pig control. Data from aerial shooting (offtake, costs, effort) is being collated from collaborators, and being used in conjunction with density estimates from aerial and camera surveys to calculate the proportion of the population removed. Movements and mortality of GPS-collared feral pigs are being monitored to also assess control effectiveness, and to determine whether such control influences pig movements. These data are being compared to mapped habitat preferences for feral pigs that will help to validate the application of these spatial layers to guide aerial shooting programs. Collectively, this study aims to enhance the cost-effectiveness and efficiency of control at different feral pig densities, to improve future management strategies.

Aerial (helicopter) surveys to estimate feral pig abundance were flown at Westmar during June and October 2022, and March 2023. Thermal surveys were also flown in June 2022.

Additionally, a grid of 60 cameras has been active on this site since April 2022. Camera images from Westmar are being uploaded into new online software (Wildlife Insights) to facilitate image classification and statistical analysis. Collaborators Southern Queensland Landscapes NRM captured 13 feral pigs that were fitted with GPS tracking collars at Westmar. Additional animals (n=38) have been ear-tagged for identification using the camera grid. An aerial survey was also conducted at Collinsville in October 2022 to estimate feral pig abundance prior to control.

Collaborators

- Southern Queensland Landscapes (regional Natural Resource Management organisation)
- Western Downs Regional Council
- Whitsunday Regional Council
- Landholders
- Australian Government's Established pest Animals and Weeds Management Pipeline Program

38. Feral pig movements, habitat suitability, control practices and population monitoring

Project dates

June 2021 – June 2024

Project team

Matthew Gentle, James Speed and Tony Pople

Project summary

Efficient feral pig management and monitoring ideally requires an understanding of movement and habitat use. This project describes and quantifies key characteristics of landscape use by feral pigs in several localities in north-eastern Australia. This is being completed through analysis of GPS tracking data from collared feral pigs undertaken as part of the project "African Swine Fever (ASF) Prevention and Preparedness (2021-24)" funded by the Queensland Government.

Analysis of GPS tracking data has quantified feral pig hourly and daily distances travelled, and home range and core home range sizes across four eastern Australian study sites. Strongly preferred sites were in close proximity to watercourses, waterbodies, cultivation, open herbaceous vegetation and medium woody vegetation. This information is being used to identity pig control and monitoring strategies for field testing. Pig movements are also being assessed to determine whether aerial shooting influences feral pig behaviour.

This project has also assisted CSIRO collaborators to model feral pig habitat suitability and potential densities across Queensland. This has produced spatial layers of suitable breeding habitats and potential densities (i.e. carrying capacity) under 12 different seasonal scenarios, and identified at-risk areas for feral and domestic pig interactions across Queensland. These are invaluable support for models of the dynamics and spread of disease in feral pig populations.

Collaborators

- Cameron Wilson (Biosecurity Queensland)
- Darren Marshall (Southern Queensland Landscapes)
- Jens Froese, Justine Murray and Matt Rees (CSIRO)
- Peter Adams and Stuart Dawson (Western Australian Department of Primary Industries and Rural Development)
- Tarnya Cox (New South Wales Department of Primary Industries)

Key publications

Gentle, **M**., **Wilson**, **C**., & **Cuskelly**, **J**. (2022). Feral pig management in Australia: implications for disease control, *Australian Veterinary Journal*, 100(10): 492-495. doi.org/https://doi.org/10.1111/avj.13198

Wilson, **C**., **Gentle**, **M**. & Marshall, D. (2023a). Factors influencing the activity ranges of feral pigs (*Sus scrofa*) across four sites in eastern Australia. *Wildlife Research*. doi.org/https://doi.org/10.1071/WR22095

Wilson, **C**., **Gentle**, **M**. & Marshall, D. (2023b). Feral pig activity and landscape feature revisitation across four sites in eastern Australia. *Australian Mammalogy*. doi.org/https://doi.org/10.1071/AM22034

39. Pest animal control – toxin permit support

Project dates

July 2022 – June 2024

Project team

Matthew Gentle and Peter Elsworth

Project summary

Toxins used for pest animal control in Queensland require ongoing assessments for potential suitability, supply or alternatives under minor-use permits or national registration through the Australian Pesticides and Veterinary Medicines Authority (APVMA). This project consults with stakeholders and collates, reviews, and evaluates data to ensure the optimal and safe use of (suitable) toxins for vertebrate pests in Queensland.

