Department of Agriculture and Fisheries

Technical highlights

Invasive plant and animal research 2015–16

Queensland Government

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COVER PHOTO: Releasing *Dactylopius tomentosus* on *Cylindropuntia* cactus, Wyandra

Contents

Introduction

This document summarises the 2015–16 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
- Robert Wicks Pest Animal Research Centre, Toowoomba
- Tropical Weeds Research Centre, Charters Towers
- Tropical Weeds Research Centre, South Johnstone.

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

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

Notable achievements of the research program for 2015–16 are outlined below.

Invasive plant research

- New biological agents continue to be assessed for control of prickly acacia, bellyache bush, Siam weed, mikania, lantana 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, and has been completed for the third cat's claw creeper agent. External funding will allow biocontrol agents to be considered for giant rat's tail grass and mother-of-millions over the next four years.
- 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 collected that will 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 several priority weeds in Queensland, including prickly acacia, calotrope, bellyache bush, Siam weed, lantana, chinee apple, night-blooming cereus, Navua sedge, stevia, Koster's curse, rubber vine, alligator weed, cabomba and Gamba, mission, grader and thatch grasses. This list of species will be expanded to include giant rat's tail grass, bogmoss (*Myaca fluviatilis*) and glush weed (*Hygrophila costata*) in 2016–17.
- 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-east Queensland and north Queensland. In south-east Queensland, the movements of rusa deer are being studied and monitoring methods developed to assess control operations in peri-urban areas. In north Queensland, collaborations with universities and interstate researchers are helping unravel the diet of chital deer and the determinants of their distribution.
- A site near Wallangarra with very high rabbit numbers has been established to monitor rabbit populations before an anticipated release of a strain of rabbit haemorrhagic disease (RHD Boost) in early 2017. Basic biological measurements on rabbit populations in far north Queensland (Charters Towers to Atherton) are being taken to understand how these populations survive in an environment that should be too hot during the breeding season for the populations to persist. We are also determining the impact of rabbits on horticultural crops and whether surface harbour is sufficient to support viable rabbit populations.
- We have completed an extensive field trial on peri-urban wild dog ecology and management in south-east Queensland. Various reports and recommendations from this work should appear during 2017.
- Two projects are underway to support management of feral cats. One uses genetics to identify boundaries for fluctuating and spatially variable populations in far-western Queensland. The second assesses a number of broadscale control methods for cats, particularly baiting (which has had success in Western Australia).
- We are also assessing the non-target impacts of two 1080 baiting practices for feral pigs—aerial application of meat baits and the use of fruit and vegetable baits. This is required by the Australian Pesticides and Veterinary Medicines Authority to support the registration of 1080 concentrate in Queensland for these uses.
- 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 are being collected on individual properties, both inside and outside the clusters. This evaluation will be invaluable as many more clusters have been proposed in the region.

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 2015–16 financial year, Biosecurity Queensland's Invasive Plant and Animal Research program received funding from a number of sources. Queensland Government base funds provided $2 million, contributions from the Land Protection Fund amounted to $2.1 million, and funding under contracts with external partners totalled $0.39 million (see 'External funding', page 26). Notable funding bodies for the latter were the Australian Government, Meat and Livestock Australia and the Invasive Animal Cooperative Research Centre.

Our research program for 2015–16 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', pages 27–28). 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 Emma Carlos

Project summary

There are many declared weeds for which we know very little about their seed ecology and longevity. In this project, the seed longevity of priority weeds is being investigated 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 and stevia.

During the past 12 months, findings on the seed longevity of chinee apple were published in *The Rangeland Journal*. A paper on the seed longevity of yellow oleander will also soon be submitted for publication. Testing of two batches of yellow oleander seeds collected two years apart and exposed to different seasonal conditions has determined that it has a short-lived seed bank with no seeds viable after 24 months, irrespective of soil type, level of pasture cover or burial depth.

In addition to the seed burial trial, a new seedling emergence study has commenced to provide additional information on the seed longevity of neem, leucaena, prickly acacia, chinee apple and mesquite. There is sometimes conjecture in the literature that seed burial trials can lead to quicker depletion of seed banks of weeds with large seeds, because they may be exposed to more fungal attack by being confined in bags. The seedling emergence trial will help confirm whether this is the case or not.

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.

2. Best practice management of wet tropics weeds

Project dates

July 2012 – June 2016

Project team

Melissa Setter and Stephen Setter

Project summary

The Wet Tropics bioregion of north Queensland is of high economic, social and environmental value. Unless they are well managed, numerous weed species threaten to degrade these values.

