Department of Agriculture and Fisheries

Technical highlights

Invasive plant and animal research 2016–17

Queensland Government

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Cover photo: Prickly acacia host-specificity trials in quarantine facilities, Ecosciences Precinct

Contents

Introduction

This document summarises the 2016–17 research program of the Invasive Plants and Animals Research group in Biosecurity Queensland. Our applied research program aims to better manage Queensland's worst weeds and pest animals, reducing their impacts on agriculture, the environment and the community.

Our work is undertaken at five centres across the state:

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

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

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

Notable achievements of the research program for 2016–17 are outlined below.

Invasive plant research

- New biological control agents continue to be assessed for control of prickly acacia, bellyache bush, Siam weed, mikania, lantana, giant rat's tail grass, mother-of-millions and several cacti (*Cylindropuntia* species). Mass rearing and release of biocontrol agents approved for release in Australia is also being undertaken for parkinsonia, lantana, parthenium and coral cactus. After many years without success, there are now a number of promising agents in the final stages of testing for bellyache bush and prickly acacia. We hope to have clear results by the end of the 2017–18 financial year.
- Projects are supporting state and national eradication programs for numerous weeds, including red witchweed, miconia, mikania and limnocharis. Effective control options are being sought and ecological data is being collected to help determine the frequency and duration of control activities. Similar work is continuing for former eradication targets Siam weed and Koster's curse.
- Trials are identifying effective herbicides, application rates and techniques for control of a number of weeds in Queensland, including prickly acacia, chinee apple, night-blooming cereus, stevia, Koster's curse, rubber vine, alligator weed, cabomba, sagittaria, bogmoss, glush weed, giant rat's tail grass and gamba grass.
- Ecological research to assist management (e.g. seed longevity, environmental requirements) is being undertaken on numerous weeds.

Pest animal research

- Projects on the ecology and management of wild deer have continued in south-eastern Queensland and northern Queensland. In south-eastern Queensland, the movements of rusa deer are being studied and monitoring methods developed to assess control operations in peri-urban areas. In northern Queensland, the collapse of the chital deer population has been monitored through a drought, providing an opportunity to maintain low numbers through control.
- A new strain of rabbit haemorrhagic disease virus was released in March 2017 and subsequent declines in population size have been monitored at a number of sites. Again, low pest density provides a strategic opportunity for long-term suppression of abundance through follow-up conventional control such as warren ripping.
- We are devoting considerable effort to assessing the efficacy of broadscale baiting to control feral cats. The difficulty has been getting cats to consume bait. The baits must obviously be attractive, but also placed where they will be encountered. Availability of alternative prey seems important, as cats must be hungry to take bait. Control must therefore be strategic to be effective.
- Meat baits (via aerial application) and fruit and vegetable baits have been used to control feral pigs. However, both practices need to have minimal non-target impact for them to continue in Queensland. Preliminary assessments indicate that these practices have little if any impact on native birds and mammals.
- We continue to monitor the abundance of kangaroos, wild dogs and other wildlife, and pasture biomass and condition before and after the erection of two large cluster fences in south-western Queensland. Data is being collected on individual properties both inside and outside the clusters. This evaluation will help direct future investment in cluster fences and fine-tune current operations.

Research services

- At Coopers Plains, our chemistry group produces 1080 solution for use in pig, dog and fox baits. The group also tests various poisons as possible causes of death for animal mortalities reported by the public. In addition, testing for residues in baits is carried out to quantify how long chemicals last in the environment.
- We obtain minor-use permits from the Australian Pesticides and Veterinary Medicines Authority as required for certain weed species, herbicides, application methods and situations or environments.

Funding, collaboration and research priorities

In the 2016–17 financial year, Biosecurity Queensland's Invasive Plants and Animals Research program received funding from a number of sources. Queensland Government base funds provided $2.5 million, contributions from the Rural Land Protection Fund amounted to $2.0 million, and funding under contracts with external partners totalled $1.2 million (see 'External funding', page 30). Notable funding bodies for the latter were the Australian Government, Meat and Livestock Australia and the Invasive Animals Cooperative Research Centre.

Our research program for 2016–17 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 and the Queensland Regional NRM Groups' Collective. The committee critically reviews proposed project outcomes and allocated investments, and makes recommendations on strategic priorities, existing research gaps and projects due for scientific review.

Further information

For further information, visit www.biosecurity.qld.gov.au (search 'Invasive plant and animal research'). To obtain journal articles and scientific reports, email the project leaders (see 'Research staff', page 31). In addition, you can browse our recent scientific publications in the eResearch archive at www.biosecurity.qld.gov.au (search 'eResearch archive').

Part 1: Invasive plant research

1. Weed seed dynamics

Project dates

August 2007 – June 2020

Project team

Shane Campbell, Dannielle Brazier and Simon Brooks

Project summary

There are many declared weeds for which we know very little about seed ecology and longevity. In this project, we are investigating the seed longevity of priority weeds by burying seeds enclosed in bags in two different soil types (black clay and river loam), under two grass cover conditions (grassed and non-grassed) and at four burial depths (0, 2.5, 10 and 20 cm). These weeds include yellow oleander, mesquite, prickly acacia, chinee apple, parthenium, lantana, gamba grass, calotrope, leucaena, yellow bells, neem, stevia and sicklepod.

We are also undertaking a seedling emergence trial to provide additional information on the seed longevity of neem, leucaena, prickly acacia, chinee apple and mesquite. This trial will also help quantify the environmental conditions (temperature and rainfall) that these weeds need for field germination and emergence.

The persistence of stevia was determined in both the Wet Tropics (Innisfail) and Dry Tropics (Charters Towers) bioregions of northern Queensland. Most viable seed buried at 0, 2.5–3 or 10 cm in soil was exhausted within 1 year. No viable seed was found after 3 years burial in either site. The findings for neem in the seedling emergence study were consistent with those in the seed longevity trial, where it demonstrated short-term persistence. Prickly acacia and leucaena are displaying typical emergence patterns for weeds with long-lived seed banks. Some germination and emergence has occurred following significant rainfall, but a large proportion of seeds remain viable and dormant.

Collaborators

- Bob J Mayer, Senior Biometrician, Department of Agriculture and Fisheries
- Faiz Bebawi

Key publications

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

Bebawi, FF, Campbell, SD & Mayer, RJ 2015, 'Seed bank longevity and age to reproductive maturity of *Calotropis procera* (Aiton) W.T. Aiton in the dry tropics of northern Queensland', *The Rangeland Journal*, vol. 37, pp. 239–247.

Bebawi, FF, Campbell, SD & Mayer, RJ 2016, 'Seed bank persistence and germination of chinee apple (*Ziziphus mauritiana* Lam.)', *The Rangeland Journal*, vol. 38, pp. 17–25.

2. Best practice research on Wet Tropics weeds

Project dates

January 2009 – June 2018

Project team

Melissa Setter and Stephen Setter

Project summary

Weeds are a major threat to the economic productivity and environmental integrity of the Wet Tropics. Many economically significant industries (including agriculture, horticulture and fisheries) are affected if Wet Tropics weeds are not managed effectively. Weed encroachment can decrease biodiversity, placing rare and threatened communities and species at risk. Socially, weed invasion can decrease people's enjoyment of the Wet Tropics (e.g. affecting recreational fishing through debilitation of fish nurseries, reducing scenic quality of natural areas, and decreasing the diversity of birds). Both the social and environmental considerations also affect the high tourism value of the region.

There is a paucity of information on several key weed species threatening the Wet Tropics bioregion. Our study species include three Weeds of National Significance (pond apple, hymenachne and bellyache bush) and several others declared under state and/or local government legislation (e.g. Navua sedge, neem and leucaena). Research is targeted at key aspects to support on-ground management (e.g. seed longevity in soil and water, age to reproductive maturity, rate of spread, dispersal mechanisms and control options, including herbicide trials).

Collaborators

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

3. Biocontrol of bellyache bush (*Jatropha gossypiifolia*)

Project dates

January 2007 – June 2018

Project team

K Dhileepan, Di Taylor, Liz Snow and Kerri Moore (from January 2017)

Project summary

Bellyache bush (*Jatropha gossypiifolia* L.), 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* F.) in 2003, which failed to establish. Jatropha rust (*Phakopsora arthuriana*) was also identified as a prospective biological control agent, and host-specificity testing of the rust is nearing completion at CABI in the United Kingdom and Trinidad. A renewed biological control effort involving exploration in South America identified a leaf-mining moth, *Stomphastis* sp. (Lepidoptera: Gracillariidae), from Bolivia and Peru, a shoot and leaf-galling midge, *Prodiplosis longifila* (Diptera: Cecidomyiidae), from Bolivia, and a leaf-feeding cecidomyiid, *Prodiplosis* sp. near *longifila* (Diptera: Cecidomyiidae), from Paraguay.

Jatropha rust

Host-range testing of Jatropha rust was conducted for 41 non-target species under quarantine conditions at CABI (United Kingdom). These were inconclusive, and so urediniospore dose-response experiments and field host-range testing were undertaken for selected species to further assess their susceptibility. The plant species included in these assessments were *Jatropha curcas*, a reported host of Jatropha rust, and the Australian natives *Aleurites moluccana*, *A. rockinghamensis* and *Beyeria viscosa*. All of these native species supported sporulation of the rust during the initial host-range testing under greenhouse conditions, but to varying degrees.

The urediniospore dose-response experiments conducted under quarantine conditions in the United Kingdom could not rule out any non-target attack, even at lower spore concentrations. However, the field host-range testing performed in Trinidad (November 2015 – June 2016), which is the country of origin of the rust strain under evaluation, identified only *J. curcas* as being susceptible and likely to come under attack in a field situation. For the two *Aleurites* species included in the field trial, no sporulation of Jatropha rust was observed and they are therefore not considered to be part of the field host range of the rust and unlikely to be at risk. Equally, no uredinial sporulation was recorded for *B. viscosa*, but infrequently underdeveloped, assumed immature telia were noted. This non-target species is not considered to be a natural, fully susceptible host of the pathogen, and while some attack by Jatropha rust in a field situation cannot be completely ruled out, the rust is unlikely to sustain itself on this Australian native.

Investigation of the life cycle of the rust is continuing, in an attempt to confirm whether the rust can complete its development on just *J. gossypiifolia*, or whether it needs an alternative host.

Jatropha leaf-miner

The Jatropha leaf-miner (*Stomphastis* sp.) was imported from Peru into Australia and a colony was established in quarantine in November 2014. Adults are small (less than 1 cm long) and live for about 10 days in the quarantine glasshouse (at 27 °C). The eggs are laid on the underside of leaves, usually next to a leaf vein. Newly emerged larvae mine directly into the leaf from the egg and remain in the leaf as they develop until pupation. Mature larvae exit the leaf mine and pupate often on the leaves.

No-choice host-specificity testing of Jatropha leaf-miner has been completed for 40 test plant species. The adults laid eggs on numerous non-target species, but larval development only occurred on bellyache bush and its congener physic nut (*J. curcas*). In choice oviposition trials, the females laid eggs equally on both bellyache bush and physic nut. Approximately 80% of eggs developed into adults on each of these species. Physic nut, native to tropical America, is a declared weed in Western Australia and the Northern Territory. It is also an approved target for biological control. Test results provide strong evidence that the leaf-miner is highly host specific and is suitable for release in Australia. An application seeking approval to release the leaf-miner will be submitted to relevant regulatory authorities in Australia.

Jatropha gall midge

The Jatropha gall midge (*P. longifila*) induces rosette galls in shoot-tips, emerging leaves, petioles and stems, resulting in shoot-tip dieback on *J. clavuligera* in Bolivia. In view of the susceptibility of *J. gossypiifolia* to the Bolivian gall-inducing *P. longifila* tested in field transplant experiments in Bolivia and no-choice quarantine facility tests in South Africa, the gall-inducing *P. longifila* in Bolivia has the potential to be used as a new association biological control agent for *J. gossypiifolia* in Australia. However, before the agent can be imported into quarantine in Australia for host-specificity tests, further morphological and genetic research are needed to ascertain that the gall-inducing *P. longifila* in Bolivia is part of a cryptic species complex.

Jatropha webber

Surveys in India identified the moth *Sciota divisella* (Lepidoptera: Pyralidae) as a potential biological control agent for this weed. The moth was imported into quarantine in July and October 2015 and a colony has been established. The adults laid eggs on leaves and stems of bellyache bush plants. The larvae fed on the leaves and fruits and, in the absence of these, bored into the stem from the shoot-tip, resulting in dieback. There was no evidence of any diapause phase during the culturing of the insect under controlled conditions in quarantine. The generation time (egg to egg) was about 6 weeks.

Host-range testing has been completed for 12 species (with five replications each) and has been partly completed for 26 species; 14 species are yet to be tested. In no-choice larval development tests to date, full larval development occurred on six non-target species. Four of these were exotics (*J. curcas, J. podagrica, Euphorbia neriifolia* and *E. grantii*), but two were Australian natives (*Macaranga tanarius* and *E. plumerioides*). However, the larval development was much slower (longer development time) with higher larval mortality on all the non-target test plant species. *J. curcas*, a declared weed, is an approved target for biological control and *S. divisella* has been known to occur on this host as well in India. *J. podagrica* and *E. neriifolia* are exotic ornamentals, while *E. grantii* is a highly toxic exotic ornamental, but all are uncommon in Australia.

More replications for the no-choice tests along with choice oviposition tests are needed to fully ascertain the susceptibility of the two Australian native Euphorbiaceae species.

Sampling native *Jatropha* species for gall midge incidence, Bolivia

Collaborators

- Marion Seier and Kate Pollard, CABI (United Kingdom)
- Naitram (Bob) Ramnanan, CABI (Trinidad)
- Stefan Neser, Plant Protection Research Institute (Pretoria, South Africa)
- Damian Rumiz, Noel Kempff Mercado Museo de Historia Natural (Santa Cruz, Bolivia)
- A Balu, Institute of Forest Genetics and Tree Breeding (Coimbatore, India)
- Tanya Scharaschkin, Queensland University of Technology
- A Raman, Charles Stuart University (Orange, New South Wales)
- Peter Kolesik, Bionomics (Adelaide)

Key publications

Dhileepan, K, Neser, S & De Prins, J 2014, 'Biological control of bellyache bush (*Jatropha gossypiifolia*) in Australia: South America as a possible source of natural enemies', *Proceedings of the XIV international symposium on biological control of weeds*, Kruger National Park, South Africa, pp. 5–10.

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

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

Project dates

January 2007 – June 2020

Project team

K Dhileepan, Di Taylor and Boyang Shi

Project summary

Prickly acacia is a Weed of National Significance and a target for biological control, but with limited success to date. Based on the field host range in India, a scale insect (*Anomalococcus indicus*), a green leaf-webber (*Phycita* sp.) and a leaf weevil (*Dereodus denticollis*) were prioritised for host-specificity tests in quarantine. However, agents from India tested to date are either not sufficiently host specific for release in Australia or proving difficult to rear in quarantine. There are no other prospective agents available from India, so the search effort for new biological control agents has been redirected to Ethiopia and Senegal.

Scale insect from India

The quarantine testing of the scale insect *A. indicus*, sourced from India, has been completed. In no-choice tests involving 84 test plant species, development of *A. indicus* females to reproductive maturity occurred on 17 of the non-target species, which included native *Vachellia* spp., *Neptunia* ssp. and *Acacia* spp. Of these, *Acacia falcata*, *V. bidwillii*, *V. sutherlandii*, *N. major* and *N. monosperma* supported high numbers of mature females in all replicates. Due to the limited ability of scale insects to disperse, non-target species that occur on the Mitchell Grass Downs (i.e. *V. sutherlandii*, *N. dimorphantha* and *N. monosperma*) are considered to be at most risk. In nymphal host-preference trials, prickly acacia was the preferred host, though nymphs also settled on some of the non-target species. This may be an artefact of laboratory conditions, as this insect is known to be host specific under field conditions in India. Therefore, choice trials commenced in India on non-target test plants, on which the scale completed development in quarantine in Australia, to ascertain the non-target risks of the Australian test plants under natural field conditions. The field choice trials will continue till June 2018.

The first field choice trial on the susceptibility of Australian native non-target test plant species (*V. sutherlandii*, *V. tortilis*, *N. major*, *A. terminalis*, *A. planifrons*, *A. falcata*, *A. auriculiformis* *Senegalia ferruginea* and *Paraserianthes lophantha*) commenced in December 2015. In December 2016, all control prickly acacia plants ($n = 10$) were found to be infected by the scale insect (*A. indicus*) and, in contrast, no scale insect was evident on non-target test plant species (*V. tortilis*, *N. major*, *S. ferruginea*, *A. planifrons*, *A. falcata* and *A. auriculiformis*).

A second field choice trial on the susceptibility of Australian native non-target test plant species (*N. major*, *N. monosperma*, *V. sutherlandii*, *A. falcata*, *A. cardiophylla*, *A. parramattensis*, *A. irrorata*, *A. deanei*, *A. decurrens*, *A. filicifolia*, *A. mearnsii*, *A. baileyana* and *A. oshanesii)* and a closely related crop plant (*Ceratonia siliqua*) to the scale insect (*A. indicus*) commenced in India in January 2016. There were again difficulties in growing test plants. In December 2016, all prickly acacia plants ($n = 100$) were infested with the scale insect, and a majority of the prickly acacia plants (73%) had died due to the scale insect attack. In contrast, there was no evidence of scale insects on any of the non-target plants (*N. major*, *A. irrorata*, *A. cardiophylla*, *A. decurrens* and *A. filicifolia*).

