Technical highlights

Invasive plant and animal research

2021–22

Queensland Government

Cover photo: Biosecurity Officer Stacy Harris deploying red-eared slider turtle cathedral traps (Photo: Malcolm Kennedy).

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

Contents

Introduction

This document summarises the 2021–22 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 2021–22 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 clidemia since 2020. This work is drawing to a close in early 2023. Approval to release some agents (e.g. prickly acacia) is expected and imminent, but others will need further assessment. That further work was always required but can be undertaken optimistically following the initial work funded by AgriFutures. The next stage for these projects will be supported by Biosecurity Queensland, the Land Protection Fund, the Australian Government and hopefully others.

- Other weeds with current biological control projects include cat's claw creeper, lantana, parthenium, bellyache bush, chinee apple, sicklepod, *Solanum torvum*, *Urena lobata*, Singapore daisy, African tulip tree, harrisia and opuntioid cacti.

- Weed biological control involves laboratory trials, overseas exploration and overseas testing which are collectively time consuming and expensive. We continue to work with collaborators to most efficiently use available resources to find and test biological control agents for weeds. To that end, a draft 20-year national weed biological control pipeline strategy has been released by the Centre for Invasive Species Solutions (CISS). This outlines a process for prioritising weed biological control targets and a framework for investment.

- We are mass-rearing and releasing approved biological control agents for Siam weed, parkinsonia and *Cylindropuntia* cacti. We are monitoring the releases of previously released biological control agents (e.g. cat's claw creeper, 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.

- For giant rat's tail grass, we are testing the pathogenicity and host-specificity of native and introduced pathogens. These could be used as classical biological control and mycoherbicides. We are also optimising the use of wick wipers to selectively apply herbicides. Projects are gathering data on the use of flupropanate, fertiliser and fire to manage giant rat's tail grass in a range of situations.

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

- Herbicide trials are being conducted for several weeds including Siam weed, sicklepod, gamba grass, Aleman grass, bogmoss and weedy shrubs and trees. Extensive trials have found that flumioxazin (under the product name Clipper®) provides excellent control of many aquatic weeds including cabomba and Amazon frogbit, with low risk to aquatic fauna. Another herbicide, Procellacor, is also showing promise for other aquatic weeds.

- We are studying the ecology of several weeds to assist management. Information gained, such as seed longevity and age at maturity, helps to determine the timing and duration of treatment at a site. For Siam weed, results from collaborative research with the Northern Territory on the weed's ecology and control with herbicide and fire will be incorporated into a best practice management manual.

- We are reviewing a list of over 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.

Pest animal research

- The Centre for Invasive Species Solutions has supported several pest animal projects through both funding and collaboration. These projects have been completed with reports available on the CISS website (https://invasives.com.au/our-publications). We are hoping that CISS will be funded beyond 2022 to support a new portfolio of projects that we have helped develop. This new portfolio includes projects to improve weed management.

- We had hoped to monitor the movement and feeding behaviour of wild dogs on north Queensland cattle properties. Logistical problems have delayed this work. It should provide quantification of wild dog impacts on cattle production, complementing previous assessments. Other projects have led to more effective baiting rates for wild dogs in southern Queensland, a guide to best practice management of peri-urban wild dogs and an evaluation of the impacts of cluster fencing on livestock production and wildlife, and the cost-effectiveness of the technique.

- Surveillance methods have been developed for two high-risk pest animals, red-eared slider turtles and Asian black-spined toads. Environmental DNA, call lures and traps can detect incursions. However, sampling using these tools needs to be sufficient to detect incursions with an acceptable probability.

- Best practice guidelines for deer management are being completed and will be available on the Pestsmart website (https://pestsmart.org.au/). Management guidelines are also being documented for peri-urban deer and wild dogs. Workshops for best practice management of wild deer were delivered to pest managers in southern and central Queensland in 2022.

- Our collaboration with NSW Department of Primary Industries has resulted in several publications on aspects of cost-effective management of deer in peri-urban, agricultural and conservation settings. A special issue of Wildlife Research will be dedicated to the ecology, impacts and management of wild deer in Australasia, with publication expected in early 2023.

- Rabbit management relies heavily on biological control, but disease impacts wax and wane in the short to medium term. In the longer term, population immunity increases while virulence declines in the biological control (at least with myxomatosis). Removing productive rabbit breeding sites (warrens, log piles) can compensate for dwindling biological control effectiveness and keep populations low following declines through drought or disease. This strategy is being evaluated in southern Queensland.

- There is renewed interest in feral pig management, particularly given the current threat of exotic livestock diseases that can be spread by pigs. Our projects cover optimal use of baits and associated permits, and broad-scale management strategies. This work has required field studies using radio telemetry, assessment of control programs, habitat modelling and development of survey techniques.

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. Thirteen minor-use or emergency-use permits were obtained in 2021-22.

Funding, collaboration and research priorities

In the 2021–22 financial year, Biosecurity Queensland’s Invasive Plants and Animals research program received funding from several sources. Expenditure from Queensland Government base funds was $1.6 million; expenditure from the Land Protection Fund amounted to almost $2.3 million; and expenditure under contracts with external partners totalled $2.2 million (see ‘External funding’, page 67-68). Notable funding bodies for the latter were the Australian Government, AgriFutures Australia, CSIRO, Manaaki Whenua Landcare Research New Zealand, Seqwater and the Centre for Invasive Species Solutions.

Our research program for 2021–22 was endorsed by the Research Review Committee—a group of senior scientific, operations and policy staff from Biosecurity Queensland plus representatives from our external stakeholders, including local government, AgForce, the Queensland Farmers' Federation, the Queensland Conservation Council and NRM Regions Queensland. The committee critically reviews proposed 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 69-70). In addition, you can browse our recent scientific publications in the eResearch archive at **daf.qld.gov.au** (search 'eResearch archive').

Part 1: Invasive plant research

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

Project dates

July 2012 – December 2022

Project team

Tobias Bickel, Christine Perrett and Bahar Farahani

Project summary

Management of aquatic weeds in natural and artificial water bodies is challenging due to the ecological sensitivity of aquatic environments and the difficulty containing herbicides in the application area.

Flumioxazin was registered as Clipper herbicide with the Australian Pesticides and Veterinary Medicines Authority in 2021 for control of a wide range of aquatic weeds, including cabomba. We conducted field trials to measure control efficacy for cabomba in different situations and with different application techniques. We found that a guar-gum-based carrier was beneficial when spot treating cabomba with flumioxazin in a larger lake, especially in areas exposed to wind and currents. The herbicide applied as a liquid was less efficient in exposed sites, presumably due to rapid dilution and displacement by water movement.

The tablet formulation of flumioxazin was applied to different areas in an urban water body heavily infested with cabomba. Cabomba was eliminated from the treated areas within two weeks, despite unfavourable conditions (low light due to the turbid water after flooding). There was some non-target damage to native water snowflake in one of the sites, but after two months these plants were recovering.

These trials demonstrated that flumioxazin is a great operational tool for cabomba management under different scenarios.

Collaborators

- Marie Bigot (CSIRO)
- Department of Environment and Science
- Seqwater
- Moreton Bay Regional Council
- Junfeng Xu (University of Queensland)
- NIWA New Zealand
- Macspred
- Sumitomo

Key publications

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

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

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

Project dates

June 2021 – June 2023

Project team

Tobias Bickel, Christine Perrett and Bahar Farahani

Project summary

Queensland's freshwater systems are plagued by a range of aquatic weeds, most of which are difficult to manage due to a lack of suitable control tools. Recently, flumioxazin (Clipper herbicide) was registered by the Australian Pesticides and Veterinary Medicines Authority for control of a wide range of aquatic weeds. The research team also identified a new aquatic herbicide, florpyrauxifen-benzyl (Procellacor) which was recently developed in the USA.

Amazon frogbit is an emerging weed which is rapidly spreading through Queensland. Laboratory experiments demonstrated that Amazon frogbit is very susceptible to flumioxazin, both to foliar and in-water applications. Flumioxazin was able to control Amazon frogbit in field trials, removing most of the weed with a single application. However, this plant produces many seeds, so long-term monitoring after herbicide application is necessary for successful management.

Florpyrauxifen-benzyl was tested in the lab on a range of aquatic weeds. This new herbicide readily kills established weeds that are otherwise difficult to control, such as sagittaria, water hyacinth, parrots feather and cabomba. Florpyrauxifen-benzyl has a very good environmental profile, and this research will assist registration of this new herbicide in Australia. Together, these two new herbicides will greatly aid the efficient management of many aquatic weeds in Australia.

Collaborators

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

3. Research supporting the management of nationally-significant tropical weeds

Project dates

July 2008 – June 2024

Project team

Simon Brooks, Kirsty Gough, Stephen Setter and Melissa Setter

Project summary

The project 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 weed eradication targets that influence the timing and location of control operations. These include seed-bank persistence, age to maturity and dispersal potential. Effective control measures are also investigated.

Field and glasshouse trials investigating *Limnocharis flava*, *Miconia calvescens*, *M. racemosa, M. nervosa* and *Mikania micrantha* seed persistence have been running for six to 12 years, with all species showing persistent seed banks. 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 field plot to measure the growth of *M. nervosa* was established in 2018. This project is helping develop a habitat suitability model to refine surveys to detect and remove *M. calvescens*. We have also germinated seed retrieved from soil samples adjacent to a new Northern Territory infestation.

Collaborators

- Kim Erbacher, Peter Green, Alex Diczbalis, Moya Calvert, Tony Salisbury, David Green and Michael Graham (Biosecurity Queensland)
- Chris Collins, Nigel Weston and Bert Lukitsch (Department of Environment, Parks and Water Security NT)
- Jacob Maher and Phil Casey (University of Adelaide)

Key publications

Brooks, S & Jeffery, M 2018, The effects of cyclones on a tropical weed eradication program. 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, pp119-23

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

4. Weed seed dynamics

Project dates

August 2007 – June 2030

Project team

Simon Brooks, Dannielle Brazier and Clare Warren

Project summary

Seed longevity influences the optimal timing and 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 different burial depths. Completed trials have shown that neem and yellow bells have relatively transient soil seed banks that are exhausted after one year. In the absence of fresh seed input, the seed banks of yellow oleander, stevia, gamba grass, chinee apple, calotrope and mesquite are likely to be exhausted in under five years. Trials of lantana and parthenium showed small numbers of seeds could retain viability for five and 10 years, respectively. In 2021, viable prickly acacia seed was retrieved after 13 years.

In field enclosures, we are recording emergence of seedlings of neem, leucaena, prickly acacia, chinee apple, mesquite and now *Argyreia nervosa* (elephant ear vine). Neem tree seedling emergence concluded in less than a year, which was consistent with the buried packet trial, while prickly acacia and leucaena emergence reflects weeds with long-lived seed banks.

A series of experiments have continued which compare the data from buried seed packet trials to a laboratory Controlled Ageing Test (CAT) of relative longevity. Correlating results from the CAT and packet trials will help to classify seeds of weeds into broad longevity categories over a shorter time frame. A long CAT (203 days) was run on 12 Fabaceae seed lots in 2021.

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

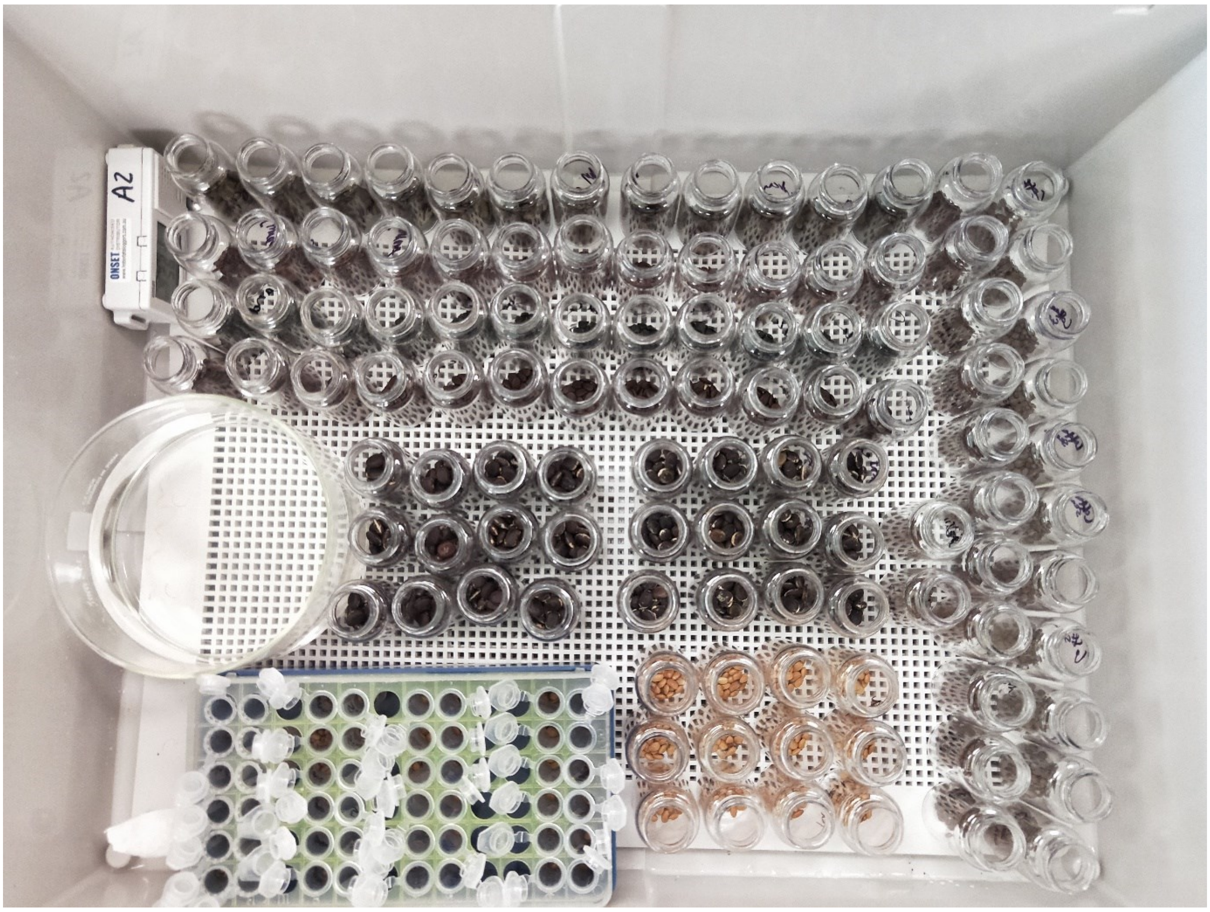

Figure 1 Controlled ageing test

Figure 2 Elephant ear vine (Argyreia nervosa)

Collaborators

- Shane Campbell (University of Queensland)
- Faiz Bebawi, Tony Salisbury, Geoff Swan and Matthew Ryan (Biosecurity Queensland)

Key publications

Long, RL, Panetta, FD, Steadman, KJ, Probert R, Bekker, RM, Brooks, SJ & Adkins, SW 2008, Seed persistence in the field may be predicted by laboratory-controlled ageing, *Weed Science* 56: 523-8.