This research directly supports on-ground weed management by investigating aspects of weed ecology such as seed longevity, time to reproductive maturity, dispersal mechanisms and control options for priority species.

Longevity of Navua sedge (*Cyperus aromaticus*) in soil

Seeds were placed in packets at various depths in the soil profile. They were retrieved after set times and subjected to germination and viability testing. The last retrieval after 10 years in 2012 still had some viable seed, and the next retrieval is due in 2017 (15 years after burial).

Chemical control of bogmoss (*Myaca fluviatilis*)

A completed laboratory experiment tested the control efficacy of a range of herbicides on submerged bogmoss. These results will be used to design and implement an experiment on the control of floating and submerged bogmoss.

A shadehouse trial on herbicide control of emergent bogmoss is in progress. Plants are being established and the herbicide treatments will be implemented once they accumulate sufficient biomass.

Seed persistence in water (several species)

Laboratory trials on the viability of Navua sedge, leuceana, hymenachne, bellyache bush and neem seed after varying periods of immersion in fresh, brackish and saline water have been completed. Seeds were retrieved after 2, 4, 7, 14, 28, 42, 70 and 98 days immersion and then underwent germination testing.

Collaborators

- Biosecurity officers
- Biosecurity Queensland research officers and centres
- Far North Queensland Regional Organisation of Councils
- Cairns Regional Council
- Cassowary Coast Regional Council
- Tablelands Regional Council
- Land managers

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

Project dates

January 2007 – June 2017

Project team

K Dhileepan, Di Taylor and Liz Snow

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. The leaf rust *Phakopsora arthuriana* was also identified as a prospective biological control agent, and host-specificity testing of the rust is in progress 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.

Host range tests for Jatropha rust (*Phakopsora arthuriana*) was completed for 41 test plant species by CABI (United Kingdom). In quarantine tests, six non-target species, including three *Jatropha* species (*J. curcas, J. multifida* and *J. integerrima*) and three Australian natives belonging to two other genera within the same tribe, Crotonoideae (*Aleurites moluccana, A. rockinghamensis* and *Beyeria viscosa*), proved to be susceptible, supporting sporulation of the rust, although to varying degrees. Urediniospore dose-response experiments were conducted under quarantine conditions, but could not rule out non-target attack.

Further susceptibility assessments were initiated in November 2015 under natural field conditions in Trinidad, the origin of the rust strain under evaluation. Sporulation of Jatropha rust was evident on all bellyache bush plants causing premature leaf drop, whereas rust infection was less widespread and severe on *J. curcas*. There were only small inconspicuous red lesions on some leaves of the Australian non-target species *B. viscosa*. Symptoms indicative of responses to attack by Jatropha rust were more evident on older leaves of *A. moluccana* and *A. rockinghamensis*, but sporulating uredinia are yet to be confirmed. The field trial was continued into June 2016 and leaf samples will be sent to CABI (United Kingdom) for final assessment.

The Jatropha leaf-miner (*Stomphastis* sp.) from Peru was imported and its colony established in quarantine in November 2014. Under quarantine conditions, the leaf-miner has a short generation time of three weeks. No-choice, host-specificity testing of *Stomphastis* sp. has been completed for 31 non-target species so far. Larval development has only occurred on bellyache bush and the congener *J. curcas*. Development of *Stomphastis* sp. on *J. curcas* is not unexpected, nor is it a hindrance to the moth being released for the biological control of bellyache bush, as *J. curcas* is also an approved target for biological control.

The Jatropha gall midge (*P. longifila*) induces galls in shoot-tips, emerging leaves, petioles and stems resulting in shoot-tip dieback on *J. clavuligera* in Bolivia. The midge induced galls on bellyache bush under quarantine conditions in South Africa and in a field transplant trial in Bolivia, highlighting the suitability of the gall midge as a 'neoclassical' biological control agent for bellyache bush. Sampling of crop plants (potato, tomato, citrus sp., cotton and castor oil) grown in the vicinity of the areas with the native *Jatropha* species with gall midge incidence revealed no visible gall midge damage/symptoms on any of the crops, highlighting that gall midge is not likely to be a polyphagous pest of multiple crops. Further field trials in Bolivia are required to clarify the host range of this insect before it can be considered for importation into our quarantine facility in Brisbane.

Recent opportunistic surveys in India identified a webber, *Sciota divisella* (Lepidoptera; Pyralidae), as a prospective biological control agent for bellyache bush. The larvae of this moth feed on the leaves and fruits, and in the absence of these, the larvae bore into the stem from the shoot-tip. The moth was imported into quarantine in July and October 2015, and a colony of the moth has been established. Life cycle studies and host-specificity tests are in progress. Larval development has occurred on *J. curcas* and the exotic *Euphorbia grantii*; however, there has been no evidence of larval development on any of the other 21 species tested to date. A further 15 plant species remain to be tested.