Galling arthropods from northern Africa

Surveys were conducted in Ethiopia and Senegal under the Australian Government's Rural Research and Development for Profit program with the Rural Industries Research and Development Corporation (now trading as AgriFutures Australia). In Ethiopia, a gall thrips (*Acaciothrips ebneri*) inducing rosette galls in shoot-tips and axillary buds and an

eriophyid gall mite (*Aceria* sp. 3) have been prioritised for detailed host-specificity testing. Field-collected gall thrips and eriophyid gall mites from Ethiopia were exported to quarantine facilities in Australia (Ecosciences Precinct) and to the Agricultural Research Council Plant Protection Research Institute (ARC-PPRI) in Pretoria, South Africa, respectively, for colony establishment and host-specificity testing. The eriophyid gall mites from Ethiopia have been sent to taxonomic expert Dr Charnie Craemer at ARC-PPRI for identification. In Senegal in March 2017, surveys were conducted at eight sites with natural groves of two native subspecies of prickly acacia (*V. nilotica* ssp. *tomentosa* and ssp. *adstringens*) along the Senegal River, in partnership with researchers from the Senegalese Institute of Agricultural Research. The gall thrips (*A. ebneri*), an eriophyid gall mite (*Aceria* sp. 4) and an unidentified gall fly inducing stem-galls (family Tephritidae) were identified as prospective biological control agents. This is the first time stem-gall-inducing Tephritidae have been recorded on prickly acacia. Cuttings of galled prickly acacia stems with developing larvae of the gall fly were exported to a quarantine facility at ARC-PPRI for identification. Seed samples of two prickly acacia subspecies (ssp. *tomentosa* and ssp. *adstringens*) were also exported to South Africa for inclusion in host-specificity tests.

A colony of the eriophyid gall mite from Ethiopia has been established in a quarantine facility at Pretoria, South Africa. In preliminary host-specificity tests, the gall mite from Ethiopia induced galls only on Australian prickly acacia (ssp. *indica*) and not on a prickly acacia native to South Africa (ssp. *kraussiana*). Prickly acacia seeds from Australia (ssp. *indica*), Ethiopia (ssp. *tomentosa*, ssp. *indica* and ssp. *leiocarpa*) and Senegal (ssp. *tomentosa* and ssp. *adstringens*) and seeds of 40 Australian native test plant species were exported to Pretoria, South Africa, in November 2016 and March 2017 for inclusion in detailed host-specificity testing for the eriophyid gall mite. The 40 test plant species, along with prickly acacia sourced from Australia, Ethiopia and Senegal, are currently being grown in glasshouses in Pretoria and will be screened against the field-collected eriophyid gall mites from Ethiopia over August–October 2017.

A colony of the gall thrips (*A. ebneri*) from Ethiopia has been established in quarantine at the Ecosciences Precinct. Life-cycle studies and host-specificity tests are in progress. Adult thrips feed on axillary and terminal buds and early signs of gall initiation become evident within a week. In the first week, the shoot-tips swell and turn red in colour. The gall continues to grow in size and in 3 weeks new nymphs are observed in the gall. After 4 weeks, the galls become inundated with new adults. Galls start turning black when mature and begin to die back. In quarantine, the gall thrips completed a generation in 4–5 weeks. To date, no-choice host-specificity tests have been conducted for 45 non-target test plant species (not all plants with 5 replications). So far, there is no evidence of gall induction or reproduction on any of the non-target test plant species tested.

Leaf-webber damage to prickly acacia

Collaborators

- A Balu, Institute of Forest Genetics and Tree Breeding (Coimbatore, India)
- Anthony King, Stefan Neser, Ayanda Nongogo and Charnie Craemer, ARC-PPRI (Pretoria, South Africa)
- Mindaye Teshome, Forestry Research Centre (Addis Ababa, Ethiopia)
- Nathalie Diagne, Senegalese Institute of Agricultural Research, Centre National de Researches Agronomique (Bambey, Senegal)
- Ocholi Edogbanya, Department of Biological Sciences, Ahmadu Bello University (Zaria, Nigeria)

Key publications

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

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

5. Biocontrol of invasive vines (*Dolichandra unguis-cati* and *Anredera cordifolia*)

Project dates

July 2001 – June 2020

Project team

K Dhileepan, Segun Osunkoya, Liz Snow, Kerri Moore (from January 2017) and Joshua Comrade Buru (PhD student, Queensland University of Technology, till October 2016)

Project summary

Cat's claw creeper and Madeira vine are Weeds of National Significance in Australia. Biocontrol is the most desirable option for managing for both weeds. Biocontrol of cat's claw creeper commenced in 2001 and, since then, three agents—a leaf-sucking tingid (*Carvalhotingis visenda)*, a leaf-tying moth (*Hypocosmia pyrochroma*) and a leaf-mining beetle (*Hedgwigiella jureceki*)—have been field released. Cat's claw creeper is a perennial vine with abundant subterranean tuber reserves, and so multiple agents attacking various parts of the plant are needed for effective control of the weed. Future research will focus on testing and releasing plant pathogens such as leaf-spot disease (*Cercosporella dolichandrae*), leaf rust (*Prospodium macfadyena*) and rust-gall (*Uropyxis rickiana*) in Australia. Biocontrol of Madeira vine commenced in 2008 and resulted in the release of one agent, a leaf-feeding beetle (*Plectonycha correntina*). There are no other prospective agents available for Madeira vine in the native range.

The leaf-sucking tingid

The tingid, field released in 72 sites from 2007 to 2011, has established widely and is causing visible damage in the field. Our focus is now on monitoring the persistence and damage levels of the tingids in selected release sites in south-eastern Queensland. Mass rearing and field release of the tingid is continued by various community groups and local governments in south-eastern Queensland and northern New South Wales.

The leaf-tying moth

The leaf-tying moth was field released in 40 sites from 2007 to 2011. Since 2012, release sites have been monitored for signs of field establishment of the moth. Evidence of field establishment was first seen in 2012 in two riparian sites (Boompa and Coominya) in south-eastern Queensland. The adults emerge in early summer (late December) and larval activity, as evident from leaf-tying, was first seen in mid-summer (mid-January). However, there was no evidence of larval activity from mid-autumn (April) onwards and, based on durations of larval activity in the field, it is thought that the moth undergoes just one generation in a year. This is in contrast to the thermal and CLIMEX model, which predicted more than two generations in a year. Since 2012, the moth has been spreading along the local creeks and established widely in areas surrounding the release site. To date, field establishment of the leaf-tying moth has been confirmed in four release sites (three riparian zones and one non-riparian zone) and 17 non-release sites (all in riparian zones). Monitoring of the spread and damage levels will continue.

The leaf-mining beetle

Field release of the leaf-mining beetle commenced in 2012 and 76 820 adults have been released over 140 sites, to date. This includes 1250 adults released at four sites during 2016–17. Mass rearing has largely finished, with a small colony being kept for supply to community groups who are currently involved with their own mass rearing and field release of the beetle. Many of the release sites have been revisited, and there was evidence of widespread establishment of the agent (as evident from the presence of adults and larval mines with developing larvae) in almost all release sites. Future research will focus on more systematic studies on monitoring the establishment, spread and damage levels of the beetle in selected release sites in south-eastern Queensland.

Leaf-spot disease

A leaf-spot pathogen (*Cercosporella dolichandrae*) causing necrotic spots and premature leaf abscission was observed in South Africa in 2012. The pathogen is highly host specific, is extremely virulent and is causing significant defoliation in cat's claw creeper in South Africa. In view of this, the leaf-spot pathogen has been prioritised as a prospective biological control agent for cat's claw creeper in Australia. The pathogen will be tested against Australian native test plant species in a quarantine facility at CABI in the United Kingdom, if funding is available. To establish a culture of the leaf-spot pathogen in quarantine, seeds of cat's claw creeper (from both long- and short-pod forms, from three sites each) were exported to the United Kingdom. Arrangements have also been made to export the leaf-spot pathogen from South Africa into the same quarantine facility to establish the pathogen there for host-specificity testing.

Leaf rust and rust-gall

Surveys in Brazil, Argentina and Paraguay identified two rust fungi, a rust-gall (*Uropyxis rickiana*) and a leaf rust (*Prospodium macfadyena*) as prospective biological control agents for cat's claw creeper in Australia. If funding is available, the two rust pathogens will be exported from Brazil to a quarantine facility at CABI in the United Kingdom, where tests on pathogenicity and host specificity of the pathogen will be conducted. Test plants for the host-specificity tests will be procured from Australia and exported to the United Kingdom.

Ecology of cat's claw creeper

In December 2016, Joshua Comrade Buru (PhD student, Queensland University of Technology) submitted his PhD thesis on morphological, ecophysiological and phenological variations between the two cat's claw creeper populations in Queensland. The PhD was awarded in April 2017.

Madeira vine leaf-feeding beetle

The Madeira vine leaf-feeding beetle (*Plectonycha correntina*) has been released at 86 sites in Queensland. The beetle has been seen widely in many of the release sites, but there is no evidence yet of any widespread damage and dispersal of the beetle in the field.

Collaborators

- Tanya Scharaschkin, Queensland University of Technology
- Anthony King, Plant Protection Research Institute (Pretoria, South Africa)
- Marion Seier and Kate Pollard, CABI, (United Kingdom)
- Robert Barreto, Universidade Federal de Viscosa (Brazil)

Key publications

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

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

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*, vol. 55, pp. 58–62.

Dhileepan, K, Snow, EL, Rafter, MA, McCarthy, J, Treviño, M & Wilmot Senaratne, KAD 2007, 'Leaf-tying moth *Hypocosmia pyrochroma* (Lepidoptera: Pyralidae), a host specific biological control agent for cat's claw creeper *Macfadyena unguis-cati* (Bignoniaceae) in Australia', *Journal of Applied Entomology*, vol. 131, pp. 564–568.

Dhileepan, K, Treviño, M & Snow, EL 2007, 'Specificity of *Carvalhotingis visenda* (Hemiptera: Tingidae) as a biocontrol agent for cat's claw creeper *Macfadyena unguis-cati* (Bignoniaceae) in Australia', *Biological Control*, vol. 41, pp. 282–290.

6. Biocontrol of parthenium (*Parthenium hysterophorus*)

Project dates

July 2004 – June 2019

Project team

K Dhileepan, Segun Osunkoya, Jason Callander, Christine Perrett, Kelli Pukallus and Judy Clark

Project summary

Parthenium (*Parthenium hysterophorus* L.), a noxious weed of grazing areas in Queensland, is a Weed of National Significance in Australia. Biocontrol of parthenium has been in progress since the mid-1980s. Eleven biological control agents (nine insect species and two rust pathogens) have been released against parthenium in Australia and all but one of these agents has become established in core parthenium-infested regions of central Queensland. Most of these agents have proven highly effective against the weed in central Queensland. To understand the spatial and temporal variations in the incidence and damage levels of various biological control agents, permanent sampling sites (three in northern Queensland and sixteen in central Queensland) are being surveyed annually in autumn.

Parthenium is spreading further south and is emerging as a serious weed in southern and south-eastern Queensland, where most biocontrol agents have not yet spread. Hence, a program to redistribute these agents from central Queensland to the south and south-east of the state has been initiated with funding from the Australian Government's Rural Research and Development for Profit program and Meat and Livestock Australia. Information on the population dynamics of parthenium in south-eastern Queensland is also needed, so the demography of parthenium (seedling emergence, establishment, growth, survival and fecundity, and the soil seed bank) and the incidence and efficacy of various biological control agents are being studied at two trial sites (Kilcoy and Helidon Spa) at monthly intervals. The size of the soil seed bank at the beginning (spring) and end (autumn) of the parthenium growing season is also being investigated.

Biocontrol agents in northern Queensland

Surveys were conducted at three sites (Plain Creek Station, Cardigan Station and Bivouac Junction) during April 2017. The stem-galling moth (*Epiblema strenuana*), the seed-feeding weevil (*Smicronyx lutulentus*), the stem-boring weevil (*Listronotus setosipennis*), the leaf-mining moth (*Bucculatrix parthenica*), the root-feeding clear-wing moth (*Carmenta ithacae*) and the sap-feeding planthopper (*Stobaera concinna*) were evident at all the sites, but their incidence levels varied widely between the three sites—there were very high levels of stem-galling moth at Plain Creek Station, very high levels of leaf-mining moth at Cardigan Station and very high levels of seed-feeding weevil at Bivouac Junction. The summer rust (*Puccinia xanthii* var. *parthenii-hysterophorae*) was found at Cardigan Station and Bivouac Junction, but not at Plain Creek Station. There was no evidence of the leaf-feeding beetle (*Zygogramma bicolorata*) or the winter rust (*Puccinia abrupta* var. *partheniicola*) at any of the sites.

Biocontrol agents in central Queensland

Field surveys and collections were conducted at 17 sites (Gracemere, Mount Hay, Wycarbah, Aphis Creek, Lotus Creek, Carfax, Clermont, Morebridge, Gaylong, Gordon Road, Sandhurst Bridge, Wyntoon, Old Orion Road, Rolleston, Consuelo, Mooleyember Creek and Hutton Creek) in October 2016 and in January, March and April 2017. The stem-galling moth and the leaf-mining moth were recovered at most of the sites surveyed, the seed-feeding weevil was recovered at 6 sites, the stem-boring weevil at 10 sites, the root-feeding clear-wing moth and the summer rust at 5 sites, and the leaf-feeding beetle at 1 site. However, the abundance of the agents varied seasonally. The winter rust was not seen in any of the sites, and not all of the sites surveyed had parthenium plants.

Biocontrol agent redistribution in southern Queensland

In consultation and collaboration with community groups and local governments, we selected 13 parthenium-infested sites for release of biological control agents. These included Cedar Vale, Kamarooka, Womillia Creek, Amby–Springfield Road and Bowood in southern Queensland and Kilcoy, Junction View, Helidon Spa, Somerset, Biggenden, Mundubbera, Cherbourg and Bundaberg in south-eastern Queensland. Field surveys conducted at these sites before any field releases found no evidence of the seed-feeding weevil, the stem-boring weevil, the root-feeding clear-wing moth or the summer rust.

To supplement field collections of biological control agents, the summer rust was mass-reared in glasshouse facilities at the Ecosciences Precinct. A glasshouse facility in Roma was recommissioned and refurbished in collaboration with the Queensland Murray–Darling Committee to provide a base of operations for rearing the summer rust closer to southern Queensland release sites. Both field-collected and glasshouse-reared agents were released throughout 2016–17.

Post-release surveys have indicated establishment of some of these agents. The winter rust has been recovered from Junction View, Kamarooka and Bowood. The summer rust was recovered at very high densities in Mundubbera and at low densities in Junction View. The stem-boring weevil was recovered in Kamarooka. The seed-feeding weevil is now prevalent in parthenium infestations in Biggenden, Mundubbera and Cherbourg as well as at Kamarooka and Cedar Vale.

Field ecological studies

We continued to monitor the population dynamics of parthenium weed at two sites (Helidon Spa and Kilcoy) in south-eastern Queensland. We examined the impact of parthenium weed on above-ground native species diversity and below-ground soil processes. Over two survey years (2014 and 2016), we sampled above ground and collected soils from 12 sites, which included sites invaded and not invaded by parthenium in cropping, grazing grassland and

riparian corridors. The data was analysed for differences in physicochemical and biotic contents.

Soil response to parthenium weed invasion varied significantly between years, regions, sites and land-use types (riparian corridor > grazing grassland ≥ cropping land), but invasion impact, except for above-ground standing vegetation diversity, was minimal. Overall, there was a tendency for increased major nutrients and microbial traits with parthenium invasion, but the differences were minimal and often non-significant due to a lack of consistency in the direction or magnitude of the impact. In 5 sites, the 95% confidence intervals of mean impact of the effect size estimates spanned both the null (no impact) and the rejection (there is impact) regions, indicating data insensitivity. Only in 1 site was the null hypothesis upheld, while for 6 of the remaining sites there was evidence to reject the null hypothesis of no invasion impact, but direction varied significantly. In contrast, there was a clear negative impact of parthenium weed invasion on above-ground plant species diversity, irrespective of land-use type.

The impact of parthenium invasion on soil processes appears to depend on context and trait of interest, and the magnitude and/or direction of weed invasion is affected by complex interactions among environmental factors that might change across invaded habitats and survey periods, perhaps making broad generalisations uninformative for soil management.

Spreading parthenium rust at a field site in south-eastern Queensland

Collaborators

- Steve Adkins, The University of Queensland
- Rachel McFadyen (St George)
- S Raghu, CSIRO Ecosystem Dynamics
- Tom Garrett and Holly Hosie, Queensland Murray–Darling Committee
- Ross Bigwood and Michelle Field, SEQ Catchments
- Bruce Lord, Healthy Waterways and Catchments
- Ross Perry and Pat Ryan, Junction View Pest Management Group
- Glen Proctor, North Burnett Regional Council
- Eric Dyke, Bundaberg Regional Council
- Stephen Downey, Biosecurity Queensland
- Trevor Armstrong, Oxley Creek Catchment Association
- Femi Akinsami, The University of Queensland and Queensland Alliance for Agriculture and Food Innovation

Key publications

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

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

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

7. Biocontrol of calotrope (*Calotropis procera*)

Project dates

July 2016 – June 2019

Project team

K Dhileepan, Di Taylor and Wilmot Senaratne (till December 2016)

Project summary

Calotropis procera (Apocynaceae), commonly known as calotrope or rubber bush, is a major environmental and rangeland weed of Australia. The weed forms dense thickets that compete with native plant species, reduce livestock-carrying capacity, increase mustering costs (due to inaccessibility) and transform the appearance of savannah plant communities in northern Australia. It is also a weed of disturbed sites, roadsides, waste areas, riparian situations, coastal sand dunes, grasslands, open woodlands and pastures of northern Australia. The weed has the potential to spread throughout most of northern Australia. Extensive infestations of *C. procera* occur in semi-arid parts of northern Queensland, particularly in the Gulf of Carpentaria and in the Gulf Islands. Current control options for *C. procera* in Australia include mechanical, chemical, fire and pasture management, but they are often not economical. Biocontrol is the most cost-effective and best long-term management option for large infestations of *C. procera* in Australia. This is the first time that biological control of *C. procera* has been attempted anywhere in the world.