This project successfully obtained an extension to a minor use permit to enable the aerial distribution of wild dog baits up to maximum of 40 baits/linear km within the Southern Downs Regional Council jurisdiction until 2026. This supports best-practice, efficacious wild dog control in rugged areas within this region, matching the technique successfully used in adjacent areas of eastern New South Wales.

A minor use application for the use of strychnine on wild dog and fox traps was also submitted and approved. This allows authorised practitioners to continue to use strychnine for this purpose until June 2024 when the recently-registered para-aminopropiophenone (PAPP) alternative should be commercially-available.

The project also provided technical input on the viability of alternative baiting techniques, risk assessment processes and labelling to the APVMA to support feral cat control (Felixer, and proposed registration of Eradicat 1080 bait). An extension to a current minor use permit to allow ground and aerial baiting using Eradicat 1080 bait to control feral cats within and adjacent to Taunton National Park was also submitted and approved.

Collaborators

- Southern Downs Regional Council
- Queensland Parks and Wildlife Service & Partnerships
- New South Wales Department of Primary Industries

Key publications

APVMA (2023**)** PER9166v2: Permit to allow a minor use of a registered AGVET chemical product containing 1080 at a rate high that that specified by the label instructions for aerial baiting of wild dogs. Issued 12 February 2023.

APVMA (2023**)** PER14004v5: Permit to allow a minor use of a registered AGVET chemical product for the control of wild dogs and foxes. Issued 23 February 2023.

APVMA (2023) PER186263v2: Permit to allow a minor use of a registered AGVET chemical product - Product for feral cat control within Taunton National Park and adjacent areas. Issued 21 June 2023.

40. Improving detection and response to red-eared slider turtles

Project dates

July 2020 – June 2024

Project team

Lana Harriott and Catherine Kelly

Project summary

The red-eared slider turtle (*Trachemys scripta elegans;* REST) is the most traded reptile in the world and has had environmental impacts where they have established outside of their native range. In south-east Queensland, an established population of REST originating from the illegal pet trade, has been the focus of several eradication attempts. However, this work is extremely challenging due to the cryptic and evasive nature of this species. This project aims to increase the effectiveness of REST management and improve confidence of detection and eradication of REST.

Through the provision of artificial pontoons mounted with camera traps, we have been able to identify and sex individual REST in the eradication area and describe their basking behaviour. This has monitored progress towards eradication, where Biosecurity Queensland (BQ) staff have reduced the number of REST from seven to one known individual. However, the pontoons have only detected adult REST, with reports suggesting juvenile REST may prefer to aquatically bask in warm shallow water. The detection of juvenile REST is important to indicate the presence of breeding populations, which could then be prioritised for management.

Research and BQ operations staff designed a semi-submerged pontoon for detecting juvenile REST, and then tested the pontoon at a known breeding site in NSW with NSW DPI and local government collaborators. This successful pilot trial detected sub-adult REST and accurately determined carapace size from an overhead camera. This project will continue to refine surveillance tools for juvenile REST, increase our understanding of REST ecology, and monitor the effectiveness of eradication efforts.

Figure 37 Pontoons for detecting juvenile REST assembled and ready for field testing

Collaborators

- Stacy Harris, Matt Ryan and Duncan Swan (Biosecurity Queensland)
- Dianne Gleeson and Jack Rojahn (University of Canberra)
- Lisa Wellman (New South Wales Department of Primary Industries)
- Eddie Ferry (Fairfield City Council, New South Wales)
- Andrew O'Brien (Sydney Feral and Commercial Pest Control Pty Ltd)

Key publications

García-Díaz, P., Ramsey, D.S., Woolnough, A.P., Franch, M., Llorente, G.A., Montori, A., Buenetxea, X., Larrinaga, A.R.., Lasceve, M., Álvarez, A. & Traverso, J.M. (2017). Challenges in confirming eradication success of invasive red-eared sliders. *Biological Invasions*, 19(9): 2739-2750.

Harriott, **L**., **Amos**, **M**., **Brennan**, **M**., **Elsworth**, **P**., **Gentle**, **M**., **Kennedy**, **M**., **Pople**, **T**., Scanlan, J., **Speed**, **J**. & **Osunkoya**, **O**.**O**. (2022). State-wide prioritisation of vertebrate pest animals in Queensland, Australia, Ecological Management and Restoration, 23(23): 209-218.