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 and S Murugesan, Institute of Forest Genetics and Tree Breeding (Coimbatore, India)
- Tanya Scharaschkin, Queensland University of Technology
- A Raman, Charles Stuart University (Orange, New South Wales)

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.

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

Project dates

January 2007 – June 2020

Project team

K Dhileepan, Di Taylor and Jason Callander

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, the former appears insufficiently host-specific for release in Australia, while the latter two have proved difficult to rear in quarantine. There no other prospective agents available from India, so the search effort for new biological control agents has been redirected to Ethiopia.

The quarantine testing of the scale insect (*A. indicus*) sourced from India has been completed. A total of 84 test plant species have been subjected to no-choice host testing. Development of *A. indicus* females to reproductive maturity was supported by 17 of the non-target species tested, including native *Vachellia* spp., *Neptunia* ssp. and *Acacia* spp. In nymphal host-preference trials, prickly acacia was the preferred host, although 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. Hence, choice trials involving non-target test plants on which the scale completed development in quarantine in Australia are being undertaken in India to ascertain non-target risks under natural field conditions.

In a trial involving 13 test plant species (*Neptunia major, Acacia falcata, A. terminalis, A. filicifolia, A. cardiophylla, A. irrorata, A. deanei, A. parramattensis, A. mearnsii, A. decurrens, Vachellia sutherlandii, Ceratonia siliqua* and *Platylobium formosum*), 23 prickly acacia plants were found infested by the scale insect, but only two *N. major* plants and a single *V. sutherlandii* seedling recorded any scale insects. The trial will continue until June 2017 to determine whether the scale is damaging to these non-target plants and a population can be supported.

Widespread surveys in Ethiopia at 41 sites in December 2015 recorded natural populations of three *V. nilotica* subspecies (ssp. *Tomentosa,* ssp. *Indica* and ssp. *Leiocarpa*). The populations in the north were ssp. *Tomentosa*, the populations in the east were either ssp. *Tomentosa* or ssp. *Indica* or their hybrids, while the populations in the south were predominantly ssp. *Leiocarpa*. A gall thrips (*Acaciothrips ebneri*) inducing rosette galls in shoot-tips and sprouting axillary buds, a gall midge inducing leaf rachis galls, an eriophyid gall mite inducing red spherical leaflet galls, an eriophyid gall mite inducing creamy white fluted leaflet galls, and an eriophyid gall mite inducing leaflet, rachis and shoot-tip galls were identified as prospective biological control agents.

Based on damage potential, field host range and geographic range, the gall thrips was imported into high-security quarantine in Brisbane in December 2015. A colony of the gall thrips has been established and host-specificity tests are in progress. Preliminary no-choice, host-specificity testing on 14 non-target test plant species have recorded no galls on any of these species. The gall mites have been sent to South Africa for identification. More extensive native range surveys in climatically suitable areas identified by the CLIMEX model in Ethiopia and in neighbouring Sudan and Eritrea will be possible, with additional funding received from the Australian Government (Rural Research and Development for Profit Program) and the Rural Industries Research and Development Corporation.

Collaborators

- A Balu and S Murugesan, Institute of Forest Genetics and Tree Breeding (Coimbatore, India)
- Stefan Neser and Anthony King, Plant Protection Research Institute (Pretoria, South Africa)
- Mindaye Teshome, Forestry Research Centre (Ethiopia)
- Marion Seier and Kate Pollard, CABI (United Kingdom)
- A Raman, Charles Sturt University (Orange, New South Wales)

Key publications

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

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

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

Project dates

July 2001 – June 2017

Project team

K Dhileepan, Segun Osunkoya, Liz Snow and Joshua Comrade Buru (PhD student, Queensland University of Technology)

Project summary

Cat's claw creeper and Madeira vine are Weeds of National Significance in Australia. For cat's claw creeper, a leaf-sucking tingid (*Carvalhotingis visenda*), a leaf-tying moth (*Hypocosmia pyrochroma*) and a leaf-mining beetle (*Hedgwigiella jureceki*) have been field released. For Madeira vine, a leaf-feeding beetle has been released.