Native range studies

C. procera is a native of North Africa, the Middle East and the Indian subcontinent. The fruit characteristics of *C. procera* in Australia are more like those of *C. procera* in southern Asia (e.g. India) than those of *C. procera* in Africa and the Arabian Peninsula. Field surveys in India, Pakistan (of *C. procera* and *C. gigantea*) and Sri Lanka (of *C. gigantea*) in the native range highlighted that these *Calotropis* species share a common phytophagous insect fauna and set of diseases. About 65 species of insects and 5 species of mites have been documented on *C. procera* and *C. gigantea* in the native range. Two pre-dispersal seed predators in the Indian subcontinent—the Aak weevil (*Paramecops farinosus*) and the Aak fruit fly (*Dacus persicus*)—have been identified as prospective biological control agents based on their field host range and damage potential.

Two PhD candidates are conducting research on two prospective biological control agents for *C. procera* in Pakistan and Sri Lanka. In Pakistan, Shahid Ali is investigating the incidence, damage levels and field host range of the Aak weevil and Aak fruit fly on *C. procera*. In Sri Lanka, Nisha Wijeweera is investigating the incidence, seasonal abundance and damage levels of the Aak weevil and the Aak fruit fly on *C. gigantea*.

Australian studies

Potted *C. procera* plants raised from field-collected seeds have been established in the greenhouse at the Ecosciences Precinct. However, flowering was evident only seasonally and there were no fruit set. As the two prioritised agents are fruit/seed-feeding insects, a continuous supply of *C. procera* plants with various growth stages of fruits are needed to maintain colonies of both Aak weevil and Aak fruit fly. Attempts to hand pollinate the flowers were not successful. Because *C. procera* is an insect-pollinated plant (mainly by carpenter bees), potted flowering *C. procera* plants were exposed to honey bees on a private property with honey bee hives in an attempt to stimulate pollination, but none occurred. Future research will focus on refining hand-pollination methods, and also exposing flowering *C. procera* plants to areas with carpenter bees. The two biocontrol agents can be imported into quarantine only when the difficulties with pollination are resolved.

Aak weevil larval damage to *Calotropis procera* fruit in Pakistan

Collaborators

- A Balu, Institute of Forest Genetics and Tree Breeding (Coimbatore, India)
- Asad Shabbir and Shahid Ali, Punjab University (Lahore, Pakistan)
- Kumudu De Silva and Nisha Wijeweera, University of Ruhuna (Matara, Sri Lanka)

Key publications

Dhileepan, K 2014, 'Prospects for the classical biological control of *Calotropis procera* (Apocynaceae) using coevolved insects', *Biocontrol Science and Technology*, vol. 24, no. 9, pp. 977–998.

Campbell, S, Roden, L & Crowley, C 2013, 'Calotrope (*Calotropis procera*): a weed on the move in northern Queensland', *Weeds–everyone's business: proceedings of the 12th Queensland symposium*, pp. 11–14.

Grace, BS 2009, '*Calotropis procera* (Aiton) WT Aiton', *The biology of Australian weeds*, vol. 3, pp. 59–70.

8. Biocontrol of chinee apple (*Ziziphus mauritiana*)

Project dates

July 2016 – June 2019

Project leader

K Dhileepan

Project summary

The tropical fruit tree *Ziziphus mauritiana* (Rhamnaceae), known as chinee apple, is a pasture and environmental weed in northern Queensland. It is a fast-growing, long-lived, spiny tree growing up to 15 m high, with a spreading crown and drooping branches. In Australia, *Z. mauritiana* has no commercial value and is not in cultivation. The thorny tree forms dense thickets that reduce livestock-carrying capacity (through loss of pasture cover), impede mustering, inhibit access by livestock to water and change the structure of native vegetation. Over the long term, the weed could spread over large areas of the Wet Tropics, Dry Tropics and semi-arid regions of northern Australia. The weed is extremely fire tolerant and current management options are restricted to the use of chemicals and machinery, which are expensive. There are no major natural enemies (pests and diseases) of the weed in Australia. A classical biological control approach incorporating specialist natural enemies from the native range would help reduce plant vigour, seed output and seedling establishment in new areas. Classical biological control is the most cost-effective option for the long-term management of *Z. mauritiana* and would complement the existing management options. This is the first time that biological control for *Z. mauritiana* has been attempted anywhere in the world.

Native range studies

Z. mauritiana, a native of the Indian subcontinent, is a tropical and evergreen multipurpose tree cultivated extensively as a horticultural crop for fruit. There are more than 170 *Z. mauritiana* cultivars in India, and they vary widely in the size and shape of the tree, leaf shape, fruiting season and fruit form, size, colour, flavour and keeping quality. Wild *Z. mauritiana* also occurs widely throughout the Indian subcontinent. Since 2010, opportunistic surveys have been conducted on wild *Z. mauritiana* and other wild *Ziziphus* species (e.g. *Z. nummularia* and *Z. oenoplia*) along roadsides, in national parks and in wasteland in India and Sri Lanka.

A total of 138 species of insects and 12 species of mites have been documented as feeding on *Ziziphus* species in their native range. Based on field host range and host records, a seed-feeding weevil (*Aubeus himalayanus*), a leaf-feeding gracillariid moth (*Phyllonorycter iochrysis*), a leaf-mining chrysomelid beetle (*Platypria erinaceus*), a leaf-folding crambid moth (*Synclera univocalis*), a leaf-galling midge (*Phyllodiplosis jujubae*) and two gall mites (*Aceria cernuus* and *Larvacarus transitans*) have been identified as prospective biological control agents.

In the native range, *Ziziphus* species are affected by several economically important diseases. Among them, the leaf rust (*Phakopsora zizyphi-vulgaris*) and the powdery mildew (*Pseudoidium ziziphi*) have host records restricted to *Ziziphus* species. The host range of the leaf rust includes many *Ziziphus* species, including *Z. oenoplia*, which is native to India and Australia, and so would not be a suitable biological control agent in Australia. However, the powdery mildew has not been reported on *Z. oenoplia*, but has been reported on more

than one *Ziziphus* species (*Z. mauritiana* and *Z. nummularia*) in the native range. Therefore, the non-target risk to the two Australian native *Ziziphus* species (*Z. quadrilocularis* and *Z. oenoplia*) needs to be resolved before the powdery mildew could be considered as a prospective biological control agent for *Z. mauritiana* in Australia.

All available information on the pests and diseases of *Z. mauritiana* is from cultivated varieties. Future surveys should focus on wild *Z. mauritiana* in the Indian subcontinent in areas that are climatically similar to the regions of northern Australia where it is currently most abundant.

Ziziphus mauritiana fruit in India

Collaborators

- A Balu, Institute of Forest Genetics and Tree Breeding (Coimbatore, India)
- Asad Shabbir, Punjab University (Lahore, Pakistan)

Key publications

Bebawi, FF, Campbell, SD & Mayer, RJ 2016, 'Seed bank persistence and germination of chinee apple (*Ziziphus mauritiana* Lam.)', *Rangeland Journal*, vol. 38, pp. 17–25.

Grice, AC 2009, '*Ziziphus mauritiana* Lam.', in FD Panetta (ed), *The biology of Australian weeds*, vol. 3, RG & FJ Richardson, Meredith, Australia, pp. 294–316.

9. Biocontrol of parkinsonia (*Parkinsonia aculeata*)

Project dates

March 2013 – September 2018

Project team

Kelli Pukallus, Judy Clark, Joshua Nicholls, Dannielle Brazier and Centaine Ferris

Project summary

This collaborative project with CSIRO, supported by funding from the Australian Government and Meat and Livestock Australia, involves the mass rearing, releasing and monitoring of *Eueupithecia cisplatensis* (UU) for the biological control of parkinsonia (*Parkinsonia aculeata*) within Queensland. UU, a leaf-feeding geometrid caterpillar from Argentina, defoliates the leaflets, causing the plant to weaken and reduce flower and seed production.

The Tropical Weeds Research Centre started releases in early 2013 at sites in Queensland encompassing the Burdekin, Whitsunday, Isaac, Central Highlands, Flinders, Cloncurry, McKinlay, Charters Towers and Townsville local government areas. Releases commenced into the Northern Territory and Western Australia in late 2016. Overall, releases of UU have been made at 87 sites and the Tropical Weeds Research Centre has released more than 3200 adults, 255 790 pupae and 481 380 larvae/eggs to date. Release sites cover various terrains and climatic conditions (from inland, dry, open woodlands to coastal riparian areas), and include private grazing properties, national parks, local government land reserves and mining leases.

Establishment has been noted at numerous release sites within northern and central Queensland. Since being released, UU has spread further afield. It has been located over 20 km from the nearest release site, and in most cases has spread over 5 km. Populations have persisted throughout all seasons.

Collaborators

- Raghu Sathyamurthy, Gio Fichera and Andrew White, CSIRO (Brisbane)
- Burdekin Shire Council
- Isaac Regional Council
- Central Highlands Regional Council
- Charters Towers Regional Council
- Townsville City Council
- Capricorn Catchments Inc.
- Fitzroy Basin Association Inc.
- CHHRUP (Emerald)
- Department of Agriculture and Fisheries and Queensland Parks and Wildlife Service regional staff
- Western Australia Department of Agriculture and Food
- Northern Territory Department of Land Resource Management

10. Biocontrol of *Mikania micrantha*

Project dates

July 2014 – June 2018

Project team

Michael Day, Natasha Riding and Wilmot Senaratne (until December 2016)

Project summary

Mikania micrantha was first reported in Queensland in 1998 and is also present in the Australian territories of Christmas Island and Cocos Island. In Queensland, the weed is the target of a national cost-shared eradication program. However, cyclones have hampered the eradication program and the latest review of the program suggested that biocontrol options should be investigated.

The rust *Puccinia spegazzinii* is deemed host specific, having been tested in five countries against a total of 273 species, representing 73 families, including 87 species in the Asteraceae family, 21 species in the Eupatorieae family and 11 species of *Mikania*. The rust was subsequently released in India, China, Taiwan, Papua New Guinea (PNG), Fiji, Vanuatu, the Cook Islands and more recently Palau. It has established in Taiwan,

PNG, Fiji and Vanuatu. It has also been reported in the Solomon Islands, although there had been no deliberate release there. It is too early to confirm establishment in Cook Islands.

In PNG, field monitoring and laboratory trials shows the rust suppresses the growth of mikania. In both PNG and Vanuatu, where it has been widely released, anecdotal information suggests that mikania is being suppressed and its flowering reduced. The rust was imported into quarantine at the Ecosciences Precinct and was tested against 14 species in the tribe Eupatorieae and 6 species in the tribe Heliantheae. Pustule development and infection only occurred on mikania and no other plant species was affected. An application seeking its release will be submitted to the federal Department of Agriculture and Water Resources and the federal Department of the Environment and Energy.

Collaborators

- CABI (United Kingdom)
- Biosecurity Vanuatu
- Ministry of Natural Resources (Palau)
- National Agricultural Research Institute (PNG)
- National Agriculture Quarantine and Inspection Authority (PNG)
- Yunnan Academy of Agricultural Sciences (China)
- Kerala Forest Research Institute (India)

Key publications

Day, M 2012, '*Mikania micrantha* Kunth—mile-a-minute', in M Julien, R McFadyen & J Cullen (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne, pp. 368–372.

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

Day, MD, Kawi, AP & Ellison, CA 2013, 'Assessing the potential of the rust fungus *Puccinia spegazzinii* as a classical biological control agent for the invasive weed *Mikania micrantha* in Papua New Guinea', *Biological Control*, vol. 67, pp. 253–261.

Day, MD, Kawi, AP, Fidelis, J, Tunabuna, A, Orapa, W, Swamy, B, Ratutini, J, Saul-Maora, J & Dewhurst, CF 2013, 'Biology, field release and monitoring of the rust *Puccinia spegazzinii* de Toni (*Pucciniales: Pucciniaceae*), a biocontrol agent of *Mikania micrantha* Kunth (Asteraceae) in Papua New Guinea and Fiji', *Proceedings of the XIII international symposium on biological control of weeds*, Forest Health Technology Enterprise Team, Morgantown, West Virginia, pp. 211–217.

11. Biocontrol of *Cylindropuntia* spp.

Project dates

March 2009 – June 2018

Project team

Michael Day, Peter Jones, Anna Williams, Kerri Moore and Wilmot Senaratne (until December 2016)

Project summary

The cacti *Cylindropuntia* spp. are native to tropical America. The group includes *Cylindropuntia kleiniae* and *C. leptocaulis* (both of which are prohibited weeds in Queensland), and *C. fulgida, C. imbricata, C. pallida, C. prolifera, C. spinosior* and *C. tunicata* (which are restricted weeds in Queensland). A biotype of *Dactylopius tomentosus* was released in Australia in 1925 to control *C. imbricata*, but this biotype does not heavily impact other *Cylindropuntia* species.

The *D. tomentosus* ('cholla' biotype), which proved very effective in South Africa, was introduced into quarantine in Brisbane and, following additional testing, was approved for field release against *C. fulgida* in December 2015. To date, it has been released at over 20 sites in Queensland, New South Wales, South Australia and Western Australia and has established at 8 sites. Near Longreach, it has infested 90% of plants in the monitoring site and spread up to 120 m in 12 months.

Four additional biotypes were collected from the United States in 2012 and tested in quarantine facilities. Applications seeking approval for their release against several other species of *Cylindropuntia* have been submitted to the federal Department of Agriculture and Water Resources. Host-specificity testing on a further 14 biotypes collected from the United States and Mexico in 2015 to target *C. prolifera* and *C. spinosior* are underway. An application seeking approval to release one of these bioytpes has been prepared and is currently being reviewed internally.

Dactylopius on *C. fulgida*, Leander nursery site, January 2017

Dactylopius on *C. fulgida*, Leander nursery site, April 2017

Hudson pear (*Cylindropuntia rosea*)

Inspecting *Dactylopius tomentosus* on coral cactus near Longreach

Collaborators

- New South Wales Department of Primary Industries
- Dr Helmuth Zimmermann (South Africa)
- Local governments in central and western Queensland
- Desert Channels Queensland
- Southern Gulf NRM
- South West NRM
- New South Wales Environmental and Aquatic Weeds Biocontrol Taskforce
- Western Australia Department of Agriculture and Food

Key publications

Holtkamp, RH 2012, '*Cylindropuntia imbricata* (Haw.) F. M. Knuth—rope pear *Cylindropuntia rosea* (DC.) Backeb.—Hudson pear', in M Julien, R McFadyen & JM Cullen (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne, pp. 198–202.

Mathenge, CW, Holford, P, Hoffmann, JH, Spooner-Hart, R, Beattie, GAC & Zimmermann, HG 2009, 'The biology of *Dactylopius tomentosus* (Hemiptera: Dactylopiidae)', *Bulletin of Entomological Research*, vol. 99(6), pp. 551–559.

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

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

12. Biocontrol of *Lantana camara*

Project dates

July 1996 – June 2018

Project team

Michael Day, Natasha Riding, Kelli Pukallus and Judy Clark

Project summary

Lantana is a major weed of grazing, forestry and conservation areas. It is found throughout coastal and subcoastal areas of eastern Australia, from the Torres Strait Islands in the north to the Victorian border in the south. Lantana can be controlled using chemicals, machinery and fire, but some of these methods are not suitable in forestry or conservation areas or are not cost-effective. Biocontrol is seen as the only viable option in many areas.

Although biocontrol has been in progress in Australia since 1914, recent research has emphasised the need to target agents that damage specific parts of the plant or are suited to the different climatic areas in which lantana grows. This project aims to improve biocontrol of lantana in Queensland through active collaboration with the Plant Protection Research Institute in South Africa, CABI in Europe and the United Kingdom, the New South Wales Environmental and Aquatic Weeds Biocontrol Taskforce and local councils and Landcare groups.

Host-specificity testing of the rust *Puccinia lantanae* by CABI has been completed, with pustules developing on two taxa, *Verbena officinalis* var. *gaudichaudii* and *Verbena officinalis* var. *africana*. However, infection is significantly lower than that which occurred on *L. camara*, and populations could not be maintained on either taxon. An application to the federal government seeking its release is being prepared.

The budmite *Aceria lantanae* has been widely field released. However, populations have persisted at only a few sites around south-eastern Queensland and the budmite is present in northern Queensland at only 5 sites—Kuranda, Cardstone, Cape Cleveland, Charters Towers and Crimea (along the Flinders Highway)—all some kilometres from the nearest release site. Field releases of the budmite are continuing. *Falconia intermedia* continues to spread on the Atherton Tableland, causing substantial damage to both pink-edged red and pink flowering plants.

Collaborators

- CABI (Europe and United Kingdom)
- Plant Protection Research Institute (South Africa)
- New South Wales Environmental and Aquatic Weeds Biocontrol Taskforce
- Queensland Parks and Wildlife Service and Department of Agriculture and Fisheries regional staff
- Local governments in coastal and subcoastal Queensland

Key publications

Day, M 2012, '*Lantana camara* L.—lantana', in M Julien, R McFadyen & J Cullen (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne, pp. 334–346.

Day, MD, Broughton, S & Hannan-Jones, MA 2003, 'Current distribution and status of *Lantana camara* and its biological control agents in Australia, with recommendations for further biocontrol introductions into other countries', *Biocontrol News and Information*, vol. 24(3), pp. 63N–76N.

Day, MD, Wiley, CJ, Playford, J & Zalucki, MP 2003, *Lantana: current management status and future prospects*, Australian Centre for International Agricultural Research, Canberra.

13. Biocontrol of *Chromolaena odorata*

Project dates

July 2011 – June 2018

Project team

Michael Day, Natasha Riding and Wilmot Senaratne (until December 2016)

Project summary

Chromolaena odorata was first reported in Queensland in 1994 and is also present in the Australian territories of Christmas Island and Cocos Island. It was the target of a national cost-shared eradication program until 2013. However, it was approved as a target for biocontrol in 2011, following several reviews of the program. The gall fly *Cecidochares connexa* is deemed host specific, having been tested in 7 countries against a total of 122 species, representing 31 families and including 38 species in the Asteraceae family, of which 6 were in the tribe Eupatorieae.