Savage, J.C. (2022). The murky turtle pool: A first population genetic analysis of the invasive red eared slider turtle (*Trachemys scripta elegans*) within Australia, Honours Thesis, School of Life and Environmental Science, The University of Sydney.

41. Development of surveillance tools for the Asian black-spined toad (*Duttaphyrnus melanostictus*)

Project dates

July 2020 – June 2024

Project team

Lana Harriott and Catherine Kelly

Project summary

The Asian black-spined toad (*Duttaphyrnus melanostictus;* ABST) is a commonly detected stowaway species that arrives in Australia via cargo and baggage, making it a species of major biosecurity concern. Established populations of ABST outside of their native range are known to cause substantial economic and environmental impacts. Many regions of Australia, but particularly northern and coastal regions of Queensland, are highly suitable environments for ABST establishment. To better manage the risk of an ABST population establishing in Queensland there is a need for a targeted, robust surveillance network with a high probability of incursion detection. However, the best tools and methods to establish a surveillance network require investigation. This project has tested a range of tools developed for cane toad control and monitoring to determine their suitability for ABST. These include the collection of eDNA samples from water bodies in Indonesia to validate an eDNA assay,

compilation and analysis of calls in a call library, developing a range of audio lures, testing audio lures in both Indonesia (native range) and Madagascar (invaded range), testing of traps in field and enclosed environments, and telemetry of movements and spawning sites across both wet and dry seasons to understand how toads move and select possible shelter sites.

Traps used for cane toads need modification, by reducing the mesh size to approximately a quarter of the original size to be suitable for ABST. While playback experiments of calls at ponds (without traps) have shown that call lures attract ABST, enclosed (arena with known toad population) and field trials using call lures have yielded poor trapping success, suggesting ABST may be more trap-shy than cane toads. This project continues to provide critical knowledge on ABST ecology and surveillance methods to develop surveillance techniques for ABST in Queensland.

Collaborators

- Lin Schwarzkopf (James Cook University)
- Ben Muller (Madagascar Fauna and Flora Group)
- Mirzura Kusrini (IPB University, Indonesia)
- Dianne Gleeson (University of Canberra)
- Peter Caley (CSIRO)
- Susan Campbell (Western Australian Department of Primary Industries and Regional Development)
- David Ramsey (Arthur Rylah Institute, Victoria)
- Phil Cassey (University of Adelaide)

Key publications

Kelly, **C**. **L**., Schwarzkopf, L., Christy, T. M. & **Kennedy**, **M**. **S**. (2023). The toad less travelled: comparing life histories, ecological niches, and potential habitat of Asian black-spined toads and cane toads. *Wildlife Research*, doi:https://doi.org/10.1071/WR22111

Licata, F., Ficetola, G.F., Falaschi, M., Muller, B.J., Andreone, F., Harison, R.H., Freeman, K., Monteiro, A.T., Rosa, S. & Crottini, A. (2023). Spatial ecology of the invasive Asian common toad in Madagascar and its implications for invasion dynamics, *Scientific Reports,* 13: 3526

42. Wild dog management and predation on cattle and wild herbivores in the Queensland dry tropics

Project dates

July 2020 – June 2024

Project team

Lana Harriott, Peter Elsworth, James Speed and Catherine Kelly

Project summary

Wild dogs (all wild living dogs, including dingoes, feral dogs, and their hybrids: *Canis familiaris*) can have significant impacts on livestock enterprises. While wild dogs and small stock are incompatible, the impacts of wild dogs on cattle production enterprises can be variable. Wild dogs can cause calf losses of up to 30%, but in other contexts calf loss can be low. Further, under some conditions, wild dogs may benefit cattle producers through the suppression of native and introduced herbivores. This project seeks to better understand the movement, predation and feeding behaviour of wild dogs on Queensland cattle properties. This will ultimately help determine the impact of wild dogs on cattle and wild herbivores.

This project will conduct a pilot trial of video-GPS collars with accelerometers to determine if these tools can record wild dog predation events and other activities. To date, two wild dogs have been fitted with video-GPS collars. These have been used to determine activity periods of wild dogs to help program collars to most efficiently capture predation events. Future trials with video-GPS collared individuals are planned to assess encounters with control and monitoring tools (canid pest ejectors and cameras) and determine the success of control programs. Trapping (424 trap nights) was undertaken in spring 2021 at Eidsvold but did not capture sufficient suitable wild dogs to collar. Subsequent field work in Autumn 2022 has been repeatedly rescheduled due to the wet weather.