5. Best practice management and remote detection of *Chromolaena odorata* in northern Australia

Project dates

June 2021 - June 2023

Project team

Simon Brooks, Clare Warren, Dannielle Brazier and Kelli Pukallus

Project summary

The Northern Territory received Australian Government funding for the project '*Advancing the detection, control and management of Siam weed in northern Australia'.* As a collaborator, we receive funding from the Northern Territory to assist with the remote detection of *Chromolaena odorata* and contributing to a best practice management manual. Both aspects are beneficial to Queensland, with the consolidation of best practice information having been requested by regional stakeholders. As well as the trials below, we are supplying a literature review and past trial data to the Northern Territory.

This project is investigating the timing of seed (achene) maturity relative to flower head morphology, and when herbicide and fire treatments prevent development of mature seed. Initial trials in 2021 retrieved viable seed from contained potted specimens from late July onwards, despite flower structures being present and fortnightly treatments with a fluroxypyr-based herbicide. This suggests a much shorter window to implement control measures, after the weed is detectible from the air. Seed is usually dispersed by multiple means from late September onwards.

This project is also investigating the efficacy of low volume foliar herbicides applied to potted specimens via a ground-based boom. Two pot trials allow for considerably greater replication when investigating rates, active ingredients and spray passes than is possible from field observations of aerial boom herbicide applications in the Northern Territory.

*Figure 3 Siam weed (*Chromolaena odorata*) treatment plot*

Collaborators

- Tom Price, Chris Collins, Nigel Weston and Michelle Franklin (Department of Environment, Parks and Water Security NT)
- Deepak Guatam (Charles Darwin University)
- David Green, Tony Salisbury and Rob Cobon (Biosecurity Queensland)

Key publications

Brooks, SJ, Gough, KL & Campbell, SD 2014, Refining low-volume, high-concentration herbicide applications to control *Chromolaena odorata* (L.) King & Robinson (Siam weed) in remote areas. *Plant Protection Quarterly* 29(2): 71-7.

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

In 2021-22 rubber vine (December 2021), leucaena (November 2021) and African tulip tree (May 2022) trials were established. Six monthly monitoring of the rubber vine trial found that the weed is very susceptible to metsulfuron-methyl, metsulfuron + aminopyralid and picloram stem injection capsules. Herbicide effects were evident in the leucaena plots after two and six months, but quantifying mortality rates will require later assessments. In 2022 the project is planning to trial the control of weeds such as pond apple and neem, with further trials and rate refinement for species from previous trials. This project has assisted a PhD candidate from the University of Queensland to establish encapsulated herbicide trials on chinee apple.

Figure 4 Encapsulated herbicide trials in progress

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)
- Tony Salisbury and David Green (Biosecurity Queensland)

Key publications

Goulter, KC, Galea VJ & Riikonen, P 2018, Encapsulated dry herbicides: A novel approach for control of trees pp. Proceedings 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. Weed biological control – *Clidemia hirta*

Project dates

April 2020 – June 2023

Project team

Jason Callander and David Comben

Project summary

Clidemia hirta (Koster's curse) is a fast-growing weed of grazing, plantations, cropping and natural ecosystems in many countries. It was discovered in north Queensland in 2001 and became the target of a national cost-share eradication program. However, as more infestations were found, eradication of the species was no longer possible, but it remains a high priority for control to contain populations. If left uncontrolled, it is possible that *C. hirta* could spread south along the Queensland coast to Hervey Bay. Prospects for the biological control of *C. hirta* are very good. This project is initially assessing *Liothrips urichi* Karny (Thysanoptera: Phlaeothripidae) as a possible biological control agent, which has been released in numerous countries and appears to be very effective. Host specificity testing is being conducted in the quarantine facility at the Ecosciences Precinct in Brisbane. If host specific, an application seeking its release will be submitted to the Australian regulators. Other potential biological control agents are also being considered for testing.

Collaborators

- Aradhana Deesh and Takala Talacakau (Ministry of Agriculture, Fiji)
- Tracy Johnson (USDA, Institute of Pacific Islands Forestry, Hawai'i)
- Queensland local governments
- Barbara Waterhouse (Northern Australia Quarantine Strategy)
- Kim Erbacher, Kim Badcock and Peter Green (Biosecurity Queensland)
- Sid Clayton (Kuranda City Council, Kuranda)
- Garry Sankowsky (Cairns)

Key publications

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

Conant, P 2009, *Clidemia hirta* (L.) D. Don (Melastomataceae), In R Muniappan, G Reddy, & A. Raman (Eds.), Biological Control of Tropical Weeds Using Arthropods (pp. 163-174), Cambridge: Cambridge University Press. doi:10.1017/CBO9780511576348.009

Conant, P 2002 Classical biological control of *Clidemia hirta* (Melastomataceae) in Hawaii using multiple strategies. In CW Smith, JS Denslow & S Hight (Eds.), *Proceedings of workshop on biological control of native ecosystems in Hawaii, Technical Report,* Vol. 129, pp. 13-20.

Nakahara, LM, Burkhart, RM & Funasaki, GY 1992, Review and status of biological control of Clidemia in Hawaii. In CP Stone, CW Smith & JT Tunison (Eds.), *Alien Plant Invasions in Native Ecosystems of Hawaii: Management and Research* (pp.452-465), University of Hawaii Cooperative National Parks Resources Studies Unit, Honolulu, Hawaii, USA.

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 potential for a greatly increased distribution. 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 cost-effective approaches to control invasive cacti in Australia. Biological control of some invasive cacti in Australia has been highly successful in many areas. However, for other species, no biological control 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 the impact and spread of invasive cacti in Queensland using host-specific and damaging biological control agents, 2) identify additional control options for land-owners to make best use of biological control agents available to them for management of tree form cacti (i.e. *Cylindropuntia imbricata* and *Opuntia tomentosa*), and 3) maintain *Dactylopius* and *Cactoblastis* colonies to supply starter colonies of biological control agents to Biosecurity Officers and local governments as required.

Collaborators

- Jeffery Newton (Longreach Regional Council)
- Duncan Swan and Tex Hayward (Biosecurity Queensland)
- Mark Oswald (Mackay Regional Council)
- Matt Tucker, Justin O'Connell and Kirstin Beasley (Department of Environment and Science)
- Lucas Mackie (Southern Queensland Landscapes)
- Andrew McConnachie (New South Wales Department of Primary Industries)
- Australian Department of Agriculture, Forestry and Fisheries
- Iain Paterson (Rhodes University, South Africa)
- Helmuth Zimmermann (Consultant, South Africa)

Key publications

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

9. Weed management in the Pacific

Project dates

July 2020 – June 2023

Project team

Jason Callander and David Comben

Project summary

Biological control options are being explored for several weeds that have not previously been targeted in Australia, or globally. The selected target weed species will depend on individual Pacific Island country priorities, African tulip tree (*Spathodea campanulata*) and Singapore daisy (*Sphagneticola trilobata*) are viewed as important in many Pacific Island countries and are restricted weeds in Queensland. Through this project, *Spathodea campanulata* has been successfully nominated as a candidate for biological control in Australia. Biological control agents already exist for *S. campanulata* and these could be imported into quarantine for host testing. Native range exploration to seek potential candidate agents for *S. trilobata* is currently underway.

Collaborators

- Manaaki Whenua Landcare Research NZ
- Secretariat of Pacific Regional Environment Programme
- 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
- Ricardo Segura Ponce de León (Mexico)

Key publications

Comben, DF, Callander, J, Day, MD & 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

Genetic complexities in lantana varieties have hampered biological control efforts of lantana to date, demonstrating a need for targeted matching of biological control agents to specific lantana varieties. As such, Biosecurity Queensland is providing in-kind support to a project on weed genomics led by NSW Royal Botanic Gardens and funded by the Australian Government. This project undertakes surveys to collect and supply lantana leaf samples from around Queensland to NSW Royal Botanic Gardens for use in cutting-edge phylogenomic analyses to unravel the evolutionary history of *Lantana camara*.

This project also seeks to evaluate the past efforts of lantana biological control in Queensland through a comprehensive insect-exclusion trial and add to the biological control toolbox for lantana by introducing and releasing two agents, the pathogen *Puccinia lantanae*, which was tested by CABI under contract, and the gall fly *Eutreta xanthochaeta*, which is aiding control in Hawai'i.

Collaborators

- CABI-UK
- Plant Protection Research Institute, South Africa
- Tracy Johnson (USDA, Institute of Pacific Islands Forestry, Hawai'i)
- New South Wales Royal Botanic Gardens
- Queensland National Parks and Wildlife Service
- Local governments in coastal and subcoastal Queensland
- Seqwater
- University of Queensland

Key publications

Katembo, N, Witkowski, ET, Simelane, DO, Urban, AJ & Byrne, MJ 2020, Impact of biological control agents on *Lantana camara* in an inland area of South Africa, *BioControl* 65, 143-154.

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

Project dates

January 2007 - June 2023

Project team

Kunjithapatham Dhileepan and Boyang Shi

Project summary

Parthenium weed (*Parthenium hysterophorus*), a noxious weed of grazing areas in Queensland, is a Weed of National Significance in Australia. Parthenium also causes severe human and animal health problems. Eleven biological control agents (nine insect species and two rust pathogens) have been released against parthenium in Australia. Most of these agents have become established and have proven effective against the weed in the central Queensland (CQ). Parthenium is spreading into south Queensland (SQ) and south-east Queensland (SEQ), where many of the widespread and effective biological control agents in

CQ are not present. Hence, the seed-feeding weevil (*Smicronyx lutulentus*), the stem-boring weevil (*Listronotus setosipennis*), the root-boring moth (*Carmenta ithacae*), the summer rust (*Puccinia xanthii* var. *parthenii-hysterophorae*) and the winter rust (*Puccinia abrupta* var. *partheniicola*) have been redistributed from CQ into SQ and SEQ. Redistribution of field collected biological control agents from CQ and monitoring their establishment status in SQ and SEQ will continue.

Figure 5 Parthenium biological control survey in Monto

Collaborators

- Seqwater
- 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 (University of Sydney)
- Ken Woodall (RAPID Workforce, Mitchell)
- Tom Garrett and Holly Hosie (Queensland Murray-Darling Committee)
- Ross Bigwood and Bruce Lord (Healthy Land and Water)
- Pat Ryan (Junction View Pest Management Group)

- Glen Proctor, Jenny Voigt, Neale Jensen and John Pieters (North Burnett Regional Council)
- Eric Dyke (Bundaberg Regional Council)

Key publications

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

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

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

Project dates

January 2007 - June 2023

Project team

Kunjithapatham 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. Biological control 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 (*Hylaeogena jureceki*) have been approved for field release. 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 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, Argentina and Paraguay have identified a rust-gall (*Uropyxis rickiana*) and a leaf-rust (*Prospodium macfadyenae*) as prospective biological control agents. More recently, a leaf-spot pathogen (*Cercosporella dolichandrae*), causing widespread defoliation in South Africa, has been identified as a prospective biological control agent as well. Preliminary host specificity testing of two plant pathogens, the leaf-spot pathogen and the rust-gall has been completed and the leaf-spot pathogen has been identified for detailed host specificity testing.

Host specificity testing for the pathogen is in progress at CABI (UK). Host specificity testing will be completed by June 2023.

Collaborators

- Seqwater
- Marion Seier and Kate Pollard (CABI, UK)
- Anthony King (Plant Protection Research Institute, Pretoria, South Africa)
- Robert Barreto and Adans Colman (Universidade Federal de Viscosa, Brazil)
- Anibal Carvalho (Instituto de Pesquisas Jardim Botanico do Rio de Janeiro, Brazil)
- Kevin Jackson (Gympie, Qld)
- Melinda Clarke (Burnett Catchment Care Association, Monto)
- New South Wales Biological Control Taskforce

Key publications

Dhileepan K, Treviño M, Bayliss D, Saunders M, McCarthy J, Shortus M, Snow EL & Walter GH 2010, Introduction and establishment of *Carvalhotingis visenda* (Hemiptera: Tingidae) as a biological control agent for cat's claw creeper *Macfadyena unguis-cati* (Bignoniaceae) in Australia, *Biological Control* 55(1):58−62.