The tingid has become established widely and caused visible damage in the field. Evidence of field establishment of the leaf-tying moth was seen in two release sites (Boompa and Coominya) in south-east Queensland. At Boompa, the leaf-tying moth appears to have spread along local creeks and established widely in areas surrounding the release site (found up to 15 km from the initial release site, along Eel Creek up to Utopia National Park, near Boompa). There is no evidence of the moth establishment on other release sites to date. Monitoring of the establishment and spread of the moth will continue.

The jewel beetle (*Hedgwigiella jureceki*) was approved for release in 2012. A mass rearing and release program has seen 78 000 beetles released at 140 sites around Queensland. Many community groups became involved with mass rearing and so there have been many more insects released in addition to those released by our department. Preliminary surveys indicate beetles are present at or nearby most initial release sites. The beetle appears able to disperse well and results so far show a maximum spread of at least 6 km over a three-year period, particularly along areas of the Brisbane River. Early observations suggest that field establishment of the jewel beetle is likely. Mass rearing has largely finished, with a small colony kept for supply to community groups to begin their own projects.

Future research will focus on monitoring the establishment and spread of the leaf-mining beetle, the leaf-tying moth and the leaf-sucking tingid. Future research will also initiate host-specificity testing of two cat's claw creeper rust pathogens—a rust gall (*Uropyxis rickiana*) and a leaf rust (*Prospodium macfadyenae*) sourced from Brazil and Paraguay by CABI in the United Kingdom—if additional funds are available.

Joshua Comrade Buru (PhD student, Queensland University of Technology) continued his studies on morphological, ecophysiological and phenological variations between the two cat's claw creeper populations. The study identified significant differences between the two cat's claw creeper populations in leaf anatomy, plant micro-morphology, seed germination, polyembryony levels, growth traits and plant physiological traits. This may explain why one form of the cat's claw creeper is more invasive than the other. The thesis also explores how the intraspecific diversity in cat's claw creeper affects the preference and performance of the three cat's claw creeper biological control agents released to date.

The Madeira vine leaf-feeding beetle (*Plectonycha correntina*) has been released at 86 sites in Queensland. The beetle continues to be seen at many of the release sites, but there is no evidence of any widespread damage and dispersal of the beetle in the field. A small population of beetles was collected from Brookfield and Chapel Hill areas, and sent to South Africa with Dr Stefan Neser to augment their colony prior to release in South Africa.

Collaborators

- Tanya Scharaschkin, Queensland University of Technology
- Anthony King and Stefan Neser, Plant Protection Research Institute (Pretoria, South Africa)
- Marion Seier and Kate Pollard, CABI (United Kingdom)

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. Biological control of parthenium *(Parthenium hysterophorus)*

Project dates

July 2004 – June 2018

Project team

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

Project summary

Parthenium weed (*Parthenium hysterophorus* L.), a noxious weed of grazing areas in Queensland, is a Weed of National Significance in Australia. Biological control 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. The majority of these agents have become established and have proven 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 north Queensland and 16 in central Queensland) are being surveyed annually in autumn.

Parthenium is spreading further south and is emerging as a serious weed in south and south-east Queensland, where most parthenium biological control 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 federal

Department of Agriculture and Water Resources (Rural Research and Development for Profit Program) and Meat and Livestock Australia. Information on the population dynamics of parthenium in south-east Queensland is also needed. Hence, 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.

In north Queensland, surveys were conducted at three sites during April 2016, recording seven agents in low abundance. In central Queensland, surveys were conducted at 16 sites in November 2015 and March and April 2016, also recording seven agents. The stem-boring moth (*Platphalonidia mystica*) was recovered from four sites, confirming its field establishment in Queensland.

Surveys in south Queensland and south-east Queensland recorded the presence of only the *Zygogramma* beetle, *Epiblema* moth, *Bucculatrix* moth and planthopper (*S. concinna*). There was no evidence of other agents such as the *Smicronyx* weevil, *Listronotus* weevil, *Carmenta* moth and summer rust. In consultation and collaboration with community and regional council groups, 10 parthenium-infested sites were identified in south and south-east Queensland to release additional biological control agents. Approximately 3000 field-collected *Smicronyx* weevils and about 400 field-collected plants infested with *Listronotus* and *Carmenta* larvae from central Queensland were released into south Queensland. Winter rust (45 rust-infected plants and over 1000 rust-infected leaves) was released at eight sites in south Queensland. Glasshouse colonies of the *Listronotus* weevil and summer rust were recently established for mass rearing and field releases.