Additionally, a domestic dog will be trained to detect 1080 and PAPP (if possible) and then used to determine if toxins can be detected in baits and so provide a possible mechanism for aversive responses to baiting by wild dogs following a sub-lethal dose or due to neophobia. Finally, fauna monitoring will continue within and outside cluster fences in south-west Queensland. This will provide a longer-term assessment of reduced wild dog abundance on wildlife.

Collaborators

- Phillip Hayward (Biosecurity Queensland)
- Megan Brady (The Turner Family Foundation)
- Benjamin Allen and Geoff Castle (The University of Southern Queensland)
- Tracey Kreplins (Department of Primary Industries and Regional Development, WA)
- Craig Murray (Detection Dog School)

Key publications

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

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

Castle, G., Smith, D., Allen, L.R., Carter, J., **Elsworth**, **P**. & Allen, B.L. (2022). Top-predator removal does not cause trophic cascades in Australian rangeland ecosystems, *Food Webs*, 31: e00229

43. Ecology and management of chital deer in north Queensland

Project dates

July 2014 - June 2024

Project team

Tony Pople, Mike Brennan and Matt Amos

Project summary

Chital deer (*Axis axis*) are long established in the north Queensland dry tropics and at high densities are considered pests by cattle graziers. Control has been limited to recreational and some commercial ground shooting and trapping. With an expansion of their range and local high densities, information on their impacts, control methods and capacity for increase and spread is needed to develop long-term management strategies.

Aerial and ground monitoring of populations on properties in the region have described a remarkably patchy local and regional distribution that is influenced by concentrations of soil phosphorous, and sodium and zinc in grasses. Drought has been a major influence on chital deer abundance resulting in an 80% decline over 10 months. Recovery to pre-drought levels was recorded in six years; a rate equivalent to their maximum rate of increase of ~34%.

Current work will firstly continue monitoring survival of over 50 adult females and their fawns and ranging behaviour using satellite telemetry and remote cameras. Secondly, deer distribution from telemetry and population surveys will be related to environmental data to hopefully explain the highly clumped local distribution. Genetic analyses are being used to gain a fuller understanding of chital deer diet and their pattern of spread in the district.

The project has seen two PhDs conferred and a third is in progress. The university collaborations have extended the project to more than just ecology of chital deer in the region. Habitat and climate modelling has been undertaken to better predict the potential distributions of all six species of deer in the wild in Australia. Machine learning is being used to identify individual chital deer in remote camera images from their unique spot patterns. This should enable precise estimation of population size, survival and reproductive output.

Collaborators

- Keith Staines and Glen Harry (Sporting Shooters Association of Australia)
- Kurt Watter (UQ)
- Dave Forsyth, Andrew Bengsen and Sebastien Comte (NSW DPI)
- Carlo Pacioni and Luke Woodford (Arthur Rylah Institute, Victoria)
- Jordan Hampton (Ecotone Wildlife Veterinary Services)
- Landholders in the Charters Towers region

- Ashley Blokland (Charters Towers Regional Council, now Biosecurity Queensland)
- Heather Jonsson (Dalrymple Landcare Committee)
- Thijs Krugers and Rachel Payne (NQ Dry Tropics)
- Catherine Kelly, Matt Quin, Jodie Nordine, Mohit Deolankar, Ben Hirsch, Lin Schwarzkopf, Jan Strugnell and Iain Gordon (JCU)
- Centre for Invasive Species Solutions

Key publications

Kelly, **C**.**L**., Schwarzkopf, L., Gordon, I.J., **Pople**, **A**., Kelly, D.L. & Hirsch, B.T. (2022). Dancing to a different tune: Changing reproductive seasonality in an introduced chital deer population. *Oecologia* **200**, 285-294. https://doi.org/10.1007/s00442-022-05232-6.

Kelly, **C**.**L**., Gordon, I.J., Schwarzkopf, L., Pintor, A., **Pople**, **A**. & Hirsch, B.T. (2023). Invasive wild deer exhibit environmental niche shifts in Australia: Where to from here? *Ecology and Evolution* **13**, e10251. https://doi.org/10.1002/ece3.10251.