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 KADW 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 2023

Project team

Kunjithapatham. 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. Surveys in Mexico, central and northern South America, and the Caribbean resulted in the release of the seed-feeding jewel bug (*Agonosoma trilineatum*) in 2003, which failed to establish. A leaf rust (*Phakopsora jatrophicola*), a leaf-miner (*Stomphastis thraustica*) and a gall midge (*Prodiplosis hirsutus*) 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 June 2022 (pending being listed on the live import list), and a release application for the leaf rust is being prepared. Future research will focus on releasing *Stomphastis thraustica* and importing the gall midge from Paraguay into the quarantine facility at the Ecosciences Precinct in Brisbane for detailed host specificity testing.

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)
- Dr Jurate De Prins (Royal Museum of Central Africa, Belgium)
- Southern Gulf NRM

Figure 6 Larval damage to bellyache bush by Stomphastis thraustica

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 FAC, Kleinjan CA & Hoffmann JH (eds), *Proceedings of the XIV International Symposium on Biological Control of Weed*, Kruger National Park, South Africa, 2-7 March 2014.

Heard TA, 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, RE McFadyen & J Cullen), CSIRO Publishing, Melbourne.

Kolesik P, Kumaran N, Oleiro M, Gonalons CM, Brookes D, Walsh GC & 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.

Taylor DBJ, Snow EL, Moore K & Dhileepan K 2017, At last, biological control of bellyache bush, pp. 4−9, In: T Sydes (ed.), *Proceedings of the 14th Queensland Weed Symposium*. The Weed Society of Queensland, Port Douglas, 4-7 December 2017

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

Project dates

January 2007 - June 2023

Project team

Kunjithapatham 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. Biological control is the most cost effective and long-term management option. Navua sedge has been approved as a target for biological control in Australia and a list of test plants for host specificity testing has been compiled. Surveys in equatorial Africa identified a smut fungus (*Cintractia kyllingae*) attacking flower heads and seeds, and a rust fungus (*Uredo kyllingae-erectae*) attacking leaves and stems, as promising biological control agents. Both pathogens have been exported to CABI (UK). Research on the biology and host specificity of the flower smut pathogen and the rust pathogen is in progress in quarantine in CABI (UK). Research on identifying native pathogens in Australia as prospective mycoherbicides is also in progress. Student research projects in Australia are in progress to fill research gaps in the biology, ecology, and management of Navua sedge. Future work will focus on surveys in other native range countries to source biological control agents and to continue the host specificity testing of priority agents.

Collaborators

- Prof Roger Shivas (University of Southern Queensland)
- Dr Marion Seier and Dr Daisuke Kurose (CABI, UK)

- Prof Florentine Singarayer, Aakansha Chadha and Bhagya Ranasinghe Hathamune Gamage (Federation University, Ballarat)
- Dr Yu Pei Tan (Queensland Plant Pathology Herbarium)
- Dr Alistair McTaggart (QAAFI, University of Queensland)
- Melissa Setter and Stephen Setter (Biosecurity Queensland, 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)
- Dr Rajaonera Tahina Ernest (University of Antananarivo, Madagascar)
- Joe Rolfe and Bernie English (Agri-Science Queensland, Mareeba)
- Rob Pagano (beef grazier, Tarazali)
- John McKenna (beef grazier, Malanda)
- Travis Sydes (Far North Queensland Regional Organisation of Councils, Cairns)
- Malanda Beef Plan Group (Malanda)
- Tablelands Regional Council (Atherton)
- Cassowary Coast Regional Council (Innisfail)
- Hinchinbrook Shire Council (Ingham)
- Herbert Cane Productivity Services Limited (Ingham)

Key publications

Chadha A, Florentine SK, 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, OO, Shi B, Florentine SK & 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 PM, Ntandu JE, Chukwuma E, Kurose D, Seier MK, Ellison CA & Shivas RG 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 OO, Chadha A, Florentine SK & 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 and ecology of chinee apple (*Ziziphus mauritiana*)

Project dates

July 2021-June 2023

Project team

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

Project summary

Ziziphus mauritiana Lamarck (Rhamnaceae), commonly known as Indian jujube or chinee apple, has become a major pasture and environmental weed in northern Australia, where its impenetrable thickets hinder stock movement and reduce pasture production. Current management options are mechanical and chemical which are expensive. Despite its presence in Australia since 1880, little information is available on its local and regional distribution and economic impacts, and limited information on prospects for biological control. This project provides preliminary research to pursue a future biological control program on the weed. Research will focus on the assessment of spread, economic loss, genetic diversity and introduction history in Australia, and developing a potential distribution model for the weed using Climex. *Ziziphus mauritiana* will need to be nominated as an approved target for weed biological control in Australia. Attempts will also be made to establish overseas collaborative partners in India, Pakistan, and Bangladesh to source biological control agents, when covid-related restrictions are lifted.

Collaborators

- Wayne Vogler, Kelli Pukallus, Bradley Gray and Moya Calvert (Biosecurity Queensland)
- Scott Hardy (Whitsundays Regional Council)
- NQ Dry Tropics
- Roger Shivas (University of Southern Queensland)
- Shane Campbell (University of Queensland, Gatton)
- Asad Shabbir (University of Sydney, Camden, NSW)
- Kumaran Nagalingam (CSIRO, Brisbane)
- Jürgen Kellermann (State Herbarium of South Australia)
- Mubarak Ali (University of Punjab, Lahore, Pakistan)
- National Bureau of Agriculturally Important Insects, Bangalore, India
- Central Institute of Arid Horticulture, Bikaner, India
- Bangladesh Agricultural University, Mymensingh, Bangladesh

Key publications

Bebawi FF, Campbell SD & Mayer RJ 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 AC 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 AC 2002, The Biology of Australian Weeds, 39. *Ziziphus mauritiana* Lam. Plant Protection Quarterly,17,2–11

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

Project dates

January 2007 - June 2023

Project team

Kunjithapatham Dhileepan, Di Taylor, Boyang Shi and Md Mahbubur Rahman

Project summary

Prickly acacia (*Vachellia nilotica* subsp. *indica*) is a weed of national significance and a target for biological control, with limited success to date. Plant phenotype and climate matching were used to prioritise countries and areas for native range surveys. Native range surveys for prospective biological control agents were conducted in Ethiopia and Senegal. 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 thrips (*Acaciothrips ebneri*) inducing shoot-tip rosette galls, a gall-inducing mite (*Aceria* sp.) deforming leaflets, rachides and shoot-tips in Ethiopia; and a gall-inducing fly (*Notomma mutilum*) inducing stem-galls in Senegal have been prioritised for further studies. 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 has been submitted. Release sites for the thrips are being selected in northern and western Queensland in anticipation of approval. Lifecycle studies and host specificity tests for the gall fly are in progress. Host specificity testing of the gall mite from Ethiopia in quarantine in South Africa has been delayed due to difficulties with gall mite importations (due to covid-related border closures and civil war in Ethiopia). Host specificity testing of the gall mite will commence when it is safe to conduct field visits to Ethiopia to collect and export the gall mites to South Africa.

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).
- Ocholi Edogbanya (Department of Biological Sciences, Kogi State University, Anyigba, Nigeria)
- Sebahat Ozman Sullivan (Ondokuz Mayis University, Turkey).
- Southern Gulf NRM
- Desert Channels Queensland

Figure 7 Prickly acacia gall thrips release site selection in the Mitchell grass downs.

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.ibiological control.org/proceedings/

17. Impact and management of Navua sedge

Project dates

July 2020 – June 2023

Project team

Olusegun Osunkoya, Christine Perrett, Kunjithapatham Dhileepan and Boyang Shi

Project summary

There are few quantitative data on the ecology and the yield loss to the grazing and cropping industries caused by Navua sedge. We have established research plots on eight far north Queensland grazing sites infested with Navua sedge. Within these plots, we continue to carry out surveys to quantify pasture diversity and soil seed bank composition in response to the weed's abundance. We will impose appropriate grazing and herbicide treatments in a subset of plots, and thereafter again survey the plots to quantify yield loss, changes in above-ground abundance of desirable pasture plants, soil seed bank composition and soil biochemistry.

In 2021-2022, using questionnaires to impacted graziers of the Atherton Tablelands, we quantified the economic loss caused by the weed. In 2022-2023 we are extending this questionnaire to cropping farmers and graziers in far north Queensland, ranging from coastal to inland and highland areas and spanning a broad latitudinal range (Townsville to Cape Tribulation).

Collaborators

- 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)
- Joe Rolfe and Bernie English (Agri-Science Queensland, Mareeba)
- Rob Pagano (Tarazali)
- Travis Sydes (Far North Queensland Regional Organisation of Councils, Cairns)
- Malanda Beef Plan Group
- Tablelands Regional Council
- Cassowary Coast Regional Council
- Hinchinbrook Shire Council
- Herbert Cane Productivity Services Limited

Key publications

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

Chadha A, Osunkoya OO, Shi B, Florentine SK & 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, OO, Chadha, A, Florentine, SK & 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

18. Risk assessment for new and emerging weed species

Project dates

July 2021- June 2023

Project team

Olusegun Osunkoya and Christine Perrett

Project summary

Our aims in this project are to (i) assess the risk of more than 200 emerging weed species using unpublished reports, published literature and field experience of local government pest officers and other land managers; (ii) evaluate the drivers of invasiveness for these 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 traffic]), and (iii) rank the emerging species for feasible management actions such as population suppression or even eradication given their stage of invasion.

Local government pest officers and regional Biosecurity Officers are often the best sources of information for recently arrived weed species and those that are increasing in distribution. These people and other stakeholders will be surveyed to provide information on local spread and abundance of emerging pests.

Collaborators

- Kristy Gooding (Local Government Association of Queensland)
- Queensland Herbarium
- Queensland local governments
- Steve Csurhes, Moya Calvert and Bradley Gray (Biosecurity Queensland)
- NRM groups
- Jens Froese and Sam Nicol (CSIRO, Brisbane)
- Jamie Camac (Centre for Biosecurity Risk Analysis Group, University of Melbourne Victoria)

Key publications

Csurhes S 2021, Risk assessment and prioritisation of 229 emerging weed threats detected in Queensland. Unpublished technical report. Biosecurity Queensland. 54 pages.

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

Osunkoya OO, Lock CB, Dhileepan K, & Buru JC 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 OO, Perrett C, Calvert M, & Csurhes S 2022, Horizon scan for incoming weeds into Queensland, Australia. Proceedings, 22nd conference of the Australasian weeds Conference, Adelaide, South Australia (in press)

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

Project dates

July 2019-June 2022

Project team

Olusegun Osunkoya and Christine Perrett

Project summary

This was an Australian Research Council linkage project involving Biosecurity Queensland, the University of Queensland, Queensland University of Technology and Queensland Parks and Wildlife Service. Managing invasive species is complex. By necessity, it involves a range of different societal groups, including government agencies and non-government sectors (e.g., indigenous management groups and individual landowners). Further complexity arises because invasive species affect a diversity of land tenures that span multiple jurisdictions. A single invasive species (e.g., foxes or parthenium weed) can occur on both agricultural lands and protected areas, across multiple local and regional governmental boundaries, and span freehold, leasehold, and public lands. Presently, invasive species management groups, like Biosecurity Queensland and Queensland Parks and Wildlife Service, almost always operate independently due to different jurisdictions and varying goals. However, the agencies might achieve better management goals if they work cooperatively. Hence in this project, we have explored the potential benefits of a collaborative approach across agencies to planning and actions. Through stakeholder-engagement and a review of the unpublished literature and scientific publications and using strategic analyses of multi-factor systems in management, we showed (1) how interactions among multiple stakeholders, though desirable, can often create misalignment between the spending and values of individual stakeholders, and (2) why current uncoordinated prioritizations lead to fewer management goals achieved for individual stakeholders. We drew two conclusions from our results. First, that current stakeholder's prioritisation methods cannot identify optimal decisions (as they purport to do) since they do not incorporate other stakeholders' decisions. Second, that practical steps can be taken to achieve better coordination between stakeholders and thereby lead to improved management outcomes.

Collaborators

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

Key publications

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

Epanchin-Niell, R.S. Hufford MB, Esian CE, Sexton JP , Port JD & Waring T 2010, Controlling invasive species in a complex landscapes, *Frontiers in Ecology and the Environment* 8(4): p. 210-216.

O'Bryan JC, Rhodes JR, Osunkoya OO, Lundie-Jenkins G, Mudiyanselage NA, Sydes T, Calvert M, McDonald-Madden E & Michael Bode M 2022, Setting Conservation Priorities in Multi-Actor Systems, Biosciences (*In Press*)

20. Weed biological control agent rear and release

Project dates

July 2019 – June 2023

Project team

Kelli Pukallus and Ainsley Kronk

Project summary

This project aims to mass-rear, release and monitor biological control agents in northern Queensland for the control and management of invasive weed species.