The gall fly was subsequently released in 12 countries, including Papua New Guinea, Indonesia, Micronesia and Timor Leste, where it is controlling or aiding the control of *C. odorata*. It was imported into quarantine at the Ecosciences Precinct in February 2012 and testing against Eupatorieae species commenced immediately. We tested 18 Eupatorieae species in 'choice minus the host plant' trials, with some larvae completing development to adult on *Praxelis clematidea*. We conducted further tests to determine whether populations of the gall fly can be sustained on *P. clematidea* and whether the gall fly shows a preference between *Chromolaena* and *P. clematidea*. Tests showed that development was poor on *P. clematidea* and populations could not be sustained. Furthermore, field observations in Palau found no gall formation on *P. clematidea*.

An application seeking its release was submitted to the former Australian Quarantine Inspection Service in April 2015. Its release was supported by all but one reviewer, who suggested testing on additional, less closely related species. A response was sent to the federal Department of Agriculture and Water Resources in April 2016 arguing against the extra testing. We are awaiting a final decision from the department.

Collaborators

- National Agricultural Research Institute (Papua New Guinea)
- National Agriculture Quarantine and Inspection Authority (Papua New Guinea)
- Bureau of Agriculture (Palau)

Key publications

Day, MD, Bofeng, I & Nabo, I 2013, 'Successful biological control of *Chromolaena odorata* (Asteraceae) by the gall fly *Cecidochares connexa* (Diptera: Tephritidae) in Papua New Guinea', *Proceedings of the XIII international symposium on biological control of weeds*, Forest Health Technology Enterprise Team, Morgantown, West Virginia, pp. 400–408.

Day, MD, Brito, AA, da Costa Guterres, A, da Costa Alves, AP, Paul, T & Wilson, CG 2013, 'Biocontrol of *Chromolaena odorata* in Timor Leste', *Proceedings of the eighth international workshop on biological control and management of* Chromolaena odorata *and other Eupatorieae*, ARC-PPRI, Pretoria, pp. 134–140.

Day, M & McFadyen, RC 2012, '*Chromolaena odorata* (L.) King and Robinson—chromolaena', in M Julien, R McFadyen & J Cullen (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne, pp. 162–169.

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

14. Biocontrol of mother-of-millions

Project dates

January 2017 – June 2020

Project team

Michael Day and Natasha Riding

Project summary

Mother-of-millions (*Bryophyllum* spp.) is native to Madagascar and has become a major weed in Queensland and northern New South Wales. Earlier work found four potential agents in Madagascar, and host-specificity testing was conducted on two of these species. These attacked closely related plants in several genera, including *Kalanchoe*, which are ornamentals. A decision was made to apply for the field release of one agent, *Osphilia tenuipes*, through the federal *Biological Control Act 1984*, where costs and benefits of the release can be openly considered. If a release is approved, governments have legal protection if there is negative impact. Populations of the two insects (including *O. tenuipes*) held in quarantine for 10 years were culled while the application was being processed.

A 4-year project to explore biocontrol options for mother-of-millions in Madagascar has been funded under the Australian Government's Rural Research and Development for Profit program in partnership with the Rural Industries Research and Development Corporation (now trading as AgriFutures Australia) and other stakeholders. Under this proposal,

O. tenuipes was collected from Madagascar and imported into a quarantine facility in Orange, New South Wales, where additional host-specificity testing will be conducted. Consequently, the application seeking its approval through the Biological Control Act has been postponed until the extra testing is completed. Other potential agents from Madagascar will be collected and imported into the quarantine facility at the Ecosciences Precinct for host-specificity testing.

Collaborators

- New South Wales Department of Primary Industries
- University of Antananarivo (Madagascar)
- Rural Industries Research and Development Corporation (now trading as AgriFutures Australia)
- Local government and NRM groups

Key publications

Palmer, B & Rafter, M 2012, '*Bryophyllum delagoense* (Ecklon & Zeher) Schinz—mother-of-millions', in M Julien, R McFadyen & J Cullen (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne, pp. 99–107.

Palmer, W & Senaratne, K 2016, 'Assessment of a stenophagous weevil, *Osphilia tenuipes* (Coleoptera: Curculionidae), as a potential biological control agent for weedy *Bryophyllum* spp. (Crassulaceae) in Australia', *Biological Control*, vol. 100, pp. 101–107.

Witt, ABR, McConnachie, AJ, Palmer, WA & Grobbelaar, E 2006, 'Distribution, biology and host range of *Rhembastus* sp. (Coleoptera: Chrysomelidae), a candidate for the biological control of *Bryophyllum delagoense* (Crassulaceae) in Australia', *Biocontrol Science and Technology*, vol. 16, no. 8, pp. 859–869.

15. Biocontrol of giant rat's tail grass

Project dates

January 2017 – June 2020

Project team

Michael Day and Natasha Riding

Project summary

Giant rat's tail grass is the common name for the species *Sporobolus pyramidalis* and *S. natalensis*, which are major weeds in coastal Queensland and northern New South Wales. Current control efforts for weedy *Sporobolus* grasses centre on the use of chemical, mechanical, plant-competition and pasture management. However, control has proved elusive, and weedy *Sporobolus* grasses continue to rapidly spread into new areas. A biocontrol project was implemented in the 1990s but did not result in the release of any biocontrol agents. More recently, biological control has focused on the indigenous fungus *Nigrospora oryzae*, but it does not appear to be as damaging to giant rat's tail grasses as it is to giant Parramatta grass. A 4-year project funded under the Australian Government's Rural Research and Development for Profit program is exploring options for biocontrol in South Africa. Following an initial visit to South Africa to establish links with Rhodes University, a contract was established. Field-monitoring protocols have been developed and the first surveys have been conducted. All insects collected have been curated.

Collaborators

- New South Wales Department of Primary Industries
- Rhodes University (South Africa)
- Rural Industries Research and Development Corporation (now trading as AgriFutures Australia)
- Bundaberg Regional Council
- Gladstone Regional Council
- HQPlantations
- Local governments in coastal and subcoastal Queensland

Key publications

Palmer, B 2012, '*Sporobolus* spp.—weedy *Sporobolus* grasses', in M Julien, R McFadyen & J Cullen (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne, pp. 569–575.

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

Witt, ABR & McConnachie, AJ 2004, 'The potential for classical biological control of invasive grass species with special reference to invasive *Sporobolus* spp. (Poaceae) in Australia', *XI international symposium on biological control of weeds*, CSIRO Entomology, Canberra, pp. 198–202.

16. Control and ecology of *Stevia ovata*

Project dates

July 2012 – June 2018

Project team

Melissa Setter, Stephen Setter and Simon Brooks

Project summary

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

A working group of stakeholders—including local government, state government, energy companies and landholders—requested research into herbicide control of candy leaf, along with studies to determine its ecology. Research into the following aspects has been completed:

- germination requirements
- reproductive maturity
- seed longevity in soil (in Wet Tropics and Dry Tropics of northern Queensland)
- seed longevity in water
- pilot herbicide screening
- herbicide screening
- herbicide rate refinement
- low-volume, high-concentration herbicide technique.

A pre-emergent herbicide trial was established on pots containing seeds of candy leaf. Fourteen herbicides are being tested for possible use across different agricultural, amenity and environmental land uses.

Collaborators

- *Stevia ovata* stakeholder group (includes community members, energy companies and local council)
- Biosecurity officers
- Biosecurity Queensland research officers and centres
- Far North Queensland Regional Organisation of Councils
- Tablelands Regional Council
- Terrain NRM

Key publication

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

17. Sicklepod ecology and control

Project dates

January 2016 – June 2021

Project team

Melissa Setter and Stephen Setter

Project summary

Sicklepod (*Senna obtusifolia*) is a serious weed of many parts of northern Queensland (from Cape York to Mackay) and occurs in pastures, crops and corridors such as road and powerline clearings and creek banks. In this project, we aim to improve management tools for sicklepod by investigating three areas.

Seed longevity and production

We plan to substantiate some of the ecological information currently being used, in particular the longevity of the seed bank under a range of local environmental conditions, which can greatly influence management decisions. We will also investigate reproductive characteristics such as timing of and age to seeding.

Pre-emergent herbicide efficacy

A number of post-emergent herbicide control options are available for sicklepod; however, regional stakeholders have specifically requested that pre-emergent herbicide options be investigated. This is because sicklepod has a relatively short life cycle that occurs during the wet season, when access to plants can be limited. To optimise the effect of pre-emergent residual herbicides, we will investigate the seasonality of seed production and environmental triggers for germination (rainfall and temperature) relative to local conditions.

Low-volume, high-concentration herbicide application

These techniques are particularly suitable for areas with poor vehicle accessibility, and we will test several selected herbicides and possibly different application equipment for their efficacy on sicklepod.

Collaborators

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

18. Aquatic weeds of northern Australia—ecology and control

Project dates

January 2015 – June 2020

Project team

Melissa Setter and Stephen Setter

Project summary

Aquatic weeds are a burgeoning problem with the increase in commercial trade of aquatic plants, particularly via the internet. Several escaped aquarium plants are particularly problematic in the Wet Tropics, and have potential distributions across large parts of northern Australia. These include hygrophila (*Hygrophila costata*), bogmoss (*Myacca fluviatilis*) and Amazonian frogbit (*Limnobium laevigatum*). This project proposes to answer specific ecological questions to improve management of current infestations and predict/restrict further infestations. Control options will also be investigated.

Specifically, research is currently planned into:

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

Other species and activities may be incorporated if the need arises.

During 2016–17, research into the potential dispersal of stem fragments of hygrophila via water was undertaken. Stem fragments were able to float and survive for 3 weeks in fresh or brackish water and 2 weeks in salt water, demonstrating the potential for dispersal via this pathway.

Sampling *Hygrophila costata*

Collaborators

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

19. Water weed management research

Project dates

October 2010 – June 2020

Project team

Tobias Bickel, Christine Perrett, Joseph Vitelli, and Yang Dai and Xu Junfeng (The University of Queensland)

Project summary

Aquatic weed management is frequently hampered by a lack of suitable control options. In particular, there are few registered herbicides. This project supports registration of the new herbicide flumioxazin through experimental work.

We investigated dose–response relationships to identify the minimum application rates of flumioxazin needed to control cabomba and sagittaria while reducing non-target impacts. Flumioxazin was able to control 96% of cabomba biomass at a 5 ppb ai (parts per billion active ingredient) subsurface application, with 100% control achieved at rates above 10 ppb. The native ribbon weed was not affected at these low herbicide concentrations. However, for satisfactory sagittaria control, doses of 200 ppb were needed.

We also measured the minimum light levels necessary for efficient aquatic weed control. Light availability (0–98% shade) did not affect cabomba control at 200 ppb, but shading delayed time to death (15 days at 0% shade to 30 days at 98% shade). Sagittaria control was more efficient in high light (0–30% shade) but, irrespective of shading, the plants regenerated from tubers in the substrate.

Flumioxazin will be an excellent tool. It enables cabomba control at extremely low application rates, and its efficacy is affected only slightly by environmental variables. Future research will establish improved sagittaria management solutions.

Collaborators

- The University of Queensland
- CSIRO
- Sumitomo Chemical
- Seqwater
- Macspred
- Brisbane City Council
- Noosa and District Landcare
- Department of Economic Development, Jobs, Transport and Resources (Victoria)
- New South Wales Department of Primary Industries
- Griffith University
- NIWA

Key publications

Bickel, TO 2017, 'Processes and factors that affect regeneration and establishment of the invasive aquatic plant *Cabomba caroliniana*', *Hydrobiologia*, vol. 788, no. 1, pp. 157–168.

Bickel, TO, Perrett, C & Vitelli, J 2016, *Effect of pH and application mode on herbicide X efficacy to control aquatic plants*, Project report to Sumitomo Inc., 26 pp.

Bickel, TO 2015, 'A boat hitchhiker's guide to survival: *Cabomba caroliniana* desiccation resistance and survival ability', *Hydrobiologia*, vol. 746, pp. 123–134.

20. Giant rat's tail grass management

Project dates

July 2016 – June 2020

Project team

Wayne Vogler and Kelsey Hosking

Project summary

The project is being conducted in conjunction with Gladstone Regional Council and Economic Development Queensland to address difficulties in managing giant rat's tail grass. The results should have broad application across most management situations. Small-scale plot trials and larger paddock trials will be conducted over a number of years to find out more about the use of flupropanate, the effective use of fertilisers, the effects of fire on flupropanate and management of giant rat's tail grass in seasonally wet areas.

Spraying giant rat's tail grass with herbicide

Collaborators

- Economic Development Queensland, Department of Infrastructure, Local Government and Planning
- Biosecurity officers
- Gladstone Regional Council
- Landholders

21. Ecology and management of *Chromolaena odorata* and *Clidemia hirta*

Project dates

July 2008 – June 2018

Project team

Simon Brooks, Kirsty Gough, Stephen Setter, Shane Campbell and Melissa Setter

Project summary

The project supports a range of stakeholders who are managing the former eradication targets *Chromolaena odorata* (Siam weed) and *Clidemia hirta* (Koster's curse). Information comes from local trials investigating seed-bank longevity, seed-bank depletion, age to maturity, germination requirements and herbicide efficacy.

During 2016–17, a pre-emergent herbicide trial was established on pots containing seeds of *C. odorata*. Fourteen herbicides are being tested for possible use across different agricultural, amenity and environmental land uses.

Seeds of both species have been included in burial trials to determine the longevity of soil seed banks. A small amount of viable *C. odorata* seed was retrieved from a trial in the Dry Tropics after 7 years of burial in four different soil types; however, no viable seed was found in samples taken after 6 years. Retrievals of *C. hirta* seeds buried in the Wet Tropics reinforces field experiences that this species develops a persistent soil seed bank, as around 30% of surface seed and buried seed was viable after 6 years of burial. Field samples have demonstrated that *C. hirta* develops a dense and persistent soil seed bank down to 15 cm.

Collaborators

- Biosecurity Queensland officers
- Queensland Parks and Wildlife Service
- Mareeba and Johnstone shire councils
- Mitchell River Watershed Management Group

Key publications

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

Brooks, 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*, vol. 29(2), pp. 71–77.

22. Eradication progress and biology of tropical weed eradication targets

Project dates

July 2008 – June 2018

Project team

Simon Brooks, Kirsty Gough, Shane Campbell, Stephen Setter and Melissa Setter

Project summary

This project determines the key biological parameters influencing the field operations of the tropical weeds eradication programs, such as seed-bank persistence, age to maturity and dispersal potential. The project also assesses control measures for these weeds and develops and refines measures of eradication progress, which is critical for interpreting field data and guiding future operations.

Field trials investigating seed persistence of *Miconia calvescens, M. racemosa, M. nervosa* and *Mikania micrantha* have been running for 3 to 6 years (depending on the species). A glasshouse trial of *Limnocharis flava* seed persistence under varying periods of immersion in water has been underway for 5 years now, with the driest annual treatments starting to exhibit lower seed viability. Annual field sampling of seed-bank persistence of *L. flava* has also been conducted at two sites since 2003 and 2015. With all species showing persistent seed banks, this project will continue researching options for in-situ depletion.

Field crew data and observations on the growth to maturity and reproductive seasonality of invasive melastomes are being collated to refine guidelines for identifying and preventing seed-producing plants and assessing survey accuracy. The botanical concept of a 'threshold size' at which plants may be mature is being investigated for each *Miconia* species; the proportion of mature plants increases above the threshold.

Collaborators

- National Tropical Weeds Eradication Program
- Biosecurity officers (north region)

Key publications

Weber, JM and Brooks, SJ 2013, 'The biology of Australian weeds 62. *Limnocharis flava* (L.) Buchenau', *Plant Protection Quarterly*, vol. 28(4), pp. 101–113.

23. War on northern invasive weeds

Project dates

July 2016 – June 2018

Project team

Wayne Vogler and Kelsey Hosking

Project summary

Spray misting of fluroxypyr (Starane Advanced®) has been established as a control option for prickly acacia regrowth. A minor use permit (PER82366) for spray misting of prickly acacia was approved by the Australian Pesticides and Veterinary Medicines Authority (APVMA) in early July 2016.

Fact sheets on heli-drop, spray misting and seed movement by cattle are published on the Southern Gulf NRM website.

A comparative trial for WeedSniper® has been established. Final assessments are due by December 2017.

Dispersal of tebuthiuron pellets using a heli-drop controlled applicator device

Collaborators

- Southern Gulf NRM
- Desert Channels Queensland
- Central and North West Queensland local governments
- Central and North West Queensland and Southern Gulf landholders
- Biosecurity officers

Key publications

Vogler, W & Carlos, E 2015, 'Using helicopters: taking prickly acacia control to the next level', *Proceedings of the 13th Queensland weed symposium*, The Weed Society of Queensland, Longreach.

Carlos, E & Vogler, W 2015, 'Using pod and seed features to indicate prickly acacia seed viability', *Proceedings of the 13th Queensland weed symposium*, The Weed Society of Queensland, Longreach.

24. Herbicide application research

Project dates

July 2009 – June 2020

Project team

Shane Campbell and Dannielle Brazier

Project summary

The objective of this project is to improve herbicide control options for priority weeds in central, western and northern parts of the state.

Recently we have been investigating the use of low-volume, high-concentration applications (splatter method) of herbicides on priority weeds. Bellyache bush, Siam weed and lantana can all now be effectively treated using this technique. Testing on rubber vine and prickly acacia has given mixed results. An initial trial on individual medium-sized rubber vine plants recorded high mortality using some herbicides (particularly triclopyr/picloram). However, further testing on dense infestations resulted in poor efficacy. For prickly acacia, an initial screening trial on potted plants gave excellent efficacy, but subsequent testing on medium-sized plants in the field gave poor results. Additional funding from the Australian Government will be used for further testing on rubber vine, prickly acacia, chinee apple and gamba grass.