Pople, **A**., **Amos**, **M**. **& Brennan**, **M**. (in press). Population dynamics of chital deer (*Axis axis*) in northern Queensland: Effects of drought and culling. *Wildlife Research*. https://doi.org/10.1071/WR22130.

Watter, K., Baxter, G.S., **Pople**, **T**. & Murray, P.J. (2019). Effects of wet season mineral nutrition on chital deer distribution in northern Queensland. *Wildlife Research* **46**, 499-508.

44. Coordinated management of feral deer in Queensland

Project dates

May 2022 - June 2025

Project team

Tony Pople, Mike Brennan, Matt Amos and Cameron Wilson

Project summary

This project is funded by the Commonwealth Department of Agriculture, Fisheries and Forestry, and aims to:

1. In collaboration with stakeholders, identify priority feral deer populations in Queensland for management and establish demonstration sites for on-ground management and research

2. Evaluate the effectiveness of control programs and control tools at demonstration sites

3. Disseminate best practice deer management through workshops with local governments and land managers

Helicopter-based culling of a large chital deer population has been monitored by aerial survey in north Queensland with a follow-up cull planned for September 2023. Project work will be concentrated during 2023-25 when most funds are provided and a dedicated project officer available.

Additional demonstration sites have been proposed in north Queensland where chital deer populations will be controlled from the air and ground. Thermal imagery can assist culling of pest animals in cool environments but its cost effectiveness in tropical regions is unknown and so these sites provide an opportunity for its assessment. Additional sites have been proposed in southern and central Queensland on management of populations of red and rusa deer which are sufficiently small and isolated to be candidates for local eradication. Larger, established populations may still be selected for control if they can be reduced below a density that landholders can then keep the population below.

Workshops run in northern, central and southern Queensland (described within project 35) were used to refine maps of regional deer populations. These maps and further discussions will help identify priority populations for control as part of regional control strategies.

Collaborators

- Annelise Wiebkin (National Deer Management Coordinator)
- Troy Crittle (NSW Department of Primary Industries)
- Jesse Wojtala and Mark Kimber (Sunshine Coast Regional Council)
- Dan Franks (Brisbane City Council)
- Bren Fuller (Whitsunday Shire Council)
- Queensland local governments
- Ted Vinson and Geoff Swan (Biosecurity Queensland)

Key publications

Bengsen, A.J., Forsyth, D.M., **Pople**, **A.R.**, **Brennan**, **M.**, **Amos**, **M.**, Leeson, M., Cox T.E., Gray, B., Orgill, O., Hampton, J.O., Crittle, T. & Haebich, K. (2022). Effectiveness and costs of helicopter-based shooting of deer. *Wildlife Research*, doi:https://doi.org/10.1071/WR21156

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National Feral Deer Action Plan. (https://feraldeerplan.org.au/).

Queensland Feral Deer Management Strategy 2022-27. (https://www.daf.qld.gov.au/__data/assets/pdf_file/0008/1644218/Feral-Deer-Management-Strategy.pdf)

External funding

Research and development contracts

Project/research area	Funding body	Funds spent ($)
Integrated management of cabomba	CSIRO	106
Weed management in the Pacific	Landcare Research New Zealand	173,463
Biocontrol of pasture weeds, Vanuatu	Landcare Research New Zealand	118,184
Biocontrol of parkinsonia	CSIRO	24,792
Biocontrol of *Miconia crenata*	AgriFutures Australia	91,455
Biocontrol of prickly acacia	AgriFutures Australia	105,612
Biocontrol of Navua sedge	AgriFutures Australia	50,624
Endemic pathogens of giant rat's tail grass	AgriFutures Australia, HQPlantations, Bundaberg Regional Council, Gladstone Regional Council, New South Wales Department of Primary Industries and New South Wales Biocontrol Task Force	335,050
Biocontrol of invasive cacti	Australian Government	119,314
Giant rat's tail grass management in central Queensland	Gladstone Regional Council	16,366
Managing established pests—giant rat's tail grass	Australian Government	1,933
Aquatic weed management tools	Australian Government	342,992
Navua sedge management	Australian Government	216,106
Strategic invasive grass control	Australian Government	63,165
Coordinated management of feral deer	Australian Government	46,069
Siam weed management in northern Australia	Northern Territory Department of Environment, Parks and Water Security	32,582
Four tropical weeds eradication	National cost share	70,295
Red witchweed response program	National cost share	34,000
Wild dog and deer management	Centre for Invasive Species Solutions	19,767
Cluster fencing evaluation	Centre for Invasive Species Solutions	57,917
Feral pig management	Australian Government	321,276
Total		**2,241,068**