The Kilcoy site witnessed very high parthenium population biomass due to above-average rainfall, with no evidence of effective biological control. At the end of the parthenium season, there were only a very few galls by the stem-galling moth and a very few leaf-feeding adult beetles. There was no evidence of winter rust, summer rust or any other biological control agents. At Helidon Spa, the parthenium abundance remained low, but residual populations continued to persist throughout the year, including in the winter period. Winter rust was widespread and highly damaging during the cooler months. The *Smicronyx* weevil (introduced in April 2014 from central Queensland) is well established at the site, but there was no evidence of any other biological control agents.

Analysis of soil samples collected in 2013–14 found that parthenium had no clear effect on soil physical properties. Parthenium invasion was associated with an increase in microbial activity and an increase in the abundance of particular trophic groups of nematodes. A significant amount of viable buried seeds of the weed was detected in invaded soils, but a small amount of seeds were recorded in 'non-invaded' patches, suggesting these areas had been invaded in the past.

Collaborators

- Steve Adkins and Bo Yong Shi, The University of Queensland
- Rachel McFadyen (St George)
- S Raghu, CSIRO Ecosystem Dynamics
- Tom Garrett and Holly Hosie, Queensland Murray–Darling Committee
- Judith Symonds, Maranoa Landcare
- Ross Bigwood and Michelle Field, SEQ Catchments
- Greg Nicholson and Pat Ryan, Junction View Pest Management Group
- Glen Proctor, North Burnett Regional Council
- 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. w

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. Biological control of *Mikania micrantha*

Project dates

July 2014 – June 2016

Project team

Michael Day, Natasha Riding and Wilmot Senaratne

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. Mikania is the target of a national cost-share eradication program. However, recent cyclones have hampered the program and the latest review suggested that biocontrol options should be investigated.

The rust *Puccinia spegazzinii* is deemed host-specific, having been tested in four countries against a total of 175 species, representing 48 families and including 70 species in the Asteraceae family. The rust was subsequently released in several countries, including 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 no deliberate release was conducted. It is too early to confirm establishment in the Cook Islands and Palau.

In PNG, field monitoring and laboratory trials show the rust suppresses the growth of mikania. In both PNG and Vanuatu, where it has been widely released, anecdotal information suggests that mikania growth is being suppressed and

flowering reduced. The rust was imported into quarantine at the Ecosciences Precinct in Brisbane and was tested against species in the Eupatorieae family. 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

- National Agricultural Research Institute (PNG)
- National Agriculture Quarantine and Inspection Authority (PNG)
- CABI (United Kingdom)
- Ministry of Natural Resources (Palau)

Key publications

Day, M 2012, '*Mikania micrantha* Kunth—mile-a-minute', in M Julien, R McFadyen & J Cullen (eds), *Biological control of weeds in AustraliaL 160 to 2010*, CSIRO Publishing, Melbourne, pp. 368–372.

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.

8. Biocontrol of *Cylindropuntia* spp.

Project dates

March 2009 – June 2018

Project team

Michael Day, Peter Jones and Wilmot Senaratne

Project summary

The cacti *Cylindropuntia* spp. are native to tropical America. The group includes *Cylindropuntia rosea* (Hudson pear) and *C. tunicata*, both of which are found in Queensland and are statewide weed eradication targets, and *C. fulgida* and *C. imbricata*, which are more widespread weeds in Queensland and are subject to ongoing management. Seven biotypes of *Dactylopius tomentosus*, including one that had already been released in Australia in 1925 to control *C. imbricata*, were tested to determine their specificity and their effectiveness against each of the eight naturalised species of *Cylindropuntia* in Australia. All seven biotypes are host-specific to the genus *Cylindropuntia*.

The *D. tomentosus* ('cholla' biotype) released in South Africa was very effective against *C. fulgida* var. *fulgida* and *C. fulgida* var. *mamillata*, and approved for field release in Australia in December 2015. To date, it has been released at six sites in Queensland and single sites in New South Wales, South Australia and Western Australia. Applications seeking permission to release four other biotypes collected from the United States are currently being prepared. Host-specificity testing on 14 biotypes collected from the United States and Mexico in 2015 is underway.

Collaborators

- NSW Department of Primary Industries
- Dr Helmuth Zimmermann
- Local governments in central and western Queensland
- Desert Channels Queensland

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.

9. Biocontrol of *Lantana camara*

Project dates

July 1996 – June 2016

Project team

Michael Day, Natasha Riding (Ecosciences Precinct), Kelli Pukallus and Judy Clark (Tropical Weeds Research Centre)

Project summary

Lantana is a serious 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 viable in forestry or conservation areas, or are not cost-effective. Biological control is seen as the only viable option in many areas.