In 2016–17, a screening trial near the Willows township investigated herbicides and techniques (e.g. basal bark, cut stump, stem injection and foliar spraying) for controlling night-blooming cereus (*Cereus uruguayanus*). The plant appears to take a long time to die and, for most treatments, monitoring for at least 2 years will be necessary before a comprehensive assessment can be made. However, at least one of the herbicides tested is promising for each of the techniques implemented. In November 2017, a rate response trial was implemented to quantify the efficacy of two ground-applied residual herbicides containing the active ingredients hexazinone and tebuthiuron.

Using a splatter gun to apply herbicide on rubber vine

Collaborators

- Northern Gulf Resource Management Group
- Central Highlands Regional Council
- Central Highlands Regional Resources Use Planning Cooperative
- Biosecurity officers

Key publications

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

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

25. Control packages for statewide weed eradication targets

Project dates

July 2008 – June 2018

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 Queensland weeds.

An integrated control study near Mackay is investigating the efficacy of agronomic practices for depleting the red witchweed seed bank and preventing the production of new red witchweed seed over a 10-year period. Pre- and post-emergent herbicides applied to sugarcane—the predominant commercially viable crop grown locally—are compared to catch crops, trap crops and fumigants. As seed burial depth increased from 0 cm to 50 cm, seed viability increased from 61% to 69% and 46% to 66%, for the 6-month and 12-month retrieval periods respectively. Preliminary studies on the biology of red witchweed have also found that plants can emerge within 10 days of germinating and flower within a further 10 days.

Ethylene gas has been used with considerable success in the United States for accelerating soil seed bank decline of red witchweed. An application was made to the APVMA to amend emergency use permit PER14361 to allow the use of a tractor-mounted ethylene system that will supply a continuous flow of ethylene (as opposed to an injection system). The permit would allow up to 70 ha to be treated each year (up from 50 ha) and 200 kg of ethylene to be applied each year (up from 25 kg).

A small trial in a glasshouse at the Ecosciences Precinct aims to confirm whether wheat and barley are potential true hosts of red witchweed. Two varieties of wheat (Suntop and Gregory) and barley (Scope and Shepherd) as well as corn and sorghum were planted with red witchweed seed. Within 4 weeks of sowing this seed into the grain pots, emergent red witchweed appeared in all pots. Before this study, wheat (*Triticum aestivum*) could not be confirmed as a host, as previous investigations (almost 60 years ago) were inconclusive.

Treating red witchweed using a tractor-mounted ethylene injection system

Collaborators

- Local governments
- Biosecurity Queensland officers, including Peter Austin and Dan Stampa

Key publications

Silcock, RG, Mann, MB, Chow, S & Vitelli, JS 2012, 'Herbicides to control poisonous *Pimelea* species (Thymelaeaceae)', *Crop Protection*, vol. 31(1), pp. 99–106.

Vitelli, JS & Madigan, BA 2011, 'Evaluating the efficacy of the EZ-Ject herbicide system in Queensland, Australia', *Rangeland Journal*, vol. 33(3), pp. 299–305.

Bebawi, FF, Vitelli, JS, Campbell, SD & Mayer, RJ 2011, 'Impact of control strategies on bellyache bush (*Jatropha gossypiifolia* L.) mortality, seedling recruitment, population dynamics, pasture yield and cost analysis', *Rangeland Journal*, vol. 33(3), pp. 277–286.

26. Land management, soil chemistry and control of giant rat's tail grass using flupropanate

Project dates

December 2016 – June 2018

Project team

Joseph Vitelli, Annerose Chamberlain, Natasha Riding, Anna Williams, Rose Campbell (Department of Agriculture and Fisheries) and Eliza Barrett and John McKenzie (Granular Products Pty Ltd)

Project summary

Current control efforts for weedy *Sporobolus* grasses centre on the use of chemical, mechanical, plant-competition and pasture management. Despite the production of a best practice manual for weedy *Sporobolus* grasses and the widespread use of these control strategies, successful control has been difficult to achieve and weedy *Sporobolus* grasses continue to rapidly spread into new areas. Of the available herbicides, flupropanate is preferred because of its knockdown ability, residual activity and availability (both liquid and granular form). However, many landholders are experiencing poor control of giant rat's tail grass when using flupropanate.

Maximising flupropanate levels in the soil will lead to more effective control and longer suppression of seedling recruitment. To address inconsistencies in control of giant rat's tail grass, we will monitor flupropanate levels in the soil and pasture to help land managers with the timing of follow-up control. A trial at Conondale is investigating whether the amount of flupropanate reaching the soil is influenced by paddocks being burnt, heavily grazed or lightly grazed prior to application. The trial will also determine how soil type, fertiliser, moisture and application rate influence flupropanate efficacy.

Giant rat's tail grass in heavily grazed (left) and herbicide-treated (right) pasture after 3 months

Collaborators

- Granular Products Pty Ltd
- AusIndustry Grants, federal Department of Innovation, Industry, Science and Research
- Peter Thompson, Elgin (Conondale)

27. Native pathogens of giant rat's tail grass

Project dates

February 2017 – June 2020

Project team

Joseph Vitelli, Annerose Chamberlain, Natasha Riding, David Holdom, Roger Shivas, Diana Leemon and Yu Pei Tan

Project summary

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

Funding through the Australian Government's Rural Research and Development for Profit program, plus contributions from industry and state and local governments, will support a biological control program against weedy *Sporobolus* grasses. This project has two components:

- using molecular tools to better target biological control agents of weedy *Sporobolus* and to study the genetic relationships of the genus
- assessing endemic Australian pathogens as potential control agents.

To date, four surveys have been undertaken in Queensland for naturally occurring pathogens on *Sporobolus* species. From these, 27 pathogens have been purified from field-infested giant rat's tail plants and are being identified. One specimen has been identified as *Ustilago sporoboli-indici*, an exotic smut from South Africa that had previously been considered as a biological control agent for giant rat's tail in Australia but was rejected due to lack of host specificity. The implications of its occurrence in Australia are being considered.

Pathogen-infested giant rat's tail grass

Giant rat's tail grass leaf smut *Ustilago sporoboli-indici*

Collaborators

- New South Wales Department of Primary Industries
- Department of Economic Development, Jobs, Transport and Resources (Victoria)
- New South Wales Environmental and Aquatic Weeds Biocontrol Taskforce, via Rous County Council
- Bundaberg Regional Council
- Gladstone Regional Council
- HQPlantations

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

Project dates

February 2017 – June 2020

Project team

Joseph Vitelli, Rose Campbell and Anna Williams

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) have made it the preferred herbicide for tussock weed management. Unfortunately, land managers are experiencing inconsistent levels of control and in some situations spending over $50 000 without killing any plants.

It is thought that soils with higher clay content are better at retaining flupropanate and so the efficacy and residual effect is greater than for sandy or loamy soils. Lighter soils are thought to leach the chemical from the soil surface faster, meaning less herbicide is available to prevent seedling germination. However, even on better soils with good moisture and structure, there is conflicting evidence about the residual period—it can vary from 6 to 24 months, but high rainfall can reduce this period further regardless of soil environment.

Despite the use of flupropanate in Australia since the early 1970s, there is a lack of reliable data regarding its fate, degradation and behaviour in the environment. Insight into the residual level of flupropanate following application will greatly improve the timing of follow-up treatments and should improve control.

Through a collaborative project with Powerlink, we have commenced two trials. The first investigates the use and control effectiveness of flupropanate on a range of soils. The second will determine the flupropanate concentration required to effectively control or suppress tussock seedling emergence and what concentrations of flupropanate begin to have adverse effects on competitive pasture emergents.

Collaborators

- Powerlink Queensland
- School of Earth and Environmental Sciences, The University of Queensland
- Peter Thompson, Elgin (Conondale)
- Larry Cooper, Redlands & QCDF Research Facility
- Judith Ruhle, Jalbirri (Bongeen)
- Errol Stenzel, Bunburra (Boonah)

29. Improved decision-support tools for weed eradication

Project dates

July 2016 – December 2018

Project team

Joe Scanlan, Steve Csurhes, Moya Calvert and Peter Austin

Project summary

A review of the 49 weeds targeted for eradication in Queensland divided them into eradicated, on track for eradication, uncertain and not eradicable. About 40% fell into the 'uncertain' category. We need an objective approach to determine how these weeds can best be managed. Also, eradication programs for individual weeds need analytical and modelling support, including assessment of the progress towards eradication. This information will influence decisions about which Queensland weeds should be prioritised for eradication. There is considerable scope to improve the utility of existing decision-support tools such as WeedSearch (e.g. to determine eradication probability from search effort), and to better utilise existing data on weed occurrence, control and surveillance effort (e.g. data collected over many years and stored in Pest Central and now BORIS).

A document outlining the prioritisation of Queensland weeds has been revised and updated in preparation for publishing on the departmental website.

Another part of this project was the development of a model of the emergence patterns of red witchweed using observations from the first 2 years of operations in the Mackay region. The model was run during the summer period, when emergence of red witchweed was expected. It provides up to a month's advance warning of the possible emergence of the weed, aiding surveillance planning. In addition, there is a general model that has been developed to use observations of weed occurrence, surveillance and control effort to assess progress towards eradication. This is a preliminary model that will require calibration for each of the current eradication targets. The framework should provide a consistent approach to analysis of progress on different species and should indicate where more-consistent data is required before a valid assessment of progress can be made.

Red witchweed flowers

Key publications

Csurhes, S 2017, 'Emerging weed threats detected in Queensland: risk assessment and prioritisation of 227 species', Department of Agriculture and Fisheries, Brisbane.

Holden, MH, Nyrop, JP & Ellner, SP 2016, 'The economic benefit of time-varying surveillance effort for invasive species management', *Journal of Applied Ecology*, doi: 10.1111/1365–2664.12617.

Moore, JL, Runge, MC, Webber, BL & Wilson, JR 2011, 'Contain or eradicate? Optimizing the management goal for Australian acacia invasions in the face of uncertainty', *Diversity and Distributions*, vol. 17(5), pp. 1047–1059.

30. Regional priorities for research and management of pest plants and animals

Project dates

June 2015 – June 2018

Project team

Olusegun Osunkoya, Christine Perrett, Tony Pople, Steve Csurhes, Shane Campbell and Salvo Vitelli

Project summary

A series of workshops (10 in total) were held across all Queensland local governments through regional organisations of councils or equivalent to identify priorities for research and on-ground management of weeds and pest animals.

Before the workshops, pest priority lists were developed for each region based on local government pest management plans. At the workshops, regional Biosecurity Queensland staff and local government officers identified regional priorities from these lists. Their assessment took into account the abundance, distribution and impacts of the weeds and pest animals as well as the feasibility of control/management.

There was reasonable agreement between the priorities from local government pest management plans and the regional rankings at the workshops (e.g. for weeds with high priority ranking, correlation coefficient $r = 0.58$ with probability < 0.05). South East Queensland (251 species) and Wide Bay Burnett (107 species) had the highest number of prioritised weeds. The least number of prioritised weeds were recorded for the Remote Area Planning and Development Board (11 species), Whitsunday (28 species) and Torres Strait Islands (25 species).

Overall, the 20 most important weeds for research and management (of the ~ 300 species listed), in decreasing order, were prickly acacia, parthenium, giant rat's tail grass, bellyache bush, rubber vine, parkinsonia, coral cactus, mesquite, harissia cactus, cat's claw creeper vine, cabomba, American rat's tail grass, fireweed, pond apple, salvinia, chinee apple, mother-of-millions, hymenachne, water hyacinth and water lettuce. Research and management needs of many of these weeds tend to fall under the following categories in decreasing order:

- biocontrol (new exploration/redistribution of existing controls and their efficacy)
- herbicide use and efficacy
- weed awareness and hygiene
- pasture management
- ecology, including weed spread via road networks
- incentive programs for farmers/landowners.

Fewer pest animal species were listed (~ 70 species) and these were more homogeneous than the weeds across regions; only North Queensland had pest animals significantly different from those of other regions. Like the weed list, however, the largest number of species was for South East Queensland (52 species) and the least for the Remote Area Planning and Development Board (9 species) and Far North Queensland (7 species).

Across regions, the pest animals in order of importance were wild dog, feral pig, feral cat, wild deer (various species), cane toad, fox, feral goat, rabbit, Indian myna, tilapia, locust, fire ant and yellow crazy ant. The research and management needs of these prime pest animals varied.

One more workshop is planned, and this will involve scientists validating and refining the pest species lists. Following this, we will undertake further comprehensive analyses of the multi-criteria datasets, then draft recommendations for regionally relevant on-ground management and research investment for the next 3–10 years.

Collaborators

- Local Government Association of Queensland
- Biosecurity Queensland officers
- Local government pest managers
- Local government executives and/or elected representatives
- Biosecurity Queensland community engagement unit
- CSIRO
- The University of Queensland

Part 2: Pest animal management

31. Rabbits in northern Queensland

Project dates

July 2013 – December 2018

Project team

Peter Elsworth, Michael Brennan and Joe Scanlan

Project summary

Rabbits have traditionally been in low numbers in northern Queensland, most likely due to the problems of breeding in this warmer part of the state. Reports from landholders and local governments suggested that numbers had increased leading into 2013. It was important to better understand the biology of rabbits in northern Queensland to assess if and how they are increasing in number.

In northern Queensland, temperatures are generally higher than what is considered tolerable for successful breeding (Cooke 1977). However, rabbits are persisting in this region and so must be successfully breeding. Surveys have shown that rabbits are using hollow logs and bushes as harbour (rather than constructing warrens) and have very small home ranges. Survival is generally low, with most rabbits not surviving past the first year. Breeding appears to be attempted year-round with reduced litter sizes and no attempt to produce successive litters. This may be a result of the need for females to regain body condition (due the more taxing nature of breeding in hot conditions) before attempting to breed again. Rabbit numbers appear to have increased following a number of years with higher than average rainfall, but during the trial period numbers have steadily declined with consecutive years of lower rainfall.

Collaborators

- Tablelands Regional Council
- Mareeba Shire Council
- Charters Towers Regional Council
- Dalrymple Landcare

Key publication

Cooke, B 1977, 'Factors limiting the distribution of the wild rabbit in Australia', *Proceedings of the Ecological Society of Australia*, vol. 10, pp. 113–120.

32. Monitoring the efficacy of new rabbit biocontrol

Project dates

April 2014 – June 2018

Project team

Peter Elsworth, Michael Brennan and Joe Scanlan

Project summary

Rabbit haemorrhagic disease virus (RHDV) has greatly reduced rabbit numbers throughout Australia. Recent evidence of genetic resistance and the presence of a non-pathogenic rabbit calicivirus (RCV-A1) that provides partial protection against RHDV have led to the importation, testing and release of an additional strain of RHDV (RHDV1-K5).

RHDV1-K5 was released at 20 sites across Queensland and led to reductions in rabbit numbers at most of those sites. Reductions (according to landholder surveys) were 'little to none' (Gold Coast), 10–15% (Wallangarra, Woolmer, Highfields), 40–70% (Toowoomba, Karara, Lockyer Valley) and 100% (Dimbulah). Many sites have not reported spotlight count data. At an intensive monitoring site at Wallangarra, rabbit numbers are the lowest they have been in decades following outbreaks of myxomatosis and RHDV2 in 2016 and the release of RHDV1-K5 in March. This has led to a community warren-ripping program being undertaken with support from the Queensland Murray–Darling Committee and Southern Downs Regional Council. This program has targeted core breeding areas and will continue to destroy as many warrens as possible in the region to ensure rabbit populations remain low.

This monitoring forms part of a national assessment of the impact of RHDV1-K5 and its epidemiology. There are now six viruses circulating in Australian rabbit populations—RHDV1 (the original Czech strain), RHDV1-K5, RCV-A1, RHDV2 (a recent incursion), RHDV1 (a Chinese strain; a recent incursion with limited distribution) and myxomatosis. It is important to understand the interaction between these viruses to ensure viral biocontrol continues to suppress rabbit populations in Australia.

Putting out RHDV1-K5 on carrots

Rabbits eating RHDV1-K5 bait

Collaborators

- Invasive Animals Cooperative Research Centre
- CSIRO
- New South Wales Department of Primary Industries
- South Australia Biosecurity
- Southern Downs Regional Council
- Darling Downs Moreton Rabbit Board

Key publications

Elsworth, PG, Kovaliski, J & Cooke, BD 2012, 'Rabbit haemorrhagic disease: are Australian rabbits (*Oryctolagus cuniculus*) evolving resistance to infection with Czech CAPM 351 RHDV?', *Epidemiology and Infection*, vol. 140, pp. 1972–1981.

Strive, T, Wright, JD & Robinson, AJ 2009, 'Identification and partial characterisation of a new lagovirus in Australian wild rabbits', *Virology*, vol. 384, pp. 97–105.

Strive, T, Elsworth, PG, Liu, J, Wright, JD, Kovaliski, J & Capucci, L 2013, 'The non-pathogenic Australian rabbit calicivirus RCV-A1 provides temporal and partial cross protection to lethal rabbit haemorrhagic disease virus infection which is not dependent on antibody titres', *Veterinary Research*, vol. 44, p. 51.

33. Assessing impact of rabbits on horticulture

Project dates

July 2013 – December 2017

Project team

Peter Elsworth, Michael Brennan and Joe Scanlan

Project summary

The economic cost of rabbits to agricultural industries in Australia was estimated at approximately $200 million per year in the late 2000s (Gong et al. 2009). These figures are, however, produced from estimated losses to the beef and wool industries from rabbit competition and grazing. Very little is known about the impact that rabbits have on horticultural crops, although it has long been known that crops are eaten by rabbits.

Queensland produces one-third of the nation's fruit and vegetables, valued at about $2 billion per year (figures from Growcom). Many of the growing areas are in regions of high rabbit numbers or regions of rabbit expansion. Rabbits inhabit creeks and farm sheds in the Lockyer Valley and damage adjoining crops. Pen trials have shown that the damage is most significant at the seedling stage, when the entire plant can be destroyed. After this stage, crop damage becomes superficial and there was no yield loss on the crops tested. Field trials show that even low to medium rabbit densities can cause significant economic loss ($100 000s) in a very short time, impacting primarily the first 15 m of crops closest to rabbit harbour. Temporary electric fencing may provide short-term relief from rabbit impacts, but long-term control is best achieved through harbour destruction.