Land Protection Fund

Project/research area	Funds spent ($)
Pesticide permits	29,849
Biocontrol of prickly acacia	127,118
Biocontrol of bellyache bush	131,165
Biocontrol of cat's claw creeper	51,175
Biocontrol of parthenium	21,231
Biocontrol of opuntioid cactus	81,156
Biocontrol of Harrisia cactus	89,385
Biocontrol of Navua sedge	108,919
Biocontrol of African tulip tree	18,705
Biocontrol of *Miconia crenata* (Koster's curse)	38,957
Biocontrol of giant rat's tail grass	69,891
Biocontrol of chinee apple	74,895
Biocontrol of lantana	24,542
Rearing and release of biocontrol agents	148,597
Biocontrol agent compendium	29,009
Quarantine management	96,648
Water weed ecology and management	53,999
Integrated management of cabomba	70,712
Aquatic weed management tools	67,203
Weed seed dynamics	68,184
Siam weed management in northern Australia	30,862
Giant rat's tail grass wick wiper	18,399
Navua sedge ecology and management	91,799
Drone-based weed identification	22,549
Weed risk assessment	63,491
Red-eared slider eradication	17,126
Asian black-spined toad surveillance	17,655
Rabbit best practice research	27,791
Feral deer best practice research	85,510
Coordinated management of feral deer	101,243
Refining management of feral deer	101,500
Wild dog exclusion fencing	95,757
Management of peri-urban wild dogs	14,863
Feral pig management	82,373
Pest animal toxin support	29,124
Total	**2,201,382**

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

Name	Position
Tony Pople	Senior principal scientist
Kunjithapatham Dhileepan	Senior principal scientist (entomologist)
Olusegun Osunkoya	Principal scientist (ecology)
Joseph Vitelli	Senior principal scientist (weeds)
Tobias Bickel	Senior scientist (aquatic weeds)
Jason Callander	Scientist
Lana Harriott	Scientist
David Holdom	Scientist
Md Mahbubur Rahman	Scientist
Boyang Shi	Scientist
Di Taylor	Scientist
Tamara Taylor	Scientist
Michael Brennan	Principal science technician
David Comben	Science technician
Bahar Farahani	Science technician
Tess James	Science technician
Eloise Martin	Science technician casual
Christine Perrett	Science technician
Melissa Brien	Science technician
Dipika Roy	Science technician
Liz Snow	Principal science technician
Tom Cowan	Science technician casual
Anna Williams	Science technician
Louise Gill	Science technician
Donna Buckley	Administration officer

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

Name	Position
Matthew Gentle	Principal scientist
Matt Amos	Scientist
Peter Elsworth	Senior science technician
Catherine Kelly	Scientist (casual)
Malcolm Kennedy	Senior scientist
Cameron Wilson	Scientist
James Speed	Senior science technician
Geoff Castle	Science technician (casual)

Tropical Weeds Research Centre, Charters Towers

PO Box 976, Charters Towers Qld 4820
Tel: 13 25 33
Email: Wayne.Vogler@daf.qld.gov.au
Email for other staff: firstname.lastname@daf.qld.gov.au

Name	Position
Wayne Vogler	Principal scientist
Simon Brooks	Senior scientist
Dannielle Brazier	Science technician
Mary Butler	Science support officer
Kirsty Gough	Science support officer
Kelli Pukallus	Senior science technician
Clare Warren	Science technician

Tropical Weeds Research Centre, South Johnstone

PO Box 20, South Johnstone Qld 4859
Tel: (07) 4220 4177 **Fax:**(07) 4064 2249
Email: firstname.lastname@daf.qld.gov.au

Name	Position
Melissa Setter	Scientist
Stephen Setter	Senior science technician

Publications and presentations

Journal articles

Amos, **M**., **Pople**, **A**. **R**., **Brennan**, **M**., Sheil, D., Kimber, M. & Cathcart, A. (2022). Home ranges of rusa deer (Cervus timorensis) in a subtropical peri-urban environment in South East Queensland. *Australian Mammalogy, 45*(1), 116-120. doi:https://doi.org/10.1071/AM21052