Australia's first biological control agent for Siam weed (*Chromolaena odorata*), the stem-galling fly (*Cecidochares connexa)*, was approved for release in late 2018. The fly has produced significant damage to Siam weed populations in 11 other countries where it has been released. Mass-rearing and release commenced in late 2019 at Tropical Weeds Research Centre, Charters Towers. Over 28,000 adult flies and 3,300 galled stems have been released within seven Queensland local government areas (LGAs) to date. Galls have been detected at and spreading from release sites in all seven LGAs. In addition to releases, pre- and post-establishment damage assessments have been conducted every two months at northern Queensland sites. Biosecurity Queensland is also working with the Northern Territory Government to assist with their *C. connexa* release program.

Monitoring 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 agents and collections of associated insects/agents are catalogued. Greater spread of previously released agents is also achieved through collection and redistribution of agents for species such as parthenium and lantana to landholders and local governments.

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

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

Project dates

February 2020 – June 2022

Project team

Kelli Pukallus, Ainsley Kronk and Mary Butler

Project summary

Parkinsonia aculeata is a woody invasive weed species 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 saw the continuation and expansion of the mass-rearing and release of the biological control agent UU2 (*Eueupithecia vollonoides*) throughout northern Australia. The project aimed to gain optimal establishment of UU2, where UU2 had not previously been released or established following a previous project. Releases were conducted in

Queensland, Northern Territory and Western Australia totalling over 180,000 pupae at 67 sites. 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
- McKinlay 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 Government –Department of Environment and Natural Resources
- Malak Malak Lands Trust
- Western Australian Department of Primary Industries and Regional Development
- Kimberley Rangelands Biosecurity Association
- Biosecurity Queensland DAF Biosecurity Officers
- Fitzroy Basin Association

22. Aquatic weeds of northern Australia - ecology and control

Project dates

January 2015 – June 2023

Project team

Melissa Setter and Stephen Setter

Project summary

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

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

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

Viable frogbit seed production was recorded in North Queensland between October and December, peaking around November, with approximately 80-90% germination (preliminary results only). Each frogbit fruit averaged 70 seeds (range 21 – 117) with fruit retained on plant but splitting when mature, releasing seeds which mostly sink.

Figure 8 Stephen Setter applying herbicides with micro sprayer to bogmoss - Myacca fluviatilis

Figure 9 Successful treatment of bogmoss (L) and control (R)

Collaborators

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

Key publications

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

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

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

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

23. Sicklepod ecology and control

Project dates

January 2016 – June 2023

Project team

Melissa Setter and Stephen Setter

Project summary

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

Early findings indicate that seeds are persisting for at least 36 months after burial, and in pot trials seedling emergence and establishment have been effectively suppressed by herbicides containing picloram.

The pot trials identified several successful herbicides which are also currently permitted herbicides for sicklepod post-emergence control. A full field trial tested these herbicides at several locations in Cape York Peninsula. Preliminary assessments indicated that some herbicides reduced seedling survival by up to 90%. After one year, some herbicides (Conqueror® and Grazon Extra®, that contain picloram) were so effective that they were re-applied to determine the effects of two consecutive years of treatment, producing highly effective results. Assessments are ongoing.

Following the results of the field trial, a demonstration plot was established in conjunction with Cook Shire Council to showcase the effectiveness of Grazon Extra® as a pre-emergent herbicide for sicklepod. The demonstration site is in a highly visible public area that should improve awareness and hopefully eventual uptake of the successful research results.

Collaborators

- Biosecurity Officers
- Cape York NRM
- Local governments in northern Queensland (e.g. Cook Shire Council)
- Queensland Parks and Wildlife Service
- North Queensland landholders

Key publications

Setter, MJ, Setter, SD, Higgins, D & Vogler, W 2019, Controlling weed recruitment in isolated areas of Cape York Peninsula, *Proceedings of the 1st Queensland Pest Animal and Weed Symposium*, 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

July 2020 – June 2023

Project team

Melissa Setter and Stephen Setter

Project summary

Field-based herbicide trials are being conducted in the lower Herbert and Murray River basins with in-kind support from North Queensland local governments and canegrowers. The first component of the trial is investigating effective herbicide and wetter rates for the control of Aleman grass in land-based field situations. The next component will use a drone to apply herbicides and monitor efficacy in an aquatic situation. If the trial identifies herbicides and application rates that provide successful control, they will be used to seek a minor use registration for Aleman grass control from the Australia Pesticides and Veterinary Medicines Authority. In addition, the trial will test the field efficacy and application of 'Nemo' wetting agent as a candidate to replace 'Bonus' which is currently the only aquatic wetter registered for use and has been withdrawn from the Australian market.

Figure 10 Aleman grass trials

Figure 11 Hinchinbrook Shire Council Argo ATV clearing buffers and marking out plots

Figure 12 Aleman grass trials - Stephen Setter and Clare Warren applying herbicides

Collaborators

- Biosecurity Officers
- Far North Queensland Regional Organisation of Councils
- Canegrowers Tully
- Cassowary Coast Regional Council
- Hinchinbrook Shire Council
- Marcus Bulstrode (Agri-Science Queensland, Department of Agriculture and Fisheries)

Key publications

Abbott BN, Wallace J, Nicholas DM, Karim F & Waltham NJ 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. Risk assessment for weed biological control

Project dates

March 2020 – March 2022

Project team

Di Taylor

Project summary

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

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

Collaborators

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

Key publications

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

26. *Harrisia martinii* biological control and integrated management

Project dates

July 2020 - June 2022

Project team

Tamara Taylor, Lauren Kelk, Zachary Shortland and Kelli Pukallus

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.

Several separate studies investigating the effectiveness of control methods on *H. martinii* are currently underway or have been recently completed and awaiting publication. These include a laboratory study of the thermal tolerance of the *Harrisia* mealybug biological control and a confirmation of the species identity using molecular and morphological techniques. A two-year field study in Goondiwindi investigating mealybug development and impact on *H. martinii* in different seasons and levels of shade will be completed in August 2022. A further field trial is underway, investigating the impact of sheep grazing on *Harrisia* density. Additionally, a comparison of soil seed bank size and viability from locations with different *Harrisia* control history has commenced. A controlled aging test to determine potential seed longevity is currently underway at the Tropical Weeds Research Centre in Charters Towers.

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. We are organising the re-importation of this biological control agent for another release during 2023. Other upcoming work includes commencing host testing of a potential new biological control agent - a stem-feeding fly (*Dasiops bourquini*) from Argentina, and a resurvey of 24 *Harrisia* infestation sites previously surveyed by Biosecurity Queensland in 2000.

Collaborators

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

Figure 13 Sheep eating Harrisia cactus

Key publications

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

Novoa, A, Brundu, G, Day, 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, 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* will be studied in New Zealand. Covid-related delays and courier issues have so far prevented import and testing of an agent for *S. tora*. However, a stem-galling weevil (*Conotrachelus* sp.) has been identified as a potential agent for the control of *S. tora* and *S. obtusifolia* (another sicklepod in Queensland). Arrangements have been made to import this insect from Mexico in late 2023 and commence host testing. New Zealand have been successful with imports and host testing agents for *Solanum torvum* and *Urena lobata.* If appropriate, these agents will be imported into Australia for further host testing. Biosecurity Queensland has exported biological control agents that are successful in Australia to Vanuatu. Releases of *Carvalhotingis visenda* for the control of cats-claw creeper (*Dolichandra unguis-cati*) in Vanuatu were made during 2019 and are now having an impact on infestations. Biosecurity Queensland are maintaining cultures of *Zygogramma bicolorata,* a biological control agent for *Parthenium hysterophorus*, and a psyllid biological control agent, *Heteropsylla spinulosa*, for the control of *Mimosa diplotricha*. Exports of these agents to Vanuatu are imminent now that travel between the countries is possible.

Collaborators

- 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)

28. Giant rat's tail grass classic biological control

Project dates

July 2016 – June 2023

Project team

Tamara Taylor and Lauren Kelk

Project summary

Giant rat's tail grass (GRT) is the common name of two species namely, *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. A biological control project for GRT, along with several other weed species, was funded by the Australian Government through AgriFutures. Biosecurity Queensland subcontracted Rhodes University in South Africa to conduct laboratory host testing of two potential biological control agents – both wasp species from the *Tetramesa* genus. Neither wasp species was able to complete development on any of the 24 grass species tested other than GRT. Extensive field-based host-range surveys, encompassing more than 50 non-target grass species at 128 sites across South Africa were conducted between 2017 and 2021. DNA barcoding was performed on multiple African *Tetramesa* species collected during these surveys, which confirmed the field host-specificity of both *Tetramesa* wasps of interest that were only present on GRT. To date, these wasps have not been recorded on any grass species other than the two target weeds. Both wasp species appear to be suitable for further host testing of native Australian grasses and an importation has been arranged to commence this research.

Collaborators

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

Key publications

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

Sutton, GF 2021, *Prioritising biological control agents for release against Sporobolus pyramidalis and Sporobolus natalensis (Poaceae) in Australia*. Doctoral dissertation, Rhodes University. http://hdl.handle.net/10962/172445.

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

29. Chemical registration - providing tools for invasive pest control

Project dates

July 2012 - June 2023

Project team

Joseph Vitelli, David Holdom and Matthew Gentle

Project summary

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

Thirteen new permits were issued to Biosecurity Queensland during 2021–22 by the Australian Pesticides and Veterinary Medicines Authority (APVMA). Eight permits related to weeds— cacti, prickly acacia, lippia, sicklepod, Kahilli ginger, white ginger, yellow ginger, fireweed, Navua sedge and environmental weeds. Five permits related to pest animals - exotic birds, foxes, wild dogs and feral pigs. A further seven permits have been lodged with the APVMA for the control of Amazon frogbit, bellyache bush, cacti (three permits, stem injection, foliar and basal bark application) and red witchweed.

Collaborators

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

Key publications

Thirteen new permits were issued by APVMA to Biosecurity Queensland during the 2021-22 financial year:

1. Permit (PER90719) Amitrole, ammonium thiocyanate, MSMA, aminopyralid, picloram, triclopyr, glyphosate / Various Crop and Non Crop Areas / Cactaceae. Expires 31 Jan 2024. (http://permits.apvma.gov.au/PER90719.PDF)
2. Permit (PER12745) Alphachloralose Bird Control Agent / Exotic Birds. Expires 30 Jun 2026. (http://permits.apvma.gov.au/PER12745.PDF
3. Permit (PER82366) Fluroxypyr / Pasture rangelands & other non-crop situations / Prickly acacia. Expires 31 Jul 2026. (http://permits.apvma.gov.au/PER82366.PDF)
4. Permit (PER10540) 2,4-D Amine, Glyphosate and Metsulfuron / Pasture and Fallow (Floodplains) / Lippia. Expires 31 Jul 2026. (http://permits.apvma.gov.au/PER10540.PDF)
5. Permit (PER82158) Triclopyr/picloram/aminopyralid / Sicklepod. Expires 31 Mar 2026. (http://permits.apvma.gov.au/PER82158.PDF) (17/12/2021)
6. Permit (PER12436) Metsulfuron-methyl, Triclopyr, Imazapyr and Picloram / Various situations / Kahili ginger, White ginger and Yellow ginger. Expires 31 Oct 2025. (http://permits.apvma.gov.au/PER12436.PDF)
7. Permit (PER11463) Various products and chemicals / Non-Agricultural areas / Environmental Weeds. Expires 30 Apr 2027. (http://permits.apvma.gov.au/PER11463.PDF)
8. Permit (PER14004) Strychnine / Wild Dogs and Foxes. Expires 31 Dec 2022. (http://permits.apvma.gov.au/PER14004.PDF) (01/04/2022)

9. Permit (PER80065) Sempra Herbicide (halosulfuron-methyl) / Roadsides, rights-of-way, footpaths, commercial and industrial areas / Navua Sedge. Expires 31 Mar 2022. (http://permits.apvma.gov.au/PER80065.PDF)
10. Permit (PER13195) 2,4-D amine / Pastures / Fireweed in pasture via helicopter. Expires 31 Mar 2022. (http://permits.apvma.gov.au/PER13195.PDF)
11. Permit (PER89377) PAKS 1080 Concentrate / Bait Stations (Fruit baits)/ Feral Pigs. Expires 31 Oct 2024. (https://permits.apvma.gov.au/PER89377.PDF)
12. Permit (PER89572) PAKS 1080 Concentrate / Various Areas (Meat baits)/ Feral Pigs. Expires 31 Oct 2022. (https://permits.apvma.gov.au/PER89572.PDF)
13. Permit (PER91667) Sodium Fluoroacetate (1080) / Southern Downs / Wild dog. Expires 31 Mar 2023. (https://permits.apvma.gov.au/PER91667.PDF)

30. Control packages for statewide weed eradication targets - focus on red witchweed eradication

Project dates

July 2014 - June 2025

Project team

Joseph Vitelli, Annerose Chamberlain, Natasha Riding and Anna Williams

Project summary

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

Through an integrated control study in a sugarcane-growing area near Mackay, we are investigating the efficacy of agronomic practices for depleting the red witchweed (RWW) seed bank and preventing further seed production over a ten-year period. Fifteen treatments, comprising pre and post-emergent herbicides, catch crops, trap crops and fumigants are being evaluated over time through the monitoring of seed viability in 5800 RWW seed sachets that were buried at five depths (0, 100, 200, 300 and 500 mm). This trial was terminated in 2020, following an external review of the National Red Witchweed Eradication Response Program. The work 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.

To evaluate eradication efforts on infested properties, an additional 300 perforated PVC canisters were buried, each containing three sachets of ~100 RWW seeds at depths of 100, 300 and 500 mm across 25 sites. The sites were spread over eight infested properties near Habana, Mackay and transected the active eradication management zone of the RWW eradication program. The 25 sites varied in soil type and topography. Soil types included friable non-cracking clay and clay loam (dermosol), cracking clay (vertosol) and sand or loam over sodic clay (sodosol). All sites were located within zones where RWW had previously been detected.