Collaborators

- The University of Queensland (Gatton)
- Darling Downs Moreton Rabbit Board
- Lockyer Valley Regional Council
- Rugby Farms Pty Ltd
- Qualipac Pty Ltd

Key publication

Gong, W, Sinden, J, Braysher, M & Jones, R 2009, *The economic impacts of vertebrate pests in Australia*, Invasive Animals Cooperative Research Centre, Canberra.

34. Warren use by adult and juvenile rabbits

Project dates

July 2016 – June 2017

Project team

Peter Elsworth, Michael Brennan and Cameron Wilson

Project summary

There has long been anecdotal observation that juvenile rabbits can enter any warren they like, while adult rabbits only enter their own warrens. This probably allows young rabbits to find suitable warrens to occupy once they are old enough to leave the parental warren. Also, young rabbits can become infected with RHDV1 but do not develop a disease and die (Robinson et al. 2002). If they are able to move freely between warrens, these infected rabbits may be an avenue for virus spread between warrens in a population. By monitoring young and adult rabbits through a virus release, we aim to establish the role that young rabbits play in the epidemiology of a virus outbreak.

Collared adult rabbits stayed in one warren and were mostly found in the same location in that warren every day. Unfortunately, an outbreak of RHDV2 early in the breeding season killed the first litters of kittens, restricting the data that could be collected on warren use by young rabbits. Initial data showed that from the age kittens emerge from underground (about 20 days old) to 6 weeks of age, they stayed close to their birth warren.

Collaborators

- Invasive Animals Cooperative Research Centre
- James Cook University

Key publication

Robinson, AJ, So, PTM, Muller, WJ, Cooke, BD & Capucci, L 2002, 'Statistical models for the effect of age and maternal antibodies on the development of rabbit haemorrhagic disease in Australian wild rabbits', *Wildlife Research*, vol. 29, pp. 663–671.

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

Project dates

March 2015 – June 2017

Project team

Michael Brennan, Matt Amos, Tony Pople, Hellen Haapakoski and Stacy Harris

Project summary

Wild deer populations (rusa, red, fallow and chital) in south-eastern Queensland have grown to a size where they are now considered serious pests. Their impacts range from agricultural production losses (crop and forestry damage, and competition with livestock), to browsing and grazing damage in conservation areas, to collisions with vehicles.

Deer populations appear to be growing, requiring plans that manage current impacts and, ideally, contain populations and develop capability for future control. There has been limited control effort in south-eastern Queensland, but control is frustrated by the few effective control tools, community opposition and concern over public safety and non-target injury when applying lethal control.

The project is focused on hotspots for deer (primarily red and rusa) in northern Brisbane, particularly within the Noosa, Sunshine Coast and Moreton Bay local government areas. These local governments are monitoring deer species and conducting some control activities. The project has also assisted Gympie Regional Council with community engagement to establish a new deer control program.

The project has established several monitoring sites and helped refine deer monitoring activities by council officers. A number of rusa deer have now been collared with satellite transmitters and are providing important information on ranging behaviour, particularly habitat use. By locating these deer, it is also possible to locate other deer with which they congregate. Five collared animals are showing very restricted space use and more homogeneous habitat use over different seasons than was expected.

Collaborators

- Darren Sheil, Moreton Bay Regional Council
- Anthony Cathcart and Mark Kimber, Sunshine Coast Council
- Ken English and Phil Herrington, Noosa Shire Council
- Ben Curley, Gympie Regional Council
- Rob Hunt, National Parks and Wildlife Service (New South Wales)
- Troy Crittle, Biosecurity, New South Wales Department of Primary Industries
- Biosecurity officers Duncan Swan, Matt Ryan and Lyn Willsher (Queensland)
- Biosecurity Queensland policy staff Petra Skoien and Carmel Kerwick
- Mark Ridge, Darling Downs Moreton Rabbit Board

Key publications

Amos, M, Baxter, G, Finch, N, Lisle, A & Murray, P 2014, 'I just want to count them! Considerations when choosing a deer population monitoring method', *Wildlife Biology*, vol. 20(6), pp. 362–370.

Doerr, ML, McAninch, JB & Wiggers, EP 2001, 'Comparison of 4 methods to reduce white-tailed deer abundance in an urban community', *Wildlife Society Bulletin*, vol. 29(4), pp. 1105–1113.

Hunt, RJ, Claridge, AW, Fleming, PJS, Cunningham, RB, Russell, BG & Mills, DJ 2014, 'Use of an ungulate-specific feed structure as a potential tool for controlling feral goats in Australian forest ecosystems', *Ecological Management & Restoration*, vol. 15, pp. 231–238.

36. Ecology and management of chital deer in northern Queensland

Project dates

July 2014 – December 2017

Project team

Tony Pople, Mike Brennan, Matt Amos and Joe Scanlan

Project summary

This project studies aspects of the ecology and management of chital deer (*Axis axis*), which were established in northern Queensland in the late 1800s. Unlike many other invasive vertebrate species, their spread has been relatively slow. However, in the last 20 years, landholders have reported an increase in chital deer abundance and an expansion of their range. Information on control methods and the impacts, capacity for increase and spread of the deer is needed to develop long-term management strategies. Limiting factors are likely to be a combination of dingo predation and food supply, particularly availability of water and high-quality food.

Aerial and ground surveys have revealed relatively high chital deer densities in areas close to homesteads and permanent water. Such densities are causing impacts for landholders through grazing competition with cattle, while trespassing by hunters is also a problem. A survey of landholders has indicated the extent of their concern and the timing of the spread of deer.

Dry conditions over 2014–2016 saw deer abundance decline markedly, with annual declines of 65–83% recorded on two properties. This coincided with an almost complete cessation of breeding and a marked drop in body condition of female chital. Shot samples of deer have been taken in dry and wet seasons on two properties to monitor the seasonal decline in body condition, the change in diet and the year-to-year variation in reproductive output. These parameters will be related to population density and pasture conditions. Dietary overlap with cattle is also being examined in a masters study.

This heavy decline in the population during drought and concentration around homesteads (for unknown reasons) perhaps partly explains the slow rate of spread. Populations will take some time to recover from low density to their previous high. Dispersal would also be delayed and seems to occur through 'island hopping' between homesteads.

A collaborative project with James Cook University and the Sporting Shooters Association of Australia is now looking at the survival and causes of mortality of chital deer, particularly juveniles. This, coupled with data on reproduction, body condition, rate of increase and pasture conditions, should give a clearer understanding of the factors driving the dynamics of chital deer populations.

The reduction in deer numbers precipitated by drought, coupled with the concentration of animals, provided a strategic opportunity to further reduce deer numbers. Working with landholders, the local Landcare group, the NRM group and local government, we undertook and assessed control. Ground shooting has reduced deer abundance on some properties, with 36% of the population removed in five days on one property. Aerial culling was used to depress populations further on five properties, and was followed up with ground shooting. The maximum rate of increase of chital deer is sufficiently low (~ 43%) for it to be feasible to hold populations at low densities, but coordination among properties will be required to gain landscape control.

Collaborators

- Keith Staines and Glen Harry, Sporting Shooters Association of Australia
- Kurt Watter, masters student, The University of Queensland
- Dave Forsyth and Luke Woodford, Arthur Rylah Institute (Victoria)
- Lauren O'Bryan, Nathan Morgan and Rodney Stevenson, Biosecurity Queensland
- Ashley Blokland, Charters Towers Regional Council
- Kirsty McBride, Dalrymple Landcare
- Byron Kearns, NQ Dry Tropics
- Catherine Kelly, Ben Hirsch, Lin Schwarzkopf and Iain Gordon, James Cook University

Key publications

Pople, A, Paroz, G & Wilke, A 2009, 'Deer management in Queensland', *Proceedings of the national feral deer management workshop*, Canberra, Australia, pp. 50–57.

Simard, MA, Dussault, C, Huot, J & Côté, SD 2013, 'Is hunting an effective tool to control overabundant deer? A test using an experimental approach', *The Journal of Wildlife Management*, vol. 77, pp. 254–269.

37. Predation of chital deer and cattle by wild dogs in northern Queensland

Project dates

July 2016 – December 2018

Project leader

Lee Allen

Project summary

Chital deer were introduced to Maryvale station north of Charters Towers in the 1880s but until recently have not been a major concern to producers. They are now found over many stations in the region and small populations are also found at Alpha and Ingham.

Wild dog predation and management may significantly affect the local and regional distribution and abundance of deer. The dogs may have a beneficial role in controlling deer, but they are also known predators of beef cattle. In the Gulf of Carpentaria, there is a 30% loss of calves in some years attributed to wild dogs.

This project monitors the diet of wild dogs from their scats on one or more cattle grazing properties north of Charters Towers. It will determine the extent and seasonal timing of their predation on cattle and deer and will contribute to a broader collaborative study proposed to assess management interventions to reduce calf loss. Preliminary results into the prey remains indicate that deer are a significant prey item for wild dogs. A broad variety of other species were discovered in scats during the first half of the year, including most commonly eastern grey kangaroo and agile wallaby, but also echidna, emu, possum and rabbit. Late in the dry season and over summer, a large proportion of scats contained debris but little fur, suggesting scavenging.

Collaborators

- Tony Pople, Michael Brennan and Jarud Muller, Agri-science Queensland

Key publication

Allen, L, Goullet, M & Palmer, R 2012, 'The diet of the dingo (*Canis lupus dingo* and hybrids) in north-eastern Australia: a supplement to the paper of Brook and Kutt (2011)', *The Rangeland Journal*, vol. 34, pp. 211–217.

38. Cluster fencing evaluation

Project dates

October 2013 – December 2018

Project team

Lee Allen, Peter Elsworth, Joe Scanlan and Tony Pople

Project summary

In 2013, South-West Natural Resource Management contracted graziers to erect several 'cluster fences' around multiple properties to allow the elimination of wild dogs and control of kangaroo and other pest populations inside the fenced area. This strategy offers some hope for Queensland's sheep industry, which is seriously affected by the dual impacts of wild dogs and kangaroos.

This project monitors the abundance of kangaroos, wild dogs and other wildlife, and pasture and condition (e.g. biomass, composition) before and after the erection of cluster fences to provide empirical information to evaluate the cluster fence strategy. Our monitoring contrasts pest abundance and pasture condition on individual properties within the Morven and Tambo clusters with that of properties outside. Ultimately, the success of cluster fencing will be determined by the extent to which livestock production in the cluster improves (there are other indirect economic and social benefits) relative to livestock production in comparable areas outside the cluster, less the cost of establishing and maintaining the cluster fence and reduced pest populations.

There is a wide range of pasture/land types within the Morven cluster and in neighbouring areas. A total of 96 sites have been inspected on up to 11 occasions since the start of the project. The amount of vegetative cover around these sites has also been determined from satellite imagery. Comparisons will be

made between satellite-recorded cover and site observations to assess the representativeness of the sampling site. Both within and outside the cluster, pasture condition has varied over time, with no consistent trends evident at present. Closer analysis will determine if there are trends in cover for the same land types within and outside of the cluster. It will take many years before any consistent differences between inside and outside the cluster can be detected.

Results from monitoring wildlife activity have been mixed. Inside the Morven cluster fence, over 400 wild dogs have been removed by contractors and wild dogs are now scarce. In contrast, kangaroos and emus are increasing relative to outside the Morven cluster. Although there are pockets of success in the Tambo cluster where individuals or groups have privately fenced properties within clusters, monitoring indicates there is little difference in dog activity inside and outside the cluster, and greater kangaroo densities inside the cluster, suggesting more needs to be done.

Pasture condition inside and outside cluster fences

Evidence of wildlife, used to monitor their relative abundance either side of cluster fences

Collaborators

- Catherine Crowden and Emma Turner, South West NRM
- Bill Johnson, Economist, Department of Agriculture and Fisheries
- Philip Maher, Department of Natural Resources and Mines

39. Non-target impacts of 1080 pig baits

Project dates

June 2014 – June 2018

Project team

Matthew Gentle, Peter Cremasco and Cameron Wilson

Project summary

This project examines two feral pig 1080 baiting practices—aerial application of meat baits in the absence of pre-feeding or bait-stations, and the use of baits prepared from fruit and vegetable materials. Both have a long history of use in Queensland to protect agriculture and the environment. The Australian Pesticides and Veterinary Medicines Authority has initially rejected the inclusion of these methods in the future registration of the Queensland 1080 concentrate, given the limited assessments available on their impacts on non-target species. However, they agreed to permit continued legacy use while studies are undertaken to collect and collate relevant data.

We designed and completed field studies in northern Queensland, where baiting of feral pigs with fruit containing 1080 is common. Field observations of a control operation using meat bait in southern Queensland have been completed.

The most common bait materials used to target feral pigs are grain and meat, but in the Wet Tropics of northern Queensland, meat and grain have limited uptake and so are unsuitable. In representative areas of the Wet Tropics, baiting campaigns using fruit (primarily bananas and mangoes) were monitored for indicators of non-target risk, including visitation and consumption of bait material by non-target species, and deaths and changes in abundance of selected non-target species. Preliminary results indicate minimal interference and uptake of fruit bait material by non-target species during best-practice pig baiting campaigns. During the monitoring, baiting resulted in an 80% reduction in pigs detected on remote cameras. More importantly, there were no significant changes in the abundance of non-target species, relative to unbaited areas. Results to date demonstrate that baiting pigs using fruit can be highly effective at managing feral pig populations with negligible risk to non-target species. This project will continue to collect data to determine the non-target impacts from fruit, vegetable and meat baiting practices to help provide guidelines for the responsible poisoning control of feral pigs.

Collaborators

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

Key publications

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

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

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

Cremasco, P & Bacchiella, D 2017, 'A strategy for effectively managing feral pig impacts in agricultural enterprises in northern Queensland', *Proceedings of the 17th Australasian vertebrate pest conference*, Invasive Animals Cooperative Research Centre, Canberra, p. 141.

40. Feral pig movements—individual and population-scale

Project dates

July 2014 – June 2018

Project team

Matthew Gentle and Joe Scanlan

Project summary

Biosecurity Queensland is assisting the Queensland Murray–Darling Committee, and other collaborators, to assess the movements of feral pigs (using GPS tracking) in an agricultural landscape of southern Queensland. This will improve our understanding of feral pig ranging behaviour, particularly habitat use, foraging and rest areas, periods when crop (or other commodity) areas are utilised and range size. Such data will help inform management strategies, such as the optimal timing, location and scale of control operations.

Tissue samples for DNA analysis are being opportunistically collected from routine feral pig control programs conducted within and adjacent to research sites. Samples are assessed for relatedness, to help determine the size and boundaries of population management units. Funding is being sought to complete DNA analysis.

The study is part of a professional doctorate that also aims to foster community engagement through scientific research. The Queensland Murray–Darling Committee are responsible for completing the field work and the community engagement component, while Biosecurity Queensland staff assist with the design of the ecological study and will support data analysis and preparation of scientific articles.

The primary field component of this project (collaring of feral pigs) is being completed on four sites, two in Queensland and two in New South Wales. As of May 2017, 28 feral pigs over three sites (Glenn Innes and Moree, New South Wales, and Bottletree, near Injune, Queensland) have been fitted with GPS collars. An additional three or four collars will be fitted to animals on each site to increase sample size. Feral pig trapping and collaring will continue at a fourth site (Miles, Arrow Energy, Queensland) in late June. Current land-use data (e.g. crop type, stage, grazing intensity) is being compiled for these sites. Initial stakeholder workshops to implement the pre-treatment community engagement component have been completed. Key informant interviews and an attitude survey have been designed and will be completed to monitor changes in community engagement resulting from the scientific component.

Collaborators

- Darren Marshall, PhD student, University of New England (Australia) and Penn State University (United States), and member of Queensland Murray–Darling Committee
- SANTOS
- North West Local Land Services
- Northern Tablelands Local Land Services
- Various landholders, including farmers and graziers
- New South Wales Department of Primary Industries

Key publications

Gentle, M, Speed, J & Marshall, D 2015, 'Consumption of crops by feral pigs (*Sus scrofa*) in a fragmented agricultural landscape', *Australian Mammalogy*, vol. 7, pp. 194–200.

Marshall, D, Gentle, M & Alter, T 2014, 'Using ecological research to reduce barriers to achieve effective feral pig management', *Program and abstracts 16th Australasian vertebrate pest conference*, Brisbane, p. 75.

Marshall, D, Gentle, M & Alter, T 2017, 'Integrating ecological research and human dimensions: improving feral pigs management by fostering innovative community engagement', *Proceedings of the 17th Australasian vertebrate pest conference*, Invasive Animals Cooperative Research Centre, Canberra, p. 55.

41. Feral cat ecology and management

Project dates

June 2014 – December 2018

Project team

Matthew Gentle, Bronwyn Fancourt, James Speed, Cameron Wilson and Glen Harry

Project summary

This project is divided into two components—DNA study of cat population boundaries and improving feral cat management techniques.

DNA study of cat population boundaries

In the Astrebla Downs National Park in western Queensland, feral cat predation is a significant threat to the endangered greater bilby. The occasional high abundance of feral cats following 'flush' periods of food surplus triggers an intensive management program by the Queensland National Parks and Wildlife Service. Although large numbers of cats are removed, it is uncertain whether these animals are residents, offspring of residents or immigrants from outlying or adjacent areas. Understanding the 'source' or population boundary of cats in the national park is important to ensure the whole, and not just parts, of the cat population can be managed.