Bengsen, A. J., Forsyth, D. M., **Pople**, **A**. **R**., **Brennan**, **M**., **Amos**, **M**., Leeson, M., Cox T. E., Gray, B., Orgill,O., Hampton, J.O., Crittle, T. & Haebich, K. (2022). Effectiveness and costs of helicopter-based shooting of deer. *Wildlife Research*, -. doi:https://doi.org/10.1071/WR21156

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Crous, P.W., Boers, J., **Holdom**, **D**., Osieck, Steinrucken, T.V., Tan, Y.P., **Vitelli**, **J**.**S**., Shivas, R.G., Barrett, M., Boxshall, A.-G., Broadbridge, J., Larsson, E., Lebel, T., Pinruan, U., Sommai, S., Alvarado, P., Bonito, G., Decock, C.A., De la Peña-Lastra, S., Delgado, G., Houbraken, J., Maciá-Vicente, J.G., Raja, H.A., Rigueiro-Rodríguez, A., Rodríguez, A., Wingfield, M.J., Adams, S.J., Akulov, A., AL-Hidmi, T., Antonín, V., Arauzo, S., Arenas, F., Armada, F., Aylward, J., Bellanger, J.-M., Berraf-Tebbal, A., Bidaud, A., Boccardo, F., Cabero, J., Calledda, F., Corriol, G., Crane, J.L., Dearnaley, J.D.W., Dima, B., Dovana, F., Eichmeier, A., Esteve-Raventós, F., Fine, M., Ganzert, L., García, D., Torres-Garcia, D., Gené, J., Gutiérrez, A., Iglesias, P., Istel, Ł., Jangsantear, P., Jansen, G.M., Jeppson, M., Karun, N.C., Karich, A., Khamsuntorn, P., Kokkonen, K., Kolarík, M., Kubátová, A., Labuda, R., Lagashetti, A.C., Lifshitz, N., Linde, C., Loizides, M., Luangsa-ard, J.J., Lueangjaroenkit, P., Mahadevakumar, S., Mahamedi, A.E., Malloch, D.W., Marincowitz, S., Mateos, A., Moreau, P.-A., Miller, A.N., Molia, A., Morte, A., Navarro-Ródenas,

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Dhileepan, **K**., Balu, A., Sudha, S. & Raghu, S. (2022). Prioritisation of damaging weed biological control agents for prickly acacia (*Vachellia nilotica* subsp. *indica*) based on native range exclusion studies. *Biological Control* 172, September 2022, 104968.

Ezeh, A.E., Hereward, J.P., **Day**, **M**.**D**., **Taylor**, **T**. & Furlong, M.J. (2023). Confirming the identity of the Hypogeococcus species (Hemiptera: Pseudococcidae) associated with *Harrisia martinii* (Labour.) Britton (Cactaceae) in Australia: implications for biological control. *Austral Entomology, 62*(2), 235-245. doi:https://doi.org/10.1111/aen.12641

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Gentle, **M**.**N**., **Wilson**, **C**. & **Cuskelly**, **J**. (2022). Feral pig management in Australia: implications for disease control. *Australian Veterinary Journal, 100*(10), 492-495. doi:https://doi.org/10.1111/avj.13198

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Pukallus, **K**. (2022). RPMG meeting. Biological control at TWRC and Cecidochares connexa update. Charters Towers. 11 August 2022.

Setter, **M**. (2023). Invasive Plants Research and Management Update, 2023, *Local Government Association of Queensland's Natural Resource Management Forum*, Melissa Setter, Cooktown, 12 May 2023.

Taylor, **T**.**K**. (2023). *Harrisia martinii - Biological Control*, presentations as part of Cacti Masterclasses for local government, Mirani and Rockhampton, 19-20 April, 2023.

Vogler, **W**. (2022). *Florestina Project Update*, Shire Rural Lands Officer Group Meeting, Charleville, 6-7 September.

Vogler, **W**. (2022). *GRT Ecology and Management*, Miriam Vale GRT Forum, Miriam Vale, 21 July.

Vogler, **W**. (2022). *High Biomass Grass and Fire*, Livingstone Disaster Coordination Committee, Yeppoon, 14 September.