Although biocontrol of lantana began in Australia in 1914, recent research has emphasised the need to target agents that damage specific parts of the plant or 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 NSW 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 non-target 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. The budmite *Aceria lantanae* has been widely released in the field. However, populations have persisted at only a few sites around south-east Queensland and it is present at two sites in north Queensland. Field releases are continuing. Recent inspections in north Queensland has found *Falconia intermedia* causing substantial damage to both pink-edged red and pink flowering plants on the Atherton Tableland.

Collaborators

- CABI (United Kingdom)
- Plant Protection Research Institute (South Africa)
- NSW 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. 334–46.

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.

10. Biocontrol of *Chromolaena odorata*

Project dates

July 2011 – June 2017

Project team

Michael Day, Natasha Riding and Wilmot Senaratne

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-share eradication program until 2013. However, it was approved as a target for biocontrol in 2011, following several reviews. The gall fly *Cecidochares connexa* is deemed host-specific, having been tested in seven countries against a total of 122 species, representing 31 families and including 38 species in the Asteraceae, of which six 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 Brisbane Ecosciences Precinct in February 2012 and testing against Eupatorieae species commenced immediately. Twenty Eupatorieae species were tested in 'choice minus the host' plant trials, with some larvae completing development to adult on *Praxelis clematidea*. Further tests were conducted 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 has been submitted to the federal Department of Agriculture and Water Resources.

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.

11. Biological control of parkinsonia (*Parkinsonia aculeata*)

Project dates

March 2013 – September 2018

Project team

Kelli Pukallus, Judy Clark and Dannielle Brazier

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 caterpillar has been mass reared at the Tropical Weeds Research Centre, and releases began in early 2013 at sites encompassing the Burdekin, Whitsunday, Isaac, Central Highlands, Charters Towers and Townsville local government areas. Releases of UU have been made at over 70 sites, with more than 3200 adults, 187 000 pupae and 444 000 larvae/eggs released from the Tropical Weeds Research Centre to date. Release sites cover various terrains and climatic conditions—inland, dry, open woodland, gully, coastal and riparian areas—on 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 5 km from the nearest release site in several locations, with populations persisting throughout the year. External funding is available for the next two years to continue releases at new sites in central and northern Queensland, and to provide UU to colleagues for distribution in the Northern Territory and Western Australia.

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

12. Water weed management research

Project dates

October 2010 – July 2017

Project team

Tobias Bickel and Christine Perrett

Project summary

There are few registered herbicides available to manage aquatic weeds in Australia. We measured the effect of environmental factors and application technique on the efficacy of a new herbicide. The results of this project will help register the herbicide and deliver an efficient tool to manage aquatic weeds in the future.

The effect of water pH on herbicide efficacy to control native and exotic aquatic plants (two invasive target and two native non-target species) at submersed 200 ppb ai (parts per billion active ingredient) treatment was tested in aquaria. While there was no effect of pH on cabomba control, efficacy declined above pH 8 for sagittaria and hydrilla. Between pH 6 and pH 8, the herbicide achieved ~85% dry mass (DM) reduction for sagittaria, while at pH 8.5 DM dropped only by 15%.

A pond experiment tested efficacy of foliar compared to subsurface application to control floating aquatic weeds and sagittaria at two rates. The application mode (foliar vs subsurface) was irrelevant for water hyacinth and salvinia control. However, subsurface application (~38% DM reduction) was more efficient than foliar (~10%) application for sagittaria, with little effect of rate. Best water hyacinth and salvinia control were achieved at high rates (submersed 400 ppb ai, foliar 420 g ai ha^{-1}) (hyacinth ~70%, salvinia ~60% DM reduction).

Overall, we found pH did little to limit successful herbicide application, even though the product breaks down rapidly at a high pH. Floating aquatic weeds can be controlled through subsurface or foliar application at the highest label rates. Sagittaria is best targeted through subsurface application.

Collaborators

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

Key publications

Bickel, TO & Perrett, C 2016, 'Precise determination of aquatic plant wet mass using a salad spinner', *Canadian Journal of Fisheries and Aquatic Sciences*, vol. 73, pp. 1–4.

Bickel, TO & Schooler, SS 2015, 'Effect of water quality and season on the population dynamics of *Cabomba caroliniana* in subtropical Queensland, Australia', *Aquatic Botany*, vol. 123, pp. 64–71, DOI: 10.1016/j.aquabot.2015.02.003.

Bickel, TO 2015, 'A boat hitchhiker's guide to survival: *Cabomba caroliniana* desiccation resistance and survival ability', *Hydrobiologia*, vol. 746, pp. 123–134, DOI: 10.1007/s10750-014-1979-1.