After four years, the viability of retrieved seeds had declined from 92.5 % to 6.5 % across all sites in response to the treatments, irrespective of treatment combination used. However, the viability of seeds was found to vary across sites, burial depth and time. For example, the viability of surface seed declined to 8.8 % after a single application of dazomet within the first year while, in the same canisters, buried seed viability was 19.5 %, 38.2 % and 46 % at 10, 30 and 50 cm. The viability of seeds collected at the same retrieval event from sites not treated with dazomet were 47.7%, 49.8% and 50.1% at 10, 30 and 50 cm.

Collaborators

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

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

Project dates

February 2019– June 2023

Project team

Joseph Vitelli, David Holdom, Annerose Chamberlain and Drew Rapley

Project summary

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

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

Twelve fungal species belonging to 44 isolates have been tested to maximise conidial yield in artificial media, with sporulation continuing to remain very species or isolate dependent. Of the 36 media and lighting combinations tested, the use of UV is proving the most effective at inducing sporulation.

A second pathogenicity testing of the GRT leaf smut (*Ustilago sporoboli-indici*) on native and naturalised Australian grasses is currently under way. Sixty species from twenty-nine grass genera, belonging to twelve tribes and seven sub-families are being evaluated. The list of grasses includes nineteen *Sporobolus* sp. (six naturalised, 13 native species including the rare species, *S. partimpatens*) belonging to five distinct clades (A, C, E, I and H).

Collaborators

- Australian Department of Agriculture, Fisheries and Forestry
- AgriFutures Australia
- New South Wales Environmental Trust
- NSW Biocontrol Fund
- Eric Dyke and James Anderson (Bundaberg Regional Council)
- Gympie Regional Council
- HQ Plantations
- AgForce Queensland
- School of Agriculture & Food Sciences, University of Queensland
- Tracey Steinrucken (CSIRO)
- Roger Shivas (University of Southern Queensland)
- Sharon Bishop-Hurley, Kaylene Bransgrove and Yu Pei Tan (Biosecurity Queensland)

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

Project dates

February 2017– June 2023

Project team

Joseph Vitelli, Annerose Chamberlain and Drew Rapley

Project summary

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

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

The decline in flupropanate in five soil types (chromosol, dermosol, ferrosol, kurosol and vertisol), irrespective of formulation between 12 (61.2%) and 24 (46.2%) months, was significant (P<0.0005), as was the amount of flupropanate found in soil-only pots (77.6%) and GRT-planted pots (29.8%). The percentage of flupropanate recovered when applied as a granular application (58.7%) was significantly higher (P<0.05) when compared to a liquid application (48.8%), irrespective of soil type, time and pot treatment.

Collaborators

- Powerlink Queensland
- School of Earth and Environmental Sciences, University of Queensland
- Peter Thompson (Property manager, Elgin, Conondale)
- Judith Ruhle (Property owner, Jalbirri, Bongeen)
- Errol Stenzel (Property owner, Bunburra, Boonah)
- David Ross (Property owner, Mapleton)

33. Giant rat's tail grass wick wiper

Project dates

February 2017 - June 2023

Project team

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

Project summary

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

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

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

The wick wiper trials consist of two parts, a pot experiment and a field component with plants at both sites infected with the GRT leaf smut. The pot experiment will examine the spray volume (2.5, 5, 10, 20 and 40 L ha^{-1}) required to control individual tillers when concentrations of glyphosate (1188 g a.i.), flupropanate (1500g a.i.) or both actives are least constant. A second component of the pot trial will examine three glyphosate concentrations (540, 1080 and 2160 g a.i.), three flupropanate concentrations (375, 750 and 1500 g a.i.) and a mixture (glyphosate (540 g a.i.) + flupropanate (375 g a.i.)) when spray volume is maintained at 10 L ha^{-1}.

GRT tussocks were grown in 150 mm pots at the Ecosciences Precinct. Four to six weeks prior to the application of herbicides, the tillers were cut at 100 or 150 cm above ground level to simulate a slashing event in the paddock. Measured quantities of herbicide were then applied to the tillers of the fresh GRT regrowth and an uncut control. Glyphosate-only treatments killed 94% of the treated tillers, when in combination with flupropanate almost 90% were controlled, whilst only 21% of tillers died when treated with flupropanate only, at six months post application.

An additional trial has been established in south-east Queensland (Mapleton) to better understand the residual effects of the most widely used herbicide (flupropanate) and determining if fertiliser can enhance forage quality and utilisation of GRT, as part of an integrated management approach.

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

Collaborators

Peter Thompson (Property manager, Elgin, Conondale)

34. Giant rat's tail grass management

Project dates

July 2017 – June 2022

Project team

Wayne Vogler and Clare Warren

Project summary

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

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

Collaborators

- Economic Development Queensland
- John Reeve and Nathan March (Biosecurity Queensland)
- Rob Teakle, Lewis Heuvel, Shaun Simon and Kelvin Dawson (Gladstone Regional Council)
- Landholders
- Brett Cawthray (Landholder and contractor)

Key publications

Vogler, W, Carlos, E & Hosking, K 2017, Extending flupropanate use - spot application on perennial mission and gamba grass, in *Proceedings of the 14th Queensland Weed Symposium*, T. Sydes, ed., Queensland Weed Society, Brisbane, 4 – 7 December

Part 2: Pest animal management

35. Management of peri-urban deer in south-east Queensland

Project dates

July 2018- June 2022

Project team

Matt Amos, Michael Brennan and Tony Pople

Project summary

Wild deer abundance and distribution are increasing across Australia, including in the peri-urban environment. A greater interaction between both growing deer and human populations in the peri-urban region is of particular concern because deer present a large road hazard and fatalities from deer collisions are being increasingly recorded in eastern Australia. There are other impacts, including loss of pasture and crops, spreading diseases, habitat modification and competition with native fauna. However, control tools are limited to trapping, shooting and fencing, but efficacy is not well known, and some methods are untenable in built-up areas.

To determine the effectiveness of control programs, monitoring of wild deer populations was conducted in the western suburbs of Brisbane, at North Pine Dam, Yeppoon and Wild Duck Island. At Brisbane, faecal pellet counts across 35 sites undertaken annually since 2018 have shown a decline in rusa and fallow deer abundance, suggesting ground shooting and trapping programs are reducing the population. A similar decline in the urban rusa deer population at Wollongong has been recorded in response to a long-term shooting and trapping control program.

At North Pine Dam, Yeppoon and Wild Duck Island, monitoring undertaken since 2019 using remote camera grids has provided density estimates of rusa deer. Data analysis of recent surveys at North Pine Dam and Yeppoon study sites is continuing. The rusa population at Wild Duck Island continues to show a decline following control by aerial shooting but appears to be partially compensated by increased recruitment. The distribution of the population has also shifted, with deer now utilising less accessible parts of the island.

A collaborative project with the Queensland University of Technology compared the efficiency of identifying rusa deer in thermal drone imagery by machine learning to conventional assessment by human observers. Machine learning was much more efficient than conventional assessment. Machine learning was similarly better than human observers in identifying deer in ground-based camera images.

A deer workshop was held with south-east Queensland land managers to describe and discuss best practice tools for controlling and monitoring deer populations. A range of topics were covered, including deer identification and control options for the various deer species, monitoring techniques, and engagement with local communities. Local governments also presented findings from their various deer management programs from south-east Queensland.

Collaborators

- Mark Kimber, Tony Cathcart and Jesse Wojtala (Sunshine Coast Regional Council)

- Jess Doman and Perry Ward (Seqwater)
- Darren Sheil (Moreton Bay Regional Council)
- Bree Galbraith (Gympie Regional Council)
- Bill Manners, Dan Franks and Robyn Jones (Brisbane City Council)
- Grant Hamilton and Ashlee Sudholz (Queensland University of Technology)
- Dave Forsyth, Andrew Bengsen and Sebastien Comte (New South Wales Department of Primary Industries)
- Steve Burke and Cam Mulville (Marine Parks, Department of Environment and Science, Yeppoon)
- 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 biological control prevalence (RHDV1, RHDVK5, 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. Harbour removal has focused on “key breeding” locations, primarily large warren systems and long-standing log piles. Removing major breeding sites is considered the key strategy to rabbit control, and thus control in other areas is unnecessary given these contribute little to population size and recovery. As stakeholders look to maximise benefit for lowest cost, this method is gaining momentum. To ensure efficient rabbit management, it is necessary to determine if breeding sites are sufficiently productive to allow rabbit populations to be self-sustaining or recover following control programs.

To evaluate the breeding success of various rabbit harbour types, remote-sensor cameras are deployed to monitor the output and survival of young, along with interactions with predators. We located established rabbit populations in southern Queensland and monitor them through the late winter and spring breeding season. Comparisons across years will allow an evaluation of how population size and reproductive output in these lower-productive harbours changes over time.

Collaborators

- Darling Downs and Moreton Rabbit Board
- Southern Downs Regional Council
- Toowoomba Regional Council

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.

Cooke, BD. Brennan, M & Elsworth, P 2018, Ability of wild rabbit, *Oryctolagus cuniculus*, to lactate successfully in hot environments explains continued spread in Australia's monsoonal north, *Wildlife Research*, 45: 267-273.

Figure 14 Ground predation of rabbits

Figure 15 Aerial predation of rabbits

37. Testing management strategies for feral pigs

Project dates

June 2021 – June 2023

Project team

Matthew Gentle, Peter Elsworth, James Speed and Tony Pople

Project summary

The effectiveness of feral pig control is hampered by the inadequate coordination of control effort in time and space. There is also a need for optimised control and monitoring practices supported by science-based information. While a variety of control tools are available, strategies for their optimal application are lacking or require field-testing.

Spatial data analysis from collared animals from four sites in Queensland and New South Wales indicate that most pigs show distinct habitat preferences. This suggests that control and monitoring tools (e.g. traps, cameras) or control effort (e.g. shooting, baiting) should be preferentially placed within these areas, but needs testing.

This project aims to refine and test optimised management and monitoring practices for feral pigs with selected landholder groups in northern Australia. This study monitors the effectiveness of control programs at key localities, including the level of population reduction, costs at a given density, with landholders, NRM groups and local government input. This project also aims to work in with interstate and inter-project researchers to test new monitoring or control techniques (e.g. thermal camera surveys or thermally-assisted shooting).

Collaborators

- Southern Queensland Landscapes
- Western Downs Regional Council
- Whitsunday Regional Council
- Landholders

Key publications

Gentle, M, Pople, A, Scanlan, JC, & Carter, J 2019, The dynamics of feral pig (*Sus scrofa*) populations in response to food supply, *Wildlife Research*. https://doi.org/10.1071/WR17176

Hone, J 2012, *Applied Population and Community Ecology: The Case of Feral Pigs in Aus*tralia, Wiley-Blackwell, United Kingdom.

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 how pigs use the landscape. This project describes and quantifies key characteristics of landscape use by feral pigs in several localities in Queensland. This is being completed through further analysis of GPS tracking data from collared feral pigs undertaken as part of a African Swine Fever (ASF) Prevention and Preparedness Project (2021-24) funded by the Queensland Government. This information will be used to further guide the development and refinement of pig control and monitoring strategies.

This project is using the above data to assist collaborators to model feral pig habitat suitability. This will provide spatial layers of suitable breeding habitats under different seasonal scenarios in Queensland. The model will also help to provide estimates of potential feral pig densities (carrying capacity) under these scenarios and identify at-risk areas for feral and domestic pig interactions across Queensland. Such data can be used for disease modelling.

Analysis of GPS tracking data and spatial modelling of feral pig habitat preferences has been used to identify strategies to improve the efficiency and effectiveness of pig control (and monitoring). New and refined monitoring approaches (e.g. thermal surveys, camera monitoring) are also being tested and compared to monitor control outcomes.

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

Bradhurst RA, Garner G, Roche SE, Iglesias R, Kung N, Robinson B, Willis S, Cozens M, Richards K, Cowled BD, Oberin M, Tharle C, Fireston S & Stevenson M 2021, Modelling the spread and control of African swine fever in domestic and feral pigs, University of Melbourne: Melbourne, Vic., Australia.

Froese, JG, Smith, CS, Durr, PA, McAlpine, CA, & van Klinken, RD 2017, Modelling seasonal habitat suitability for wide-ranging species: Invasive wild pigs in northern Australia. *Plos One,* 12(5). doi:https://doi.org/10.1371/journal.pone.0177018

Gentle, M, Finch, N, Speed, J, & Pople, A 2018, A comparison of unmanned aerial vehicles (drones) and manned helicopters for monitoring macropod populations, *Wildlife Research, 45*(7), 586-594. doi:https://doi.org/10.1071/WR18034

39. Peri-urban wild dog management

Project dates

April 2018 – June 2022

Project team

Matthew Gentle, Lana Harriott, James Speed and Catherine Kelly

Project summary

Wild dogs are common in peri-urban regions of Australia. Various forms of control are implemented but their use is limited due to small landholdings, varied land use, proximity to human habitation, and poor adoption by the community. In this project we tested tools and strategies for the best practice management of peri-urban wild dogs.