Tissue samples (› 3000) have been collected through the Queensland Parks and Wildlife Service management program. Samples from three western Queensland national parks and south-eastern Queensland sites were selected for initial proof-of-concept testing. DNA from 330 cat samples using eleven loci markers were extracted using a commercially available kit (MeowPlex®). Comparisons of DNA profiles suggest limited genetic differentiation between animals in the three western areas, supporting high mobility and gene flow between feral cat populations. The lack of population genetic structure suggests difficulty in determining and delineating management units. The results also indicate that immigration from unmanaged populations is likely to limit the long-term effectiveness of feral cat management campaigns.

Improving feral cat management techniques

Intensive control (such as that undertaken at Astrebla Downs National Park) is labour-intensive and costly, and broadscale control options for populations of feral cats are limited. In recent times, a chipolata-style sausage containing either 1080 or PAPP toxin ('Eradicat' or 'Curiosity' respectively) has shown some success for broadscale control via aerial baiting. However, this success needs testing and comparison to current techniques used in Queensland environs.

Alternatively, other means of presenting poison to cats (e.g. Felixer™ grooming traps) may be applicable, but these are still in development. Improved trapping technologies (e.g. elevated traps) may also have applications to feral cat management, particularly to improve trapping target specificity. This project is investigating the range of available options to control feral cats and testing the most suitable for Queensland environs. Feral cat mortality from control operations is being monitored using GPS collars, which also provide critical ecological data about habitat use, range size and activity patterns to improve management and monitoring strategies. Remote camera-monitoring techniques are also being refined to ensure the effectiveness of control techniques can be adequately assessed. The response to, and benefits of, cat removal on prey species is also being investigated through collaboration with external researchers.

We performed a feral cat baiting trial in Taunton National Park (Scientific) in central Queensland to test the efficacy of fresh meat bait (1080) and measure the uptake of baits by target and non-target species. Over 14 days, 54% of 50 monitored baits were removed by non-target species (mostly birds—corvids), with 46% removed in the first 4 days. Cameras used to monitor baits did not detect any feral cats consuming or removing baits, although several cats were detected interacting with baits. The lack of bait uptake by feral cats together with movement data obtained from GPS collars suggests that track-based baiting operations are unlikely to be effective at controlling feral cat populations in these environs.

The movements of nine feral cats were investigated using GPS collars between May and July 2016. Home ranges of males were around three times larger than those of females, with overlap within and between the sexes, and were considerably larger than those reported in similar environs. Preliminary analyses suggests that feral cats do not regularly use roads and tracks, and riparian habitats may be favoured, but more analysis of habitat use is required.

Analysis of camera data at Taunton showed that feral cats and dingoes exhibited marked overlap in spatial and temporal activity across the park, indicating coexistence between these predators at this site. Time and distance between individual predator detections were negatively related, suggesting within-night avoidance of dingoes by cats. However, cats remained active, abundant and widespread across the park, with evidence of cats hunting and breeding successfully in areas occupied by dingoes. These findings suggest that feral cats can coexist with dingoes, without significant suppression of cat abundance or fitness.

Collaborators

- Barry Nolan, Department of National Parks, Sport and Racing (Airlie Beach)
- Maree Rich, Department of National Parks, Sport and Racing (Longreach)
- John Augusteyn, Department of National Parks, Sport and Racing (Rockhampton)
- Jane Oakey and Craig Smith, Biosecurity Queensland (Coopers Plains)
- Jessica Peatey and Diana Fisher, The University of Queensland
- Various private landholders

A feral cat with a GPS collar

Setting a trap for feral cats

Key publications

Fancourt, B, Speed, J & Gentle, M 2017, 'Do dingoes supress feral cats? Spatial and temporal activity of sympatric feral cats and dingoes in central Queensland', *Proceedings of the 17th Australasian vertebrate pest conference*, Invasive Animals Cooperative Research Centre, Canberra, p. 119.

Fancourt, B, Speed, J & Gentle, M 2016, 'Fighting like cats and dogs? Spatial and temporal activity of sympatric feral cats and dingoes in central Queensland', *62nd annual scientific meeting and symposium of the Australian Mammal Society,* Alice Springs.

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

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

Part 3: Research services

42. Chemical registration—providing tools for invasive pest control

Project dates

July 2012 – June 2018

Project team

Joe Vitelli and David Holdom

Project summary

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

Ten new permits were issued to Biosecurity Queensland during 2016–17 by the Australian Pesticides and Veterinary Medicines Authority (APVMA). Eight permits related to weeds (fireweed, hymenachne, *Mimosa pigra*, Navua sedge, prickly acacia, red witchweed, running bamboo and salvinia), one permit related to sodium hypochlorite and one permit related to pest animals (feral cats). A further four permits [American rat's tail grass and Parramatta grass, bellyache bush, hymenachne (glyphosate) and hymenachne (haloxyfop)] have been lodged with the APVMA.

Collaborators

- Local governments
- Seqwater
- Agribusiness, including Sumitomo Chemical, Nufarm Australia, Macspred and DowAgroSciences
- Department of National Parks, Recreation, Sport and Racing
- Department of Transport and Main Roads
- Biosecurity Queensland officers, including Sonia Jordan, Steve Csurhes, Corey Bell, Craig Hunter, Michael Graham, Lyn Willsher, John Reeves, Stacey Harris and Michelle Smith

Key publications

Ten new permits were issued by the APVMA to Biosecurity Queensland during the 2016–17 financial year:

1. Permit (PER11540) Haloxyfop/Ponds, drainage areas, waterways, pastures, roads and utility reserves/Hymenachne, expires 30 June 2017, ‹http://permits.apvma.gov.au/PER11540.PDF›.
2. Permit (PER13195) 2,4-D amine/Pastures/Fireweed, expires 31 March 2022, ‹http://permits.apvma.gov.au/PER13195.PDF›.
3. Permit (PER10892) Glyphosate/Aquatic areas in Queensland/Salvinia molesta, expires 31 August 2019, ‹http://permits.apvma.gov.au/PER10892.PDF›.
4. Permit (PER80065) Sempra herbicide (halosulfuron-methyl)/Roadsides, rights-of-way, footpaths, commercial and industrial areas/Navua sedge, expires 31 March 2022, ‹http://permits.apvma.gov.au/PER80065.PDF›.
5. Permit (PER82366) Fluroxypyr/Pasture rangelands and other non-crop situations/Prickly acacia, expires 31 July 2021, ‹http://permits.apvma.gov.au/PER82366.PDF›.
6. Permit (PER82156) Conqueror, Grazon Extra/non-crop areas/Rubber vine, expires 30 June 2021, ‹http://permits.apvma.gov.au/PER82156.PDF›.
7. Permit (PER12818) Sodium hypochlorite/Agricultural quarantine situations/Contaminated equipment, expires 31 July 2026, ‹http://permits.apvma.gov.au/PER12818.PDF›.
8. Permit (PER14015) Curiosity 1080 (sodium fluoroacetate) cat bait/Forests, pastures, non-crop, pre-plant and fallow land/Feral cats, expires 30 September 2019, ‹http://permits.apvma.gov.au/PER14015.PDF›.
9. Permit (PER83165) Flupropanate/small infestations/Running and clumping bamboo species, expires 30 June 2020, ‹http://permits.apvma.gov.au/PER83165.PDF›.
10. Permit (PER14004) Strychnine/Wild dogs and foxes, expires 31 March 2019, ‹http://permits.apvma.gov.au/PER14004.PDF›.

43. Pest management chemistry

Project dates

Ongoing

Project team

Stephen Were, Patrick Seydel and Alyson Herbert

Project summary

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

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

Forensic toxicology

Over the year, our laboratory performed more than 55 investigations into possible animal poisonings—38 for sodium fluoroacetate, 6 for strychnine, 7 for anticoagulants, 3 for metaldehyde and 1 for zinc phosphide. While most investigations related to domestic dogs and cats, some involved livestock or macropods.

Formulation chemistry

During the year, our formulation facility produced 2405 L of 1080 36 g/L pig bait solution in accordance with upcoming registration of the formulation with the APVMA.

The labels for several formulations were redesigned to comply with the Globally Harmonized System (GHS), which became mandatory under work health and safety laws on 1 January 2017.

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

External funding

Research and development contracts

Project/research area	Funding body	Funds ($)
Biological control of bellyache bush	Meat and Livestock Australia	199 000
Biological control of parkinsonia	CSIRO	93 000
Biological control of prickly acacia	Meat and Livestock Australia	14 000
Biological control of prickly acacia	Australian Department of Agriculture and Water Resources	69 000
Biological control of parthenium	Meat and Livestock Australia	388 000
Biological control of giant rat's tail grass	Australian Department of Agriculture and Water Resources	74 000
Endemic pathogens of giant rat's tail grass	Australian Department of Agriculture and Water Resources	45 000
Biological control of prickly acacia and giant rat's tail grass	Rural Industries Research and Development Corporation (now trading as AgriFutures Australia), Bundaberg Regional Council, Gladstone Regional Council, HQPlantations, New South Wales Department of Primary Industries, New South Wales Environmental and Aquatic Weeds Biocontrol Taskforce	29 000
Giant rat's tail grass management	Economic Development Queensland, Department of Infrastructure, Local Government and Planning	20 000
Giant rat's tail grass management in central Queensland	Gladstone Regional Council	40 000
Giant rat's tail grass flupropanate control	Granular Products Pty Ltd	38 000
Giant rat's tail grass management	Powerlink	17 000
Cabomba management	CSIRO	50 000
Biological control of *Cylindropuntia* cactus	New South Wales Department of Primary Industries	80 000
Aquatic weed herbicide evaluation	Sumitomo Chemical	17 000
TOTAL		**1 173 000**

Rural Land Protection Fund

Project/research area	Funds ($)
Weed seed dynamics	22 000
Herbicide application research	62 000
Biological control of bellyache bush	132 000
Biological control of parthenium	273 000
Biological control of prickly acacia	86 000
Biological control of cat's claw creeper	62 000
Biological control of giant rat's tail grass	15 000
Biological control of cactus	194 000
Biological control of lantana	46 000
Biological control of mother-of-millions	61 000
Rearing and release of weed biological control agents	161 000
Water weed ecology and management research	176 000
Wet Tropics best-practice research	10 000
Feral deer best-practice research	174 000
Wild dog best-practice research	113 000
Rabbit best-practice research	263 000
Pesticide authorities	79 000
Pest management chemistry and chemical registration	94 000
TOTAL	**2 023 000**

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Dr Bronwyn Fancourt	Project officer
Dr Matt Amos	Project officer

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Stephen Setter	Experimentalist

Publications and presentations

Journal articles

Allen, BL, Carmelito, E, Amos, M, Goullet, MS, Allen, LR, Speed, J, Gentle, M &, Leung, LKP 2016, 'Diet of dingoes and other wild dogs in peri-urban areas of north-eastern Australia', *Scientific Reports*, vol. 6, p. 23028.

Allen, L 2017, 'Is landscape-scale wild dog control the best practice?', *Australasian Journal of Environmental Management*, vol. 24, pp. 5–15.

Allen, LR, Stewart-Moore, N, Byrne, D & Allen, BL 2017, 'Guardian dogs protect sheep by guarding sheep, not by establishing territories and excluding predators', *Animal Production Science*, vol. 57, pp. 1118–1127.

Bebawi, FF, Campbell, SD & Mayer, RJ 2016, 'Seed fall, seed predation, twigging and litter fall of *Cascabela thevetia* (L.) Lippold', *The Rangeland Journal,* vol. 38, pp. 569–577.

Bickel, TO 2017, 'Processes and factors that affect regeneration and establishment of the invasive aquatic plant *Cabomba caroliniana*', *Hydrobiologia*, vol. 788(1), pp. 157–168.

Buru, JC, Dhileepan, K, Osunkoya, OO & Firn, J 2016, 'Plant traits differences between uncommon and abundant forms of a non-native vine, *Dolichandra unguis-cati* (Bignoniaceae) in Australia', *NeoBiota*, vol. 30, pp. 91–101.

Buru, JC, Dhileepan, K, Osunkoya, OO & Scharaschkin, T 2016, 'Germination dynamics and the occurrence of polyembryony in the two forms of cat's claw creeper, *Dolichandra unguis-cati* (L.) Lohmann (Bignoniaceae): implications for invasiveness and management options in Australia', *American Journal of Plant Sciences*, vol. 7, pp. 657–670.

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

Dhileepan, K 2017, 'Biological control of *Ziziphus mauritiana*: feasibility, prospective agents and research gaps', *Annals of Applied Biology*, vol. 170, pp. 287–300.

Engeman, RM, Allen, LR & Allen, BL (in press), 'Study design concepts for inferring functional roles of mammalian top predators', *Food Webs*, doi.org/10.1016/j.fooweb.2017.02.007.

Fancourt, BA 2016, 'Avoiding the subject: the implications of avoidance behaviour for detecting predators', *Behavioral Ecology and Sociobiology*, vol. 70, pp. 1535–1546.

Fancourt, BA, Sweaney, M & Fletcher, DB 2017, 'More haste, less speed: pilot study suggests camera trap detection zone could be more important than trigger speed to maximise species detections', *Australian Mammalogy*, doi https://doi.org/10.1071/AM17004.

Gentle, M, Speed, J, Allen, BL, Harris, S, Haapakoski, H & Bell, K 2017, 'The longevity of PAPP wild dog baits and the implications for effective and safe baiting campaigns', *Environmental Science and Pollution Research*, vol. 24, pp. 12 338 – 12 346.

Legge, S, Murphy, BP, McGregor, H, Woinarski, JCZ, Augusteyn, J, Ballard, G, Baseler, M, Buckmaster, T, Dickman, CR, Doherty, T, Edwards, G, Eyre, T, Fancourt, BA, Ferguson, D, Forsyth, DM, Geary, WL, Gentle, M, Gillespie, G, Greenwood, L, Hohnen, R, Hume, S, Johnson, CN, Maxwell, M, McDonald, PJ, Morris, K, Moseby, K, Newsome, T, Nimmo, D, Paltridge, R, Ramsey, D, Read, J, Rendall, A, Rich, M, Ritchie, E, Rowland, J, Short, J, Stokeld, D, Sutherland, DR, Wayne, AF, Woodford, L & Zewe, F 2017, 'Enumerating a continental-scale threat: how many feral cats are in Australia?', *Biological Conservation*, vol. 206, pp. 293–303.

McNeill, AT, Leung, LKP, Goullet, MS, Gentle, M & Allen, BL 2016, 'Dingoes at the doorstep: home range sizes and activity patterns of dingoes and other wild dogs in peri-urban areas of north-eastern Australia', *Animals*, vol. 6, p. 48.

Palmer, W & Senaratne, K 2016, 'Assessment of a stenophagous weevil, *Osphilia tenuipes* (Coleoptera: Curculionidae), as a potential biological control agent for weedy *Bryophyllum* spp. (Crassulaceae) in Australia', *Biological Control*, vol. 100, pp. 101–107.

Conference and workshop proceedings

Allen, BL, Allen, LR, Amos, M, Carmelito, E, Gentle, MN, Goullet, M, Leung, LKP, McNeill, AT & Speed, J 2016, 'Peri-urban wild dogs: diet and movements in north-eastern Australia', *Proceedings of the 5th Queensland pest animal symposium*, Townsville, pp. 87–90.

Amos, M, Pople, T & Brennan, M 2017, 'Negative social impacts of wild deer in Australia', *2016 national wild deer management workshop proceedings, Adelaide, 17–18 November 2016*, Invasive Animals Cooperative Research Centre, Canberra, Australia.

Brennan, M & Pople, A 2016, 'Chital deer—an expanding problem in North Queensland', *Queensland pest animal symposium*, Townsville.

Brooks, S, Setter, S, Gough, K & Setter, M 2016, 'Increasing foliar herbicide options for controlling *Clidemia hirta* (L.) D. Don.', *Proceedings of the 20th Australasian weeds conference*, Weeds Society of Western Australia, Perth, pp. 321–325.

Callander, JT & Dhileepan, K 2016, 'Biological control of parthenium weed: field collection and redistribution of established biological control agents', *Proceedings of the 20th Australasian weeds conference*, Weeds Society of Western Australia, Perth, pp. 242–245.

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

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

Dhileepan, K 2016, 'Update on biocontrol of weedy vines: cat's claw creeper and Madeira vine', *Working together to combat vine weeds in the SEQ bioregion*, Tweed Shire Council, Murwillumbah.

Elsworth, P, Wang, R, Rusli, M, Steinke, L, Minnis, S & Leung, L 2017, 'Rabbits do love their veg! the impacts on horticulture in south-east Queensland', *Proceedings of the 17th Australasian vertebrate pest conference*, Invasive Animals Cooperative Research Centre, Canberra.

Fancourt, B, Speed, J & Gentle, M 2016, 'Fighting like cats and dogs? Spatial and temporal activity of sympatric feral cats and dingoes in central Queensland', *62nd annual scientific meeting and symposium of the Australian Mammal Society*, Alice Springs.

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

Fancourt, B, Speed, J & Gentle, M 2017, 'Do dingoes supress feral cats? Spatial and temporal activity of sympatric feral cats and dingoes in central Queensland', *Proceedings of the 17th Australasian vertebrate pest conference*, Invasive Animals Cooperative Research Centre, Canberra, p. 119.

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.

Gentle, M, Oakey, J, Speed, J & Allen, B 2017, 'The application of genetics to improving peri-urban wild dog management', *Proceedings of the 17th Australasian vertebrate pest conference*, Invasive Animals Cooperative Research Centre, Canberra, p. 117.

Gentle, M, Oakey, J, Speed, J, Allen, BL & Allen, L 2016, 'Dingoes, domestic dogs or hybrids? genetics of peri-urban wild dogs in NE Australia', *Proceedings of the 5th Queensland pest animal symposium*, Townsville, pp. 83–86.

Gentle, M, Speed, J, Allen, BL, Harris, S & Haapakoski, H 2016, 'The persistence of PAPP in wild dog baits and considerations for peri-urban baiting campaigns', *Proceedings of the 5th Queensland pest animal symposium*, Townsville, pp. 107–110.