13. 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 Tablelands region of north 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 ranked as the sixth highest priority weed in the *Tablelands Regional Council local area pest management plan: 2013–2017*. Candy leaf is also included in 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 *Stevia ovata* 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 better understand its ecology. Research into the following aspects has been completed:

- germination requirements
- reproductive maturity
- seed longevity in soil (in the wet and dry tropics of north Queensland)
- seed longevity in water
- pilot herbicide screening
- herbicide screening
- herbicide rate refinement.

Candy leaf is capable of reaching reproductive maturity quickly (within three months) under optimum conditions, and flowering and seeding is synchronized. Soil seed banks are short-lived with no viable seeds recorded after three years in trials undertaken in both the dry and wet tropics. In terms of herbicide control, foliar spraying with fluroxypyr (Starane™ Advanced), triclopyr/picloram/aminopyralid (Grazon™ Extra) and aminopyralid/fluroxypyr (Hotshot™) provides high mortality at certain rates. During 2015–16, a final herbicide experiment was implemented to see if these chemicals would also be effective if applied using splatter gun style equipment (i.e. low-volume, high-concentration applications).

Collaborators

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

14. Invasive grass ecology and management

Project dates

July 2006 – June 2016

Project team

Wayne Vogler

Project summary

Field studies on flupropanate effects on Gamba grass, perennial mission grass and thatch grass have been completed and all sites returned to the landholders. Spot application of flupropanate was effective in controlling Gamba grass and perennial mission grass and, once approved for use, offers an effective way of treating small infestations of these grasses. Thatch grass was not affected by flupropanate, meaning effective selective control for this grass has not been identified.

The use of flupropanate for pre-emergence control of grader grass has shown promising results; however, more research is needed to determine if this will be an effective control method.

Field testing of hormone herbicides (2,4-D and Dicamba) on grader grass to reduce seed set to near zero remains to be completed.

Collaborators

- Queensland Parks and Wildlife Service
- Biosecurity officers
- Mareeba Shire Council officers
- Landholders

Key publications

Abom, R, Vogler, W & Schwarzkopf, L 2015, 'Mechanisms of the impact of a weed (grader grass, *Themeda quadrivalvis*) on reptile assemblage structure in a tropical savannah', *Biological Conservation*, vol. 191, pp. 75–82.

Vogler, W & Green, W 2011, 'Spray topping: a potential tool for managing grader grass (*Themeda quadrivalvis*)', *Proceedings of the 11th Queensland weed symposium*, The Weed Society of Queensland, Brisbane.

Vogler, W & Owen, N 2008, 'Grader grass *(Themeda quadrivalvis*): changing savannah ecosystems', *Proceedings of the 16th Australian weeds conference*, The Weed Society of Queensland, Brisbane, p. 213.

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

Project dates

July 2008 – June 2017

Project team

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

Project summary

The project supports a range of stakeholders implementing transitional management plans by providing biological and management information on the former eradication target species *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 2015–16, a herbicide trial on *C. hirta* identified several low-volume and high-volume options to effectively control this weed in a rainforest environment. Following publication of research on low-volume herbicide applications for treating remote patches of *C. odorata*, this technique is becoming increasingly popular amongst field operators.

Both species have been included in seed packet burial trials to determine the longevity of soil seed banks. No viable *C. odorata* seed was retrieved from a trial in the dry tropics after six years burial in four different soil types, which is a similar time frame to previous trials in the wet tropics. Retrievals from a *C. hirta* buried packet experiment in the wet tropics reinforces field experiences that this species develops a persistent soil seed bank, as 20% of surface seed and 32–36% of buried seed was viable after five years burial. To better understand the potential distribution of both species, local seed lots were included in a constant and alternating temperature (thermo-gradient) experiment.

Collaborators

- Biosecurity officers
- Queensland Parks and Wildlife
- 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.

16. Progress reporting and biology of tropical weed eradication targets

Project dates

July 2008 – June 2018

Project team

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

Project summary

This project determines the key biological parameters influencing the field operations of the tropical weed eradication programs, such as seed-bank persistence, age to maturity and dispersal potential. The project also assesses control measures for these weeds.

Buried packet field trials investigating *Miconia calvescens, M. racemosa, M. nervosa* and *Mikania micrantha* seed persistence have been running for two to five years (depending on the species), with samples retrieved annually. A glasshouse trial of *Limnocharis flava* seed persistence under varying periods of immersion in water has been underway for four years now, with the driest annual treatments starting to exhibit lower seed viability. Seed-bank persistence of *L. flava* in the field has been monitored annually since 2003, with no viable seed retrieved in 2015, providing the first indication of possible seed-bank exhaustion for this species. During 2015–16, an additional site was established to further monitor seed-bank persistence and seedling population dynamics of *L. flava*.