Canid pest ejectors (CPEs) were assessed through field trials and desktop modelling. Camera footage of wild dog behaviour and outcomes of control programs were also collected. Results show that while wild dog CPE encounter rates are high, increasing the interaction and activation rates would improve the efficiency and effectiveness of control. The efficiency and cost-benefits of CPEs and traditional trapping methods were also compared through assessments of capture rates. Monitoring the effectiveness of an integrated management program showed that wild dog activity decreased significantly over the four-year period, and community requests for assistance (complaints) to local government also declined.

The project findings have been incorporated into a published best-practice guide for the management of wild dogs in peri-urban environments. This guide presents key lessons, useful approaches and actions to manage the impacts of wild dogs in peri-urban areas, for the benefit of individual landholders and community members.

Collaborators

- Tony Cathcart, Jesse Wojtala, Bruce Knuckey, Ben Field, Peter Bell and Rita Everitt (Sunshine Coast Regional Council)
- Bree Galbraith (Gympie Regional Council)
- Dan Franks (Brisbane City Council)
- Darryl Low Choy and Pazit Taygfeld (Griffith University)
- Ben Allen (University of Southern Queensland)
- Carlo Pacioni (Victorian Department of Environment, Land, Water and Planning)
- Rowland Cobbold and Tamar Michaelian (University of Queensland)
- New South Wales Department of Primary Industries
- Landholders
- Centre for Invasive Species Solutions

Key publications

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

Harriott L, Allen, BL, & Gentle, M 2021, The effect of device density on encounters by a mobile urban carnivore: Implications for managing peri-urban wild dogs, *Applied Animal Behaviour Science,* 243. doi:10.1016/j.applanim.2021.105454

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

40. Increased aerial baiting rate for strategic control of wild dogs in the Southern Downs Region

Project dates

July 2021- June 2022

Project team

Matthew Gentle and Peter Elsworth

Project summary

In the Southern Downs Region, aerial baiting is conducted in strategic areas to manage deleterious wild dog impacts to agriculture and the environment. In Queensland, 1080 label conditions stipulate that a maximum of 10 baits/linear km may be applied to target wild dogs. Recent research in forested, mesic environments adjacent to the Great Dividing Range in north-eastern New South Wales found aerial baiting at 40 baits/linear km resulted in a 90% mortality rate in wild dogs exposed to baits, compared to only 55% of wild dogs at 10 baits/linear km.

Southern Downs Regional Council (SDRC) requested assistance to improve the efficiency and efficacy of wild dog aerial baiting in areas of rugged terrain through increasing the baiting rate from 10 to 40 baits/linear km. This would require approval by the Australian Pesticides and Veterinary Medicines Authority (APVMA) under a minor use permit.

This project successfully 1) collated supporting data, 2) assessed the risk profile of (local) non-target species in contrast to that in northern NSW, and 3) submitted a minor use application to the APVMA to enable the aerial distribution of baits up to maximum of 40 baits/linear km in rugged terrain within the SDRC jurisdiction.

Collaborators

- Peter Fleming (New South Wales Department of Primary Industries)
- Mat Warren (Southern Downs Regional Council)

Key publications

Permit (PER83516) The use of baits containing 1080 at a rate high that that specified by the label instructions for aerial baiting of wild dogs (NSW jurisdictions). Expires 31 March 2023.

Permit (PER91667) The use of baits containing 1080 at a rate high that that specified by the label instructions for aerial baiting of wild dogs (Southern Downs, QLD). Expires 31 March 2023.

41. Feral pig baits – registration, refinements and alternatives

Project dates

July 2020- June 2022

Project team

Matthew Gentle and Peter Elsworth

Project summary

This project progressed, and assessed alternatives to, the registration of two feral pig 1080 baiting practices that have a long history of use in Queensland to protect agriculture and the environment: meat baits in the absence of pre-feeding or bait-stations, and baits prepared from fruit materials. Data on bait efficacy and impact on non-target species were submitted to the Australian Pesticides and Veterinary Medicines Authority for the limited use of fruit (Wet Tropics, northeast Queensland) and meat baits for feral pig control. Supporting information on historical use, viability of alternative baiting techniques, risk assessment and labelling were also submitted. Two minor use permits were subsequently issued, supporting the use of 1080 in meat baits (aerial or ground deployment) and banana or mango baits (ground deployment) in key localities in Queensland with commercial 1080 solutions.

Hoggone® meSN® (microencapsulated sodium nitrite) may supplement conventional (ground) 1080 baiting techniques but had not been tested in Wet Tropics agricultural production environments. We collaborated with local government and industry end-users to test the effectiveness and safety of Hoggone® meSN®, and alternative safety mechanisms for fruit baiting (e.g. excluder devices including the Bait Box) for feral pigs. The Bait Box excluders were successful, with no evidence of non-target species accessing Bait Boxes in field trials in north Queensland. Further work is recommended to optimise the use of excluders (e.g. free-feeding period) and sodium nitrite (e.g. weather and climate) for feral pig control in the Wet Tropics.

Collaborators

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

Key publications

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

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

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

42. Wild dog predation on cattle and wild herbivores

Project dates

July 2020 – June 2024

Project team

Malcolm Kennedy, James Speed and Catherine Kelly

Project summary

Wild dogs (free-living domestic dogs, dingoes and their hybrids: *Canis familiaris*) can have significant impacts on livestock enterprises. While wild dogs and small stock are incompatible, 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 suppression of native and introduced herbivores.

This project seeks to better understand the movement, predation and feeding behaviour of wild dogs on Queensland cattle enterprises. This will ultimately help determine the impact of wild dogs on cattle and wild herbivores. This work will entail satellite telemetry of wild dogs, including a pilot trial of video-GPS collars with accelerometers and of next generation, light weight, solar powered satellite tags (Ceres tags) to determine if these tools can record wild dog predation events and other activities. Satellite telemetry will allow us to also determine the effectiveness of biannual baiting on wild dog numbers. The project has Animal Ethics Committee approval, equipment has been procured, and a number of field sites have been evaluated. 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.

Collaborators

- Phillip Hayward (Biosecurity Queensland)
- Megan Brady (The Turner Family Foundation)

Key publications

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

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

Figure 16 Dog trapping in preparation for satellite telemetry tracking

43. Improving the detection and response to red-eared slider turtles

Project dates

July 2020 – June 2023

Project team

Malcolm Kennedy and Peter Elsworth

Project summary

Red-eared slider turtles (REST) are the most traded reptile in the world and have substantial environmental impacts where they establish outside of their native range. Established populations in south-east Queensland, originating from the illegal pet trade, were the focus of control programs from 2005. Individuals have recently been detected within the area of previously established populations and control has again been undertaken from September 2018. This work is challenging due to the cryptic and evasive nature of REST.

This project aims to increase effectiveness of REST management and improve confidence of detection and eradication of REST. Using pontoon-mounted camera traps we have been able to identify and sex individual REST in the eradication area. This has assisted the REST eradication program, such that Biosecurity Queensland staff have reduced the number of

REST from seven, to one known individual. The remaining individual is a male meaning the known population is functionally eradicated. The project has been able to quantify REST basking behaviour in terms of timing and duration of basking and has assisted collaborators from the University of Canberra (supported by the Centre for Invasive Species Solutions) to develop and test a novel approach to eDNA collection for aquatic basking species. This project will seek to develop surveillance tools for juvenile REST and will continue to increase understanding of REST ecology, effectiveness of eradication efforts, and assist in responding to 'at large' detections of REST.

Figure 17 Red-eared slider turtle eDNA collection trap

Figure 18 Red-eared slider turtle necropsy

Figure 19 Stacy Harris deploying red-eared slider trap

Collaborators

- Stacy Harris (Biosecurity Queensland)
- Dianne Gleeson and Jack Rojahn (University of Canberra)
- Nathan Cutter and Ian Turnbull (New South Wales Department of Primary Industries)

Key publications

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

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

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

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

Project dates

July 2020 – June 2023

Project team

Malcolm Kennedy, Catherine Kelly and Peter Elsworth

Project summary

As the most common stowaway species arriving in Australia in cargo and baggage, the Asian black-spined toad (ABST, *Duttaphyrnus melanostictus*) is a species of major biosecurity concern. ABSTs have established populations in several locations outside their native range in Asia, with substantial economic and environmental impacts. Much of northern and eastern Australia is suitable for establishment of ABSTs.

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

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

Figure 20 Recording Asian black-spined toad calls in Indonesia


Figure 21 Processing water samples for Asian black-spined toad eDNA in Indonesia


Figure 22 Water sampling for Asian black-spined toad eDNA in Indonesia

Figure 23 Asian black-spined toad at the water's edge in Indonesia

Collaborators

- Lin Schwarzkopf (James Cook University)
- Mirzura Kusrini (IPB University, Indonesia)
- Dianne Gleeson and Doug Beattie (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

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

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

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

Project dates

April 2018 – June 2022

Project team

Malcolm Kennedy, Peter Elsworth and Tony Pople

Project summary

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

Wildlife monitoring has been undertaken in two clusters since 2013. Since the Morven cluster was closed in 2015, wild dog activity inside the fenced area declined rapidly and is now very low. Wild dog abundance is also declining, albeit more slowly, in the Tambo cluster. Apart from macropods, whose abundance declined within and outside clusters over time following drought, there has been no significant decline in native species inside fences, compared to outside fences. Mesopredators (foxes and feral cats) have not increased in abundance in response to reduced wild dog numbers.

Remote sensing of pasture has been undertaken using multiple paired sites inside and outside of six clusters. There was no significant difference in annual average or seasonal green cover between inside and outside clusters. The lack of detected change may be influenced by insufficient time since fence establishment, a low responsiveness of cover to total grazing pressure, drought conditions, delayed reduction in wild dog numbers and enclosure of ‘outside’ sites by new fences.

Economic data have been collected from case study properties and developed into a bioeconomic model. Results demonstrate fencing, coupled with wild dog control made a significant difference to lambing for the study properties, although the increase was more modest than expected.

Collaborators

- Lester Pahl (Agri-Science Queensland, Department of Agriculture and Fisheries)
- John Carter (Department of Environment and Science)
- Megan Star (Central Queensland University)
- Ben Allen and Geoff Castle (University of Southern Queensland)

Key publications

Castle, G, Smith, D, Allen, LR, & Allen, BL 2021 Terrestrial mesopredators did not increase after top-predator removal in a large-scale experimental test of mesopredator release theory, Scientific Reports, 11(1), 1-18.

Castle, G, Smith, D, Allen, LR, Carter, J, Elsworth, P, & Allen, BL 2022, Top-predator removal does not cause trophic cascades in Australian rangeland ecosystems, *Food Webs*, 31, e00229.

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

46. Ecology and management of chital deer in north Queensland

Project dates

July 2014 - June 2024

Project team

Tony Pople, Michael 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.

Multiple vehicle surveys per year monitored chital density on two properties over 2013-2022. Seasonal shot samples of deer on both properties assessed reproductive output over 2014-2016. Aerial surveys determined chital densities on seven properties, prior to aerial culling on four properties. Finally, the maximum rate of increase of chital was calculated from life history data.

Regionally, chital are patchily distributed and so are best monitored locally where they can be very abundant. Regular vehicle surveys recorded a ~90% decline in chital populations over 7-10 months in early 2015 with a similar rate recorded by aerial survey at a third site. There was little if any recruitment during the drought, but the decline was driven by adult mortality. Aerial shooting further reduced populations by up to 90% to low densities on four properties. Where there was apparently no continuing control, culled populations recovered to pre-cull densities or higher after 2.5 years. One unculled property recovered to its pre-drought density after six years. Rates of recovery were at or higher than the maximum annual rate of increase for chital estimated as ~34%.

Future work will concentrate firstly on monitoring survival of adult females and fawns and ranging behaviour using satellite telemetry. Secondly, telemetry and population surveys will be related to environmental data to hopefully explain the highly clumped local distribution.

Collaborators

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

- Heather Jonsson (Dalrymple Landcare Committee)
- Thijs Krugers and Rachel Payne (NQ Dry Tropics)
- Catherine Kelly, Matt Quin, Jodie Nordine, Ben Hirsch, Lin Schwarzkopf, Jan Strugnell and Iain Gordon (James Cook University)
- Centre for Invasive Species Solutions

Key publications

Bengsen A, Forsyth D, Pople T, Brennan M, Amos M, Leeson M, Cox T, Gray B, Orgill O, & Hampton J 2022, Effectiveness and costs of helicopter-based shooting of deer, *Wildlife Research*.

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

Kelly CL, Schwarzkopf L, Gordon IJ, Pople A, Kelly DL & Hirsch BT 2022, Dancing to a different tune: Changing reproductive seasonality in an introduced chital deer population, *Oecologia*.

Watter, K, Baxter, GS., Pople, T & Murray, PJ 2019, Effects of wet season mineral nutrition on chital deer distribution in northern Queensland, *Wildlife Research* **46**, 499-508.

47. Coordinated management of feral deer in Queensland

Project dates

May 2022- June 2025

Project team

Tony Pople, Michael Brennan, Matt Amos and Lana Harriott

Project summary

This project will support coordinated management of feral deer in Queensland regions. There are currently four species of feral deer with expanding populations in the state. Three long-established populations are large and widespread, requiring control to both contain and reduce impacts. Outside these populations are small, satellite populations that could be eradicated or at least held at low density and contained. Clear, often differing objectives (i.e. early detection, eradication, containment and control) are needed to cost-effectively manage deer populations across regions and this is clearly articulated in the draft National Deer Action Plan. This will also underpin the current revision of the Queensland Feral Deer Management Strategy.