Harriott, L, Gentle, M, Traub, R, Soares Magalhaes, RJ & Cobbold, R 2016, 'Echinococcus granulosis and other zoonotic pathogens of peri-urban wild dogs in south-east Queensland', *Proceedings of the 5th Queensland pest animal symposium*, Townsville, pp. 92–94.

Jeffery, M & Brooks, S 2016, 'Eradication in the tropics: constantly changing and adapting', *Proceedings of the 20th Australasian weeds conference*, Weeds Society of Western Australia, Perth, pp. 23–27.

Jones, PK, Oakey, J, Day, MD & Vitelli, JS 2016, 'Improving the effectiveness of the release strategy for the array of *Dactylopius tomentosus biotypes* for the biocontrol of *Cylindropuntia* species by using DNA analysis', *Proceedings of the 20th Australasian weeds conference*, Weeds Society of Western Australia, Perth, pp. 137–140.

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

Marshall, D, Gentle, M & Alter, T 2017, 'Integrating ecological research and human dimensions: improving feral pigs management by fostering innovative community engagement', *Proceedings of the 17th Australasian vertebrate pest conference*, Invasive Animals Cooperative Research Centre, Canberra, p. 55.

Pople, A, Brennan, M, Amos, M, Kearns, B, McBride, K & Blokland, A 2017, 'Management of an expanding chital deer population in north Queensland', *Proceedings of the 17th Australasian vertebrate pest conference*, Invasive Animals Cooperative Research Centre, Canberra.

Pople, A, Gentle, M & Brennan, M 2016, 'Achieving pest control through sustainable wildlife use', *Conservation through sustainable use of wildlife conference*, Brisbane.

Pople, T, Mitchell, J & Kearns, B 2017, 'Managing wild deer in Queensland by trapping', *2016 national wild deer management workshop proceedings, Adelaide, 17–18 November 2016*, Invasive Animals Cooperative Research Centre, Canberra.

Snow, EL, Dhileepan, K & Taylor, DBJ 2016, 'The Jatropha webber (*Sciota divisella*): a potential biological control agent for *Jatropha gossypiifolia* (bellyache bush) from India', *Proceedings of the 20th Australasian weeds conference*, Weeds Society of Western Australia, Perth, pp. 237–240.

Taylor, DBJ & Dhileepan, K 2016, 'Prospects for the biological control of *Jatropha gossypiifolia: Stomphastis* sp. as a potential agent from South America', *Proceedings of the 20th Australasian weeds conference*, Weeds Society of Western Australia, Perth, pp. 233–236.

Vitelli, JS, Williams, AM, Riding, N, Chamberlain, A, Austin, P & Stampa, D 2016, 'Operation witch hunt; conjuring eradication of the parasitic red witchweed plant with trickery and potions', *Proceedings of the 20th Australasian weeds conference*, Perth, pp. 292–295.

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

Reports, newsletters, factsheets and theses

Bickel, TO, Perrett, C & Vitelli, J 2016, *Effect of pH and application mode on herbicide X efficacy to control aquatic plants*, Project Report to Sumitomo Inc., 26 pp.

Buru, JC 2016, *Comparative biology of two forms of an invasive vine, Dolichandra unguis-cati (L.) Lohmann (Bignoniaceae): implications for weed spread and biocontrol*, PhD thesis, Queensland University of Technology, 15 December 2016.

Dai, Y 2016, *Competitive performance of Cabomba caroliniana and native macrophytes in monoculture and mixed cultures in relation to density*, MSc thesis, School of Agriculture and Food Sciences, The University of Queensland.

Dhileepan, K 2016, *Prickly acacia biocontrol phase II: host specificity testing of agents from India*, final report (B.NBP.0638) submitted to Meat and Livestock Australia, July 2016, p. 56.

Dhileepan, K & Taylor, DBJ 2017, *Biological control of bellyache bush: host specificity testing of Jatropha leaf-miner*, final report (B.WEE 0147) submitted to Meat and Livestock Australia, April 2017, p. 18.

Gentle, M, Allen, B & Speed, J 2017, *Peri-urban wild dogs in north-eastern Australia: ecology, impacts and management*, PestSmart toolkit publication, Invasive Animals Cooperative Research Centre, Canberra, p. 91.

Haapakoski, H 2016, *NSW feral deer research trip, May 2016: lessons for Queensland*, report for the South East Queensland Feral Deer Working Group, Biosecurity Queensland.

Lee, A 2017, 2017 *cluster fence project newsletter*, Department of Agriculture and Fisheries, Toowoomba, 10 pp.

Minnis, S 2016, *How effective are fire, post-fire fumigation and destroying rabbit burrows, and post-fire shooting in reducing introduced rabbits but not native bandicoots?*, Hons thesis, The University of Queensland.

Steinke, L 2016, *The ecology and management of the European rabbit (Oryctolagus cuniculus) in the Lockyer Valley: a study into abundance, home range, spatial distribution and bait preference of rabbits living in farm sheds*, Hons thesis, The University of Queensland.

Vitelli, JS, Williams, AM, Riding, N, Chamberlain, A, Austin, P & Stampa, D 2016, *1st RWW efficacy report*, CEEPI, 6 March, 22 pp.

Vogler, W, Hosking, K & March, M 2016, *Heli-drop—an innovative herbicide application technique for prickly acacia control,* Department of Agriculture and Fisheries and Southern Gulf NRM.

Vogler, W, Hosking, K & March, M 2016, *Managing cattle movement of prickly acacia for spread prevention*, Department of Agriculture and Fisheries and Southern Gulf NRM.

Vogler, W, Hosking, K & March, M 2016, *Spray misting—a new method for prickly acacia control,* Department of Agriculture and Fisheries and Southern Gulf NRM.

Print media

Day, MD 2016, 'Sap-sucking bug delivers coral cactus treat', *Queensland Country Life*, 6 December.

Day, MD 2016, 'Cochineal bug doing the job on coral cactus', *North Queensland Register*, 8 December.

Dhileepan, K 2016, 'Finding the natural enemies: population migration', *Feedback* (Meat and Livestock Australia's members magazine), August/September 2016, p. 31.

Vogler, W 2016, 'Spray new help in battle', *Northern Miner*, 15 August.

Radio/TV

Campbell, SD 2017, *Dry Tropics pest advisory forum and Tropical Weeds Research Centre open day*, Southern Cross Austereo radio stations and ABC Rural, 5–9 June.

Day, MD 2016, *Biocontrol of coral cactus*, ABC Radio, 3 November.

Elsworth, P 2017, *RHDV K5 rabbit control at Yatala*, ABC Gold Coast, 10 May.

Vogler, W 2016, *Navua sedge biology in 'Sempra & Banjo for control of Navua sedge in pasture*', Nufarm YouTube channel, December, ‹https://youtu.be/s6MMsWiZI2s›.

Conference presentations

Allen, L 2016, 'Production v profitability: beef production and pest management in northern Australia', *5th Queensland pest animal symposium*, Townsville, 8–10 November.

Elsworth, P & Brennan, M 2016, 'Rabbits in north Queensland', *5th Queensland pest animal symposium*, Townsville, 7–10 November.

Setter, MJ, Setter, SD, Brooks, SJ & Campbell, SD 2016, '*Stevia ovate*—not so sweet', *20th Australasian weeds conference*, Perth, 14 September.

Williams, AM 2016, 'Operation witch hunt: conjuring eradication of the parasitic red witchweed plant with trickery and potions', *20th Australasian weeds conference*, Perth, 14 September.

Posters

Cremasco, P & Bacchiella, D 2017, 'A strategy for effectively managing feral pig impacts in agricultural enterprises in northern Queensland', *Proceedings of the 17th Australasian vertebrate pest conference*, Invasive Animals Cooperative Research Centre, Canberra, 1–4 May, p. 141.

Pukallus, K 2016, '30 years of entomological biological control on invasive weeds from the Tropical Weeds Research Centre, North Queensland', *4th combined Australian and New Zealand entomological societies conference*, Melbourne, 27–30 November.

Forums and workshops

Allen, L 2016, *Wild dog ecology; Types of sets; Trap locations*, Trapper training workshop, Brian Pastures RS Gayndah, 6–8 September.

Allen, L 2017, *Wild dog ecology; Types of sets; Trap locations*, Trapper training workshop, Brian Pastures RS Gayndah, 21–23 March.

Brooks, SJ 2016, *Research update*, National Tropical Weeds Eradication Program Management Committee meeting, Cairns, 8 September.

Campbell, SD 2016, *Herbicide and fire research on invasive grasses*, Invasive grasses workshop, Townsville, 22 November.

Campbell, SD 2016, *Navua sedge*, Navua sedge information day, Malanda, 18 October.

Campbell, SD 2016, *Research update*, Gulf Pest Taskforce meeting, Hughenden, 22 November.

Cremasco, P 2016, *Aerial baiting of feral pigs with 1080 injected meat*, Southern Downs local government biosecurity workshop, Stanthorpe, 12 December.

Day, MD 2016, *Capacity-building workshop for the small island developing states of the Pacific*, Convention on biological diversity/South Pacific Regional Environment Program/Secretariat Pacific Communities, Apia, Samoa, 8–9 August.

Day, MD 2016, *Fifth international steering committee meeting*, CABI, Yogyakarta, Indonesia, 22–23 September.

Day, MD 2016, *Fourth Pacific invasives learning network meeting*, South Pacific Regional Environment Program, Lepa, Samoa, 4–5 August.

Day, MD 2016, *Second regional workshop on classical biological control (CBC) of invasive alien species and action planning*, CABI, Bogor, Indonesia, 18–19 August.

Day, MD 2017, *Dry Tropics pest advisory forum and Tropical Weeds Research Centre open day,* Tropical Weeds Research Centre, Charters Towers, 9 June.

Day, MD 2017, *Plant protection technical training course in South and Southeast Asia*, Yunnan Academy of Agricultural Sciences, Kunming, China, 19–30 June.

Dhileepan, K 2016, *Sub project 7—parthenium (fast-tracking and maximising the long-tasting benefits of weed biological control for farm productivity),* Meat and Livestock Australia project team meeting, Melbourne, 5 and 6 September.

Dhileepan, K 2016, *Update on biocontrol of parthenium weed in south and southeast Qld*, SEQ pest advisory forum, December.

Dhileepan, K 2017, *Biological control of bellyache bush*, Mareeba Council Pest Management Advisory Committee meeting, Mareeba, 20 April.

Dhileepan, K 2017, *Parthenium (fast-tracking and maximising the long-tasting benefits of weed biological control for farm productivity)*, Meat and Livestock Australia project team meeting presentations, Melbourne, 8 and 9 March.

Dhileepan, K 2017, *Prickly acacia (new biocontrol solutions for sustainable management of weed impacts to agricultural profitability)*, RIRDC project team meeting presentations, Melbourne, 8 and 9 March.

Gentle, M 2016, *Peri-urban wild dog research—an update*, South-east Queensland pest advisory forum, Highfields, 12 September.

Hosking, K 2016, P*rickly acacia: spray misting, heli-drop and cattle feeding trial*, Gulf Pest Taskforce meeting, Hughenden, 22 November.

Hosking, K 2016, *War on western weeds*, Charters Towers School of Distance Education students, Charters Towers, 25 October.

Osunkoya, 00 2016, *Prioritization of pest plants and animals for improved research and management decisions*, South East Queensland pest advisory forum, Brisbane, November.

Pukallus, K 2016, *Biological control*, The University of Queensland St Lucia northern tour students and glasshouse walk-through, Tropical Weeds Research Centre, Charters Towers, 13 July.

Pukallus, K 2016, *Biological control*, Tropical Weeds Research Centre facilities tour, distance education students, Charters Towers, 26 October.

Pukallus, K 2016, *DAF stand*, Dalrymple trade training centre careers expo day, Charters Towers, 27 July.

Pukallus, K 2016, *DAF/CTRC stand*, Charters Towers show, Charters Towers, 1 August.

Pukallus, K 2016, *Tour of facilities & biological control overview*, Biosecurity Queensland science leaders visit, Tropical Weeds Research Centre, Charters Towers, 8 September.

Pukallus, K 2017, *Current biological control projects at TWRC tour of facilities*, Regional Pest Management Group, Tropical Weeds Research Centre, Charters Towers, 28 February.

Pukallus, K 2017, *DAF soil workshop for students*, Tropical Weeds Research Centre, Charters Towers, 19 May.

Pukallus, K 2017, *Tour of biological control facilities & identification of established agents*, Dry Tropics pest advisory forum and Tropical Weeds Research Centre open day, Charters Towers, 9 June.

Speed, J 2016, *Ejectors in peri-urban areas—research findings*, South-east Queensland pest advisory forum, Highfields, 12 September.

Vitelli, JS 2017, *Herbicides—the ying and yang of weed control*, Dry Tropics pest advisory forum and Tropical Weeds Research Centre open day, Tropical Weeds Research Centre, Charters Towers, 9 June.

Vitelli, JS 2017, *RWW eradication response (efficacy) trial progress*, Update on RWW management to the sugar cane industry and infested owners forum, Canegrowers boardroom, Mackay, 8 May.

Vitelli, JS 2017, *Update on GRT research*, Fraser Coast Regional Council giant rat's tail grass—an integrated approach information day, Woocoo Hall, Oakhurst, Maryborough, 29 April.

Vogler, W 2016, *Prickly acacia war on western weeds project*, DAF regional leaders team meeting, Charters Towers, 8 September.

Vogler, W 2016, *Prickly acacia war on western weeds project*, The University of Queensland students, Charters Towers, 13 July.

Vogler, W 2017, Collecting, preparing and submitting herbarium specimens, Dry Tropics pest advisory forum and Tropical Weed Research Centre open day, Charters Towers, 9 June.

Vogler, W 2017, *War on western weeds: taking the WoWW out of prickly acacia*, Regional Pest Management Group meeting, Charters Towers, 8 June.

Vogler, W 2017, *Weedy grasses—is there a management collective for all?* Regional Pest Management Group meeting, Charters Towers, 28 February.

Williams, AM 2016, *BQ's red witchweed experience*, Weed Society of Queensland annual general meeting, Leslie Research Facility, Toowoomba, 25 November.

Lectures and seminars

Bickel, TO 2017, *Weed science PLNT3012/6894: aquatic plant ecology and management*, The University of Queensland, Gatton, 12 May.

Brooks, SJ 2016, *Research on eradication target species*, The University of Queensland students, Charters Towers, 13 July.

Campbell, RE 2017, *Influence of soil type on flupropanate availability*, School of Earth & Environmental Science, The University of Queensland, St Lucia, 30 May.

Campbell, RE 2017, *Influence of soil type on flupropanate availability: a case study on weedy Sporobolus grasses*, School of Earth & Environmental Science, The University of Queensland, St Lucia, 23 May.

Campbell, SD 2016, *Introduction to the Tropical Weeds Research Centre*, The University of Queensland students, Charters Towers, 13 July.

Campbell, SD 2017, *Introduction to weeds*, Blackheath and Thornburgh College year 7 students, Charters Towers, 20 March.

Day, MD 2016, *Biological control of* Mikania micrantha, Yunnan Academy of Agricultural Sciences, Kunming, 6 December.

Day, MD 2016, *Biological control of weeds*, Yunnan Academy of Agricultural Sciences, Kunming, 6 December.

Day, MD 2017, *Biological control of weeds*, The University of Queensland, Gatton, 26 April.

Day, MD 2017, *Careers in weed biocontrol*, The University of Queensland, St Lucia, 25 May.

Gentle, M 2017, *Vertebrate pests—overview and control strategies*, Veterinary School, The University of Queensland, Gatton, 21 March.

Snow, L 2017, *Cat's claw creeper biological control program with a local case study*, Brisbane biodiversity seminar—west, Latvian Hall, Woolloongabba, 7 March.

Vitelli, JS 2016, *Herbicide review—Gympie Regional Council*, Gympie Regional Council's parthenium information day, John St Depot, Gympie, 13 September.

Vitelli, JS 2016, *Parthenium prevention is certainly better than the cure*, Gympie Regional Council's parthenium information day, Kilkivan Hall, Kilkivan, 5 November.

Vitelli, JS 2017, *GRT research update*, Fraser Coast Regional Council giant rat's tail grass management—an integrated approach information day, Woocoo Hall, Oakhurst, Maryborough, 29 April.

Field days

Bickel, TO 2017, *Management of water hyacint*h, Corinda State High School, Corinda, 22 May.

Campbell, SD 2016, *Control research*, Willows cactus information day, The Willows, 16 November.

Campbell, SD 2017, *Determining the longevity of weed seed banks*, Dry Tropics pest advisory forum and Tropical Weeds Research Centre open day, Charters Towers, 9 June.

Campbell, SD 2017, *TWRC display*, Northern beef producers expo, Charters Towers Showgrounds, Charters Towers, 3 March.

Elsworth, P 2017, *Rabbit control: warren ripping demonstration*, Rabbit management field day, Queensland Murray–Darling Committee and Southern Downs Regional Council, Wallangarra, 5 May.

Jones, P 2016, *Biocontrol of Cylindropuntia* spp., South West Natural Resource Management, Charleville, 13 December.

Jones, P 2017, *Biocontrol of Cylindropuntia* spp., North West Plains Sustainability Group, Grawin, New South Wales, 15 March.

Pukallus, K 2017, *Biological control on parkinsonia*, NQ Dry Tropics woody weed control demo day, Crooked Waterhole, Giru, 20 March.

Pukallus, K 2017, *TWRC biological control display and information*, Northern beef producers expo, Charters Towers Showgrounds, Charters Towers, 3–4 March.

Scientists in School program

Pukallus, K 2016, *Beetles and bugs (overview of insects)*, PCYC, Charters Towers, 4 July.

Pukallus, K 2016, *Brain break*, National Science Week, Millchester State School, Charters Towers, 12 August.

Pukallus, K 2016, National Science Week (robotics), Millchester State School, Charters Towers, 15–19 August.

Pukallus, K 2017, *DAF hermitage plant science competition*, Millchester State School, Charters Towers.

Technical highlights
Invasive plant and animal research 2016–17
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