Vogler, **W**. (2022). *High Biomass Grass and Fire*, Livingstone Disaster Coordination Committee, Yeppoon, 14 September.

Vogler, **W**. (2022). *Weed Management Practice*, NQ Dry Tropics Field Day, Collinsville, 9 November.

Vogler, **W**. (2023). *GRT Ecology and Management*, Calliope GRT Forum, Calliope, 24 May.

Vogler, **W**. (2023). *Invasive Grass Masterclass*, Gatton, 1 June.

Vogler, **W**. (2023). *Invasive Grass Masterclass*, Nambour, 29 May.

Vogler, **W**. (2023). *Invasive Grass Masterclass*, Redlands, 31 May.

Vogler, **W**. (2023). *Invasive Grass Masterclass*, Woolooga, 30 May.

Vogler, **W**. (2023). *TWRC Research Update*, Mackay Regional Pest Management Group Meeting, Sarina, 15 February.

Vogler, **W**. (2023). *High Biomass Grasses*. Queensland Local Government NRM Forum, Yeppoon. 23 May.

Vogler, **W**. (2023). *Weed Management Practice*, Cape York NRM Weed Roadshow, Lakeland, 3 May.

Vogler, **W**. (2023). *Weed Management Practice*, Cape York NRM Weed Roadshow, Laura, 4 May.

Lectures and seminars

Brooks, **S**. **& Brazier**, **D**. (2023). Encapsulated herbicide trials. Internal seminar, Online. 26th May.

Brooks, **S**. (2023). *Research results from NT project*. Department of Environment, Parks and Water Security NT 2nd May.

Brooks, **S**. (2023). *Seed dynamics project and research overview*, Department of Primary Industries (NSW) Wagga Wagga, 17th March 2021.

Day, **M**.**D**. (2022). Introduction to biological control of weeds, Webinar: Weed Biological Control, Asian-Pacific Forest Invasive Species Network, 24 November.

Day, **M**.**D**. (2022). Minimizing risk in weed biocontrol: host specificity testing of natural enemies, Webinar: Weed Biological Control, Asian-Pacific Forest Invasive Species Network, 24 & 25 November.

Day, **M**.**D**. (2022). Options for weed biological control in Asia, Webinar: Weed Biological Control, Asian-Pacific Forest Invasive Species Network, 25 November.

Day, **M**.**D**. (2022). Successes in weed biological control, Webinar: Weed Biological Control, Asian-Pacific Forest Invasive Species Network, 25 November.

Elsworth, **P**. (2023). *Biological Control of Vertbrate Pests* – AGRC3042, School of Veterinary Science, The University of Queensland, Gatton, 23 March.

Elsworth, **P**. (2023). *Vertbrate Pest Impacts on Crops* – Integrated Crop Health and Management, School of Agriculture and Food Sciences, The University of Queensland, Gatton, 03 April.

Elsworth, **P**., (2023). *Vertbrate Pest Impacts on plants and the Environment* – Plant and Environmental Health, School of Agriculture and Food Sciences, The University of Queensland, Gatton, 31 March.

Gentle, **M**. (2023). *Enhancing feral pig monitoring and control*, National Feral pig Action Plan Implementation Committee Meeting, Toowoomba, 9 February.

Gentle, **M**. (2023). *Invasive vertebrate Pests* – AGRC3042, School of Veterinary Science, The University of Queensland, Gatton, 16 March.

Kelk, **L**. (2023). IP&A Seminar Series, *Integrated management of Harrisia martinii – do sheep eat cactus?* Seminar presented to DAF IP&A research and operational groups, Policy and Stakeholder Engagement and DAF management team. Ecosciences Precinct, Dutton Park, (and online), 17 February, 2023.

Kurose, D., Seier, M. & **Dhileepan**, **K**. (2022). Potential for classical biological control of Navua sedge and Rubber vine. University of Antananarivo, Madagascar, 20 October 2022

Vogler, **W**. (2022). *High Biomass Grass and Fire*, Livingstone Disaster Coordination Committee, Yeppoon, 14 September.

Vogler, **W**. (2022). *Invasive Grasses and Fire Behaviour,* QFES Fire Behaviour in the Landscape Information Series Number 4, Online Presentation, 18 November.

Field days

Pukallus, **K**. (2023). Careers Expo. Charters Towers PCYC. 25 May 2023.