The project starts in mid-2022 and aims to:

1. Collaborate with stakeholders to 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

Deer will be managed by aerial and ground shooting at several demonstration sites in a range of Queensland environments. These will be priority populations identified in workshops with local governments, the Queensland Department of Environment and Science (DES), NRM groups and other stakeholders based on feasibility, current and future impact and potential for spread. These demonstrations and the prioritisation of populations will support local and regional management plans for deer. The project will help develop these with local governments, DES and other land managers. The cost-effectiveness of reductions will be determined along with new tools such as thermal-assisted shooting for more effective control, the use of detection dogs in eradication attempts and early detection enabling rapid response and eDNA for proof-of-freedom and determining genetic population structure.

Collaborators

- Annelise Wiebkin (National Deer Management Coordinator)
- Troy Crittle (New South Wales Department of Primary Industries)
- Jesse Wojtala and Mark Kimber (Sunshine Coast Regional Council)
- Bren Fuller (Whitsunday Shire Council)
- Queensland local governments
- Queensland Department of Environment and Science
- Queensland NRM groups
- Ted Vinson and Geoff Swan (Biosecurity Queensland)
- Mark Lamb

Key publications

Bengsen A, Forsyth D, Pople T, Brennan M, Amos M, Leeson M, Cox T, Gray B, Orgill O, & Hampton J 2022, Effectiveness and costs of helicopter-based shooting of deer, *Wildlife Research*.

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.

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

External funding

Research and development contracts

Project/research area	**Funding body**	**Funds spent ($)**
Integrated management of cabomba	CSIRO	113,193
Weed management in the Pacific	Landcare Research New Zealand	108,466
Biological control of pasture weeds, Vanuatu	Landcare Research New Zealand	101,566
Biological control of parkinsonia	CSIRO	92,986
Biological control of *Clidemia hirta*	AgriFutures Australia	129,083
Biological control of prickly acacia	AgriFutures Australia	121,433
Biological control of giant rat’s tail grass	AgriFutures Australia	89,703
Biological control of Navua sedge	AgriFutures Australia	218,328
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	137,510
Biological control risk	Victorian Department of Jobs, Precincts and Regions	19,863
Biological control of invasive cacti	Australian Government	115,005
Biological control of *Cylindropuntia*	New South Wales Department of Primary Industries	1,889
Giant rat’s tail grass management in central Queensland	Gladstone Regional Council	36,006
Giant rat’s tail grass management in Aldoga, Gladstone State Development Area	Economic Development Queensland	24,052
Managing established pests—giant rat's tail grass	Australian Government	20,000
Aquatic weed management tools	Australian Government	202,414
Navua sedge management	Australian Government	223,821
Tolerance to pre-emergent herbicide	CSIRO	1,012
Siam weed management in northern Australia	Northern Territory Department of Environment, Parks and Water Security	17,802
Four tropical weeds eradication	National cost share	70,185
Red witchweed response program	National cost share	64,640
Wild dog and deer management	Centre for Invasive Species Solutions	216,208
Cluster fencing evaluation	Centre for Invasive Species Solutions	15,718
Feral pig management	Australian Government	68,745
Total		**2,209,631**

Land Protection Fund

Project/research area	**Funds spent ($)**
Pesticide permits	53,016
Biological control of prickly acacia	177,115
Biological control of bellyache bush	58,073
Biological control of cat's claw creeper	75,631
Biological control of parthenium	26,781
Biological control of opuntioid cactus	95,076
Biological control of Harrisia cactus	102,295
Biological control of Navua sedge	116,018
Biological control of parkinsonia	21,824
Biological control of clidemia	33,570
Biological control of giant rat's tail grass	50,419
Biological control of chinee apple	69,159
Biological control of lantana	75,309
Weed biological control non-target risk	5,573
Rearing and release of biological control agents	155,627
Quarantine management	62,418
Water weed ecology and management	57,875
Integrated management of cabomba	87,121
Aquatic weed management tools	70,361
Weed seed dynamics	64,483
Siam weed management in northern Australia	24,632
Giant rat's tail grass flupropanate control	7,744
Giant rat's tail grass wick wiper	64,970
Prioritising pest management	31,437
Navua sedge ecology and management	93,817
Weed risk assessment	37,221
Research management	47,047
Red-eared slider eradication	41,268
Asian black-spined toad surveillance	38,748
Rabbit best practice research	26,511
Feral deer best practice research	129,849
Management of peri-urban wild dogs and deer	156,596
Wild dog exclusion fencing	24,663
Wild dog predation on cattle and wild herbivores	44,897
Wild dog aerial baiting	27,959
Non-target impacts of 1080 feral pig baits	44,425
Total	**2,299,529**

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
Michael Day	Principal scientist (entomologist)
Kunjithapatham Dhileepan	Senior principal scientist (entomologist)
Olusegun Osunkoya	Principal scientist (ecology)
Joseph Vitelli	Senior principal scientist (weeds)
Tobias Bickel	Senior scientist (aquatic weeds)
Sharon Bishop-Hurley	Senior scientist
Jason Callander	Scientist
Lana Harriott	Scientist
David Holdom	Scientist
Md Mahbubur Rahman	Scientist
Boyang Shi	Scientist
Di Taylor	Scientist
Tamara Taylor	Scientist
Michael Brennan	Principal science technician
Annerose Chamberlain	Science technician
David Comben	Science technician
Bahar Farahani	Science technician
Tess James	Science technician
Eloise Martin	Honours student (giant rat's tail grass)
David Officer	PhD candidate (giant rat's tail grass)
Christine Perrett	Science technician
Drew Rapley	Science technician
Natasha Riding	Science technician
Dipika Roy	Science technician
Liz Snow	Principal science technician (and quarantine manager)
Kusinara Wijayabahdara	PhD Candidate (fireweed)
Tracey Steinrucken	CSIRO post-doctoral fellow (biological control of invasive plants)
Anna Williams	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	Senior science technician (casual)
Malcolm Kennedy	Senior scientist
James Speed	Senior science technician

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 technician
Kirsty Gough	Science support officer
Ainsley Kronk	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

Ali S, **Dhileepan K**, Hussain A & Shabbir A 2021, Reproductive biology, abundance, and control potential of *Paramecops farinosus* (Wiedemann) (Coleoptera: Curculionidae): a prospective biological control agent for *Calotropis procera* (Apocynaceae). *Biocontrol Science and Technology* 31(12):1365−1376.

Augusteyn J, McCarthy MA, Robley A, **Pople A**, Nolan B, Hemson G, Melzer R, Richards S, & Dinwoodie A 2022, Bringing back the endangered bridled nail-tailed wallaby at taunton national park (scientific) through effective predator control, *Wildlife Research*, 49, 382-398. doi: https://doi.org/10.1071/WR21067.

Bengsen AJ, Forsyth DM, Ramsey DSL, **Amos M, Brennan M, Pople AR**, Comte S & Crittle T, 2022 Estimating deer density and abundance using spatial mark–resight models with camera trap data, *Journal of Mammalogy* **103**, 710-722. doi: 10.1093/jmammal/gyac016.

Castle, G, Smith, D, Allen, LR, Carter, J, **Elsworth, P** & Allen, BL 2022, Top-predator removal does not cause trophic cascades in Australian rangeland ecosystems, *Food Webs*, *31*, e00229.

Chadha A, **Osunkoya, OO, Shi B**, Florentine SK & **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, 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. ‘

Dhileepan K, Musili PM, Ntandu JE, Chukwuma E, Kurose D, Seier MK, Ellison CA & Shivas RG 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.

Dhileepan K, Musili PM, Ntandu JE, Chukwuma E, Kurose D, Seier MK, Ellison CA & Shivas RG 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.

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

Etebari K, **Taylor DBJ, Rahman MM, Dhileepan K**, Furlong MJ & Asgari S 2022, Exploration of RNA-Seq data to identify a potential pathogen of the leaf-mining moth, *Stomphastis thraustica* (Meyrick) (Lepidoptera: Gracillariidae), *Data in Brief* 40, 107708, doi.org/10.1016/ j.dib. 2021.107708.

Fancourt, BA, Harry, G, **Speed, J**, & **Gentle, MN** 2022, Efficacy and safety of Eradicat® feral cat baits in eastern Australia: population impacts of baiting programmes on feral cats

and non-target mammals and birds, *Journal of Pest Science, 95*(1), 505-522. doi:10.1007/s10340-021-01433-9

Finch N, **Pople A**, McLeod SR & Wallace G 2021, Advances in aerial survey methods for macropods in New South Wales and Queensland, *Ecological Management & Restoration* **22**, 99-105. doi: https://doi.org/10.1111/emr.12486.

Harriott L, Allen, BL, & **Gentle, M** 2021, The effect of device density on encounters by a mobile urban carnivore: Implications for managing peri-urban wild dogs, *Applied Animal Behaviour Science,* 243. doi:10.1016/j.applanim.2021.105454

Huaman JL, Pacioni C, Sarker S, Doyle M, Forsyth DM, **Pople A**, Carvalho TG & Helbig KJ 2021, Novel picornavirus detected in wild deer: Identification, genomic characterisation, and prevalence in Australia, *Viruses* **13**, 2412.

Huaman JL, Pacioni C, Sarker S, Doyle M, Forsyth DM, **Pople A**, Hampton JO, Carvalho TG & Helbig KJ 2021, Molecular epidemiology and characterization of picobirnavirus in wild deer and cattle from Australia: Evidence of genogroup i and ii in the upper respiratory tract, *Viruses* **13**, 1492.

Huaman JL, Pacioni C, Forsyth DM, **Pople A,** Hampton JO, Carvalho TG & Helbig KJ 2022, Detection and characterisation of an endogenous betaretrovirus in Australian wild deer, *Viruses* **14**, 252.

Kolesik P, Kumaran N, Oleiro M, Gonalons CM, Brookes D, Walsh GC & **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.

Kreplins, T L, Miller, J, & **Kennedy, MS** 2021, Are canid pest ejectors an effective control tool for wild dogs in an arid rangeland environment?, *Wildlife Research* 49, 227-236

Kreplins, TL, Adams, PJ, Bateman, PW, Dundas, SJ, **Kennedy, MS**, & Fleming, PA 2021, A self-training device to teach conservation-working dogs to avoid poison baits, *Wildlife Research* 49, 274-282

McLeod SR, Finch N, Wallace G & **Pople AR** 2021, Assessing the spatial and temporal organization of red kangaroo, western grey kangaroo and eastern grey kangaroo populations in eastern Australia using multivariate autoregressive state-space models, *Ecological Management & Restoration* **22**, 106-123. doi: https://doi.org/10.1111/emr.12488.

Rahman MM, Shi B, Taylor DBJ & **Dhileepan K** 2022, Studies on gall-inducing behaviour and life cycle to aid host specificity testing of *Notomma mutilum* (Tephritidae: Diptera) - a prospective biological control agent for prickly acacia (*Vachellia nilotica* subsp. *indica*), *Biocontrol Science and Technology* 32: doi:10.1080/09583157.2022.2090512.

Rapley, D, Steinrucken TV, Vitelli, JS, Holdom, DG & Tan, YP 2022, *Pestalotiopsis chiaroscuro*, Fungal planet description sheet: 1429. Persoonia 48: 354–355.

Shi B, Dhileepan K & Adkins SW 2021, The impact of parthenium weed amended substrates on the germination and early growth of a range of pasture and crop species. *Agronomy* 11(9), 1708, doi.org/10.3390/agronomy11091708.

Shi B, Osunkoya OO, Chadha A, Florentine SK & **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.

Steinrucken TV, Vitelli, JS, Holdom, DG, Tan, YP & Shivas, RG 2022, *Keissleriella sporoboli*. Fungal planet description sheet: 1427, Persoonia 48: 350–351. https://doi.org/10.3767/persoonia.2022.48.11

Steinrucken TV, Vitelli, JS, Holdom, DG, Tan, YP & Shivas, RG 2022), *Leptosphaerulina queenslandica*. Fungal planet description sheet: 1428, Persoonia 48: 352–353.

Steinrucken TV, Vitelli, JS, Holdom, DG, Tan, YP & Shivas, RG 2022, *Stagonospora tauntonensis*. Fungal planet description sheet: 1430, Persoonia 48: 356–357.

Steinrucken TV, Vitelli, JS, Holdom, DG, Tan, YP & Shivas, RG 2022, *Wongia ficherai*. Fungal planet description sheet: 1431, Persoonia 48: 358–359.

Steinrucken TV, Vitelli, JS, Holdom, DG, Tan, YP & Shivas, RG 2022, The diversity of fungal species associated with "Clade A" *Sporobolus* grasses in Queensland, Australia, Frontiers in Fungal Biology, (in press)

Stobo-Wilson, AM, Murphy, BP, Crawford, HM, Dawson, SJ, Dickman, CR, Doherty, TS, Fleming, PA, **Gentle, M**, Legge, SM Newsome, TM, Palmer, R, Rees, MW, Ritchie, EG, **Speed, J**, Stuart, JM, Thompson, E, Turpin, JM & Woinarski, JCZ 2021, Sharing meals: Predation on Australian mammals by the introduced European red fox compounds and complements predation by feral cats, *Biological Conservation*, 261, 109284. doi:https://doi.org/10.1016/j.biocon.2021.109284

Stobo-Wilson, AM, Murphy, BP, Legge, SM, Caceres-Escobar, H, Chapple, D G, Crawford, HM, Dawson, SJ, Dickman, CR, Doherty, TS, Fleming, PA, Garnett, ST, **Gentle, M**, Newsome, TM, Palmer, R, Rees, MW, Ritchie, EG, **Speed, J**, Stuart, JM, Suarez-Castro, AF, Thompson, E, Tulloch, A, Turpin, JM & Woinarski, JCZ 2022, Counting the bodies: Estimating the numbers and spatial variation of Australian reptiles, birds and mammals killed by two invasive mesopredators, *Diversity and Distributions,* 28(5), 976-991. doi:10.1111/ddi.13497

Sudholz A, Denman S, **Pople A, Brennan M, Amos M &** Hamilton G 2022, A comparison of manual and automated detection of rusa deer (*Rusa timorensis*) from RPAS-derived thermal imagery, *Wildlife Research* **49**, 46-53. doi: https://doi.org/10.1071/WR20169.

Wijeweera WPSN, de Silva MPKSK, **Dhileepan K** & Senaratne KADW 2022, Temporal variation of insects of *Calotropis gigantea* in southern province of Sri Lanka, *Rajarata University Journal* 7(1):1−6.

Wijeweera WPSN, Senaratne KADW, **Dhileepan K** &, de Silva, MPKSK 2022, Insect diversity on *Calotropis gigantea* (L.) in Sri Lanka, *Ceylon Journal of Science* 51(2):121−128.

Wijeweera WPSN, Senaratne KADW, **Dhileepan K** & de Silva MPKSK 2021, Determination of the distribution of *Calotropis gigantea* (L.) in Sri Lanka using MaxEnt modelling technique, *Ruhuna Journal of Science* 12(2):144−154

Wijeweera WPSN, Senaratne KADW & **Dhileepan K** 2021, Distribution, development biology and behaviour of *Dacus persicus* associated with *Calotropis gigantea* in Sri Lanka, *Ceylon Journal of Science* 50(3):219−226.

Woinarski, JCZ, Stobo-Wilson, AM, Crawford, HM, Dawson, SJ, Dickman, CR, Doherty, TS, Fleming P A, Garnett, ST, **Gentle, MN**, Legge, SM, Newsome, TM, Palmer, R, Rees, MW, Ritchie, EG, **Speed, J**, Stuart, JM, Thompson, E, Turpin, J & Murphy, BP 2021, Compounding and complementary carnivores: Australian bird species eaten by the

introduced European red fox *Vulpes vulpes* and domestic cat *Felis catus*, *Bird Conservation International.* doi:10.1017/S0959270921000460

Conference proceedings and presentations

Dhileepan K 2021, Chinee Apple Biological Control Project Updates. Burdekin Dry Tropics Regional Pest Management Group meeting, Bowen, Qld, Team Meeting, 19 August 2021.

Dhileepan K 2021, Chinee Apple Biocontrol Project Meeting with landholders. Whitsundays Regional Council and Bowen Landcare Group, Teleconference, 26 July 2021.

Gentle, M 2021, Feral pig management in Australia: implications for ASF. *Australian Veterinary Association Centenary Week*, virtual conference, Australia, 29 Nov-3 Dec 2021.

Kreplins, T, Fleming, P, Algar, D & **Kennedy, M** 2021, Managing wild dogs across large landscapes with poison baits, *Australasian Wildlife Management Society Conference*, Canberra 7-9 December

Osunkoya OO, Perrett C, Calvert M & Csurhes S 2022, Horizon scan for incoming weeds into Queensland, Australia. In Proceedings, 22nd conference of the Australasian weeds Conference, Editor: Adelaide, South Australia

Steinrucken, TV & Vitelli, JS 2021, Endemic fungal pathogens as biological control agents of weedy *Sporobolus* grasses in Australia. 2ND Australian Biosecurity Symposium, Royal Pines Resort, Benowa, Gold Coast, Queensland. (1-3 December 2021).

Wijeweera WPSN, de Silva MPKSK, **Dhileepan K** & Senaratne KADW 2022, Temporal variation of flower visitors of *Calotropis gigantea* (L.) in Southern Province of Sri Lanka, *RISTCON 2022* – 9th *Ruhuna International Science and Technology Conference*. University of Ruhuna, Sri Lanka, 19 January 2022.

Books and book chapters

Saunders D, **Pople T** & Mcleod S 2022, Studying wildlife from the air. In 'Wildlife Research in Australia: Practical and Applied Methods', (Ed. BP Smith, HP Waudby, C Alberthsen, and JO Hampton), pp. 96-107. (CSIRO Publishing: Clayton South, Victoria)

Print media

Biological control agent reduces the spread of Siam weed, 2022, https://www.cassowarycoast.qld.gov.au/news/article/689/, 23 May.

Invasive weed ‘has beaten us’, 2022, North Queensland Register, Townsville, 2 June.

Reports, newsletters, fact sheets and theses

Bickel, TO, Nagalingam, K & Sathyamurthy, R 2021, Integrated cabomba management: Milestone report 8 (submitted to Department of Agriculture and Water Resources), DAF and CSIRO, Brisbane, 9pp

Bickel, TO, Perret, C, Farahani, B, & Oudyn F 2022, Control of invasive aquatic plants with Procellacor (florpyrauxifen-benzyl) in Australia – Appendix 1. Report (submitted to SePro, USA), DAF, Brisbane, 11pp

Bickel, TO 2022, New Aquatic Weed Management Tools. Milestone report 1 (submitted to Department of Agriculture and Water Resources), DAF, Brisbane, 15pp

Kelly CL 2021, Ecology of chital deer in north Queensland. (James Cook University, Townsville).

McVay, M 2021, Control of Amazon Frogbit (*Limnobium laevigatum*) with Flumioxazin: A Study on Control Efficacy, Application Techniques and Exposure Time Requirements, Honours Thesis, University of Queensland.

Pukallus, K 2021, Siam weed biological control newsletter. Biosecurity Qld, July 2021 (edition 3).

Shi B, Dhileepan K 2021, Application to release the gall-inducing thrips (*Acaciothrips ebneri*) for biological control of the weed prickly acacia (*Vachellia nilotica* subsp. *indica*), Release application submitted to the Department of Agriculture, Water Resources and the Environment, Australian Government, August 2021.

Taylor DBJ 2021, Prospects for the biological control of bellyache bush and prickly acacia. Queensland Entomological Society meeting. Entomological Society of Queensland New Bulletin, Volume 49, Issue 5, August 2021, pp 80-83

Taylor DBJ, Dhileepan K 2022, Revised application to release *Stomphastis* thraustica, an agent for the biological control of *Jatropha gossypiifolia* in Australia, Release application submitted to the Department of Agriculture, Water Resources and the Environment, Australian Government, April 2022.

Taylor DBJ & Dhileepan K 2022, *Aceria* species *nilotica*, a potential biological control agent for prickly acacia (*Vachellia nilotica* ssp. *indica*), Unpublished report submitted to the Department of Agriculture, Water Resources and the Environment, Australian Government, September 2021.

Taylor DBJ & Dhileepan K 2022, *Prodiplosis hirsuta* Kolesik sp. nov., a potential biological control agent for bellyache bush (*Jatropha gossypiifolia*) - information required to support an application to import, Unpublished report submitted to Department of Agriculture, Fisheries and Forestry, Australian Government June 2022.

Taylor, T 2021, *Biocontrol research for Harrisia cactus.* Cactus Quarterly – Autumn 2021, NSW North West Local Land Services and Northern Slopes Landcare, p1, available at: www.northernslopeslandcare.com.au/news/cactus-quarterly.html

Radio, television and web

Harriott, L 2022, *Talking wild dogs* with Rod Corfe, 2WEB 2nd June

Vogler, W 2022, *Giant rats tail grass – seed spread management*, Gladstone Regional Council YouTube Channel, June. https://www.youtube.com/watch?v=9rx1cH7nZ1I

Vogler, W 2022, *Giant rats tail grass – herbicides*, Gladstone Regional Council YouTube Channel, June. https://www.youtube.com/watch?v=4vHOzCQrLkU

Posters

Steinrucken, TV & Vitelli JS 2022, The enemy of my enemy is my friend - Fungal pathogens as biological control agents of Giant Rat's Tail grass in Australia. Poster A decade of

biosecurity: turning a moment into a movement. 2nd Australian Biosecurity Symposium. 3-5 May 2022, Gold Coast, Queensland.

Forums and workshops

Amos, M 2022, *History of Deer in Queensland – Community Conversations – Feral Deer,* City of Gold Coast,18 March.

Bickel, TO 2022. Amazon frogbit control with flumioxazin. Natural Resource Management Forum, Caloundra, 16 March 2022.

Brennan, M, Pople, A, Amos, M, Gentle, M & Vinson, T 2022, *Feral deer management workshop*, Tor St, Toowoomba, 10 March 2022.

Brooks, Simon 2021, Regional Pest Management Working Group, Townsville 18th November 2021.

Dhileepan K 2021, Biological control of prickly acacia and Navua sedge. Biocontrol of Weeds 2 – 3rd Project Committee Meeting, AgriFutures Australia, Team Meeting, 4 Nov 2021.

Dhileepan, K 2021, Gympie and district landcare group second annual Bio-control forum. Ecosciences Precinct, Boggo Road, Dutton Park, 4102. 20th October 2021.

Dhileepan K 2022, Biological control of Parthenium Weed in Australia: How Bangladesh can benefit. Knowledge and Management of Parthenium Weed in Bangladesh (Feed the Future Bangladesh Integrated Pest Management Program), Zoom meet, 23 February 2022.

Dhileepan K, Shi, B 2022, Biological control of Prickly acacia: a new gall thrips from Ethiopia. LGAQ Natural Resource Management Forum, Richmond, Qld, 29 March 2022.

Dhileepan K 2021, Biological control of prickly acacia and Navua sedge. Biocontrol of Weeds 2 – 3rd Project Committee Meeting, AgriFutures Australia, Team Meeting, 4 Nov 2021.

Gentle, M 2022, Feral pig research update. *Local Government Association Queensland Natural Resource Management Forum*, Ingham, Queensland, 17 May 2022.

Pukallus, K 2021, Biological control overview to Cert III Distance Education students. TWRC, Charters Towers. 25 August.

Pukallus, K 2021, *Cecidochares connexa* (stem-galling fly) on Siam Weed (*Chromolaena odorata*); Mass-rearing and release program at DAF's Tropical Weeds Research Centre, Charters Towers. Burdekin Dry Tropics RPMG Meeting. Townsville (via Teams). 18 November.

Rahman MM, Shi B, Taylor DBJ, Dhileepan K 2022, An update on the new biological control agent gall fly (*Notomma mutilum*) for prickly acacia (*Vachellia nilotica* subsp. *indica*) in Australia. IP&A Seminar Series-5, Ecosciences Precinct, Dutton Park Brisbane, Australia.

Setter, M & Setter, S 2022, *Queensland National Parks & Wildlife Service Operations Pest Forum, BQ Weeds Research Overview*, South Johnstone, March 2022.

Setter M & Setter S 2022, *Biosecurity Team Meeting, Research Update*, Cairns, March.

Taylor, T 2022, Harrisia cactus research update from Queensland. Presentation at *Harrisia cactus taskforce meeting*. Northern Slopes Landcare Association, 21 April 2022 via Zoom.

Taylor DBJ 2021, Prospects for the biological control of bellyache bush and prickly acacia. Queensland Entomological Society meeting. August 2021

Vogler, W 2021, *GRT Ecology and Management*, Ingham Beef producer Meeting, Ingham, 22 September.

Vogler, W 2021, *Navua Sedge Ecology and Management*, Ingham Beef producer Meeting, Ingham, 22 September.

Vogler, W 2022, *TWRC Research Update*. Mackay Regional Pest Management Group Meeting, Nebo. 18 May.

Vogler, W 2022, *Florestina management*. Queensland Local Government NRM Forum, Longreach. 23-24 May.

Lectures and seminars

Elsworth, P 2022, *Biological control: vertebrate pest applications*, School of Veterinary Sciences, The University of Queensland, Gatton, 4 April.

Gentle, M 2022, *Vertebrate Pests – Overview and Control Strategies*, School of Veterinary Science, The University of Queensland, Gatton, 21 March.

Taylor DBJ 2022, An update on the biological control of bellyache bush: the leaf miner. IP&A seminar series, June 2022

Taylor DBJ 2021, Prospects for the biological control of bellyache bush and prickly acacia. Queensland Entomological Society meeting. August 2021

Field days

Bickel, TO 2022, Aquatic Weed Management Introduction to “Clipper” herbicide, Maroochydore, 9 September 2021.

Dhileepan, K. Conducted field visit to Far North Queensland from 15 to 18 June 2022 to select Navua sedge infested properties for Management trials. Three properties – a grazing property in Malanda, a sugarcane field in Babinda and a roadside site in Ingham, all with severe Navua sedge infestations were selected, in consultation with QDAF – Animal Science (Mareeba), Malanda Beef Plan Group (Malanda), Sugar Research Australia (Gordonvale) and Herbert Cane Productivity Services (Ingham).

Vogler, W 2022, *Prickly acacia management field day*, Desert Channels Queensland, Winton, 13 April.

STEM Professionals in Schools

Kronk, A 2021, National Science Week activities. Distance Education. Charters Towers. 19 August.

Pukallus, K & Kronk, A 2021, National Science Week activities. Millchester State School. Charters Towers. 16-19 August.

Pukallus, K & Butler, M 2021, Under 8's Day. Distance Education. Charters Towers. 22 October.

Technical highlights
Invasive plant and animal research 2021–22

biosecurity.qld.gov.au
BiosecurityQld
DAFQld
13 25 23

DAF1783 09/2022

Queensland Government