Field crew data and observations on the growth to maturity and reproductive seasonality of invasive melastomes are being collated to refine guidelines for identifying and preventing seed-producing plants and investigations of survey accuracy. The third stage of an age-to-maturity pot trial on *M. micrantha* found most plants grew from cuttings to flowering in 112 to 154 days in a quarantine glasshouse. Initial flowering was only recorded in May, indicating that it is seasonally driven.

The project also develops and refines measures of eradication progress, and considerable advances were made in refining eradication reporting data to meet program milestones and improve spatial and temporal consistency for all target species.

Collaborators

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

Key publication

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

17. War on western weeds—adaptive management

Project dates

November 2013 – June 2017

Project team

Wayne Vogler, Emma Carlos, Nathan March and Kelsey Hosking

Project summary

The ability of spray misting to control prickly acacia regrowth has been shown using fluroxypyr (Starane Advanced®). A minor use permit for spray misting of prickly acacia is due for release in early July 2016.

Studies to identify seed and pod factors that indicate seed viability continued in 2015–16. The work determined that pod thickness, pod colour and seed colour are the key visual identifiers of seed viability. Seed is viable at low levels when it is hard and fully green, and highly viable when it is green/brown or fully brown. Some seed is also viable in pods that

are fully green but have begun to thicken. Pod colour is not a reliable indicator of seed viability, as even hard, brown seed can be found in pods that are almost entirely green. This study has identified that there is significant risk of seed movement by cattle when they graze pods, due to the variability of seed maturity within pods and the range of pod maturity present on prickly acacia trees.

Herbicide application technique trials have confirmed that heli-drop, quad bike spreader and the Epple scatter gun are effective tools for tebuthiuron application and have produced high rates of plant mortality.

Collaborators

- Southern Gulf Catchments
- Desert Channels Queensland
- Central West local government
- Central-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.

18. Herbicide application research

Project dates

July 2009 – June 2017

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. Bellyache bush, Siam weed and lantana can all now be effectively treated using this technique.

A screening trial involving six herbicide treatments (including an untreated control) was completed on rubber vine during 2015–16, with triclopyr/picloram (Picloram + triclopyr 400) found to be most effective on medium-sized plants that were growing as shrubs and not climbing up neighbouring trees. A second trial has now been implemented to refine rates for triclopyr/picloram (Picloram + triclopyr 400) and metsulfuron-methyl (Brush-Off®). Metsulfuron methyl has been included to see if higher rates than those used in the screening trial will provide greater mortality.

A rate refinement trial on prickly acacia was also completed during 2015–16. Aminopyralid/fluroxypyr (Hotshot™) was the best performing herbicide, but only moderate mortality (69–84%) was obtained across four application rates. Registration will not be progressed for prickly acacia using the splatter gun technique based on these findings.

In 2015–16, a screening trial was implemented near the Willows township to find effective herbicides and techniques (e.g. basal bark, cut stump, stem injection and foliar spraying) to control night-blooming cereus (*Cereus uruguayanus*). It is a cactus species that has become prolific around the gemfields of central Queensland.

Collaborators

- Northern Gulf Resource Management Group
- Central Highlands Regional Council
- Biosecurity officers

Key publication

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.

19. Using molecular approaches to detect the presence of invasive species

Project dates

July 2012 – June 2017

Project team

Joseph Vitelli, Jane Oakey, Peter Jones, Rose Campbell (industrial placement) and Barb Madigan (volunteer)

Project summary

This project aims to develop a methodology for the detection of environmental DNA (eDNA) of invasive species in aquatic systems. The initial test species are *Mimosa pigra* and *Annona glabra*, two wetland-associated pest plants. Both are Weeds of National Significance and are currently either the target of eradication (*M. pigra*) or extensive control efforts (*A. glabra*) within Queensland. Using eDNA to detect invasive species in aquatic systems could increase surveillance accuracy, decrease costs of surveys and increase sampling efficiency and therefore sample size, potentially leading to better delimitation and early detection of invasive species in these systems. The project will have a statewide focus and will combine field, glasshouse and laboratory studies.

The project consists of three parts:

1. probe development to amplify, confirm and validate eDNA detection
2. an assessment of eDNA release by the target species and decay rates to determine optimal water sampling strategies
3. field validation in catchments infested with either *M. pigra* or *A. glabra*.

Coding has recently been completed for *M. pigra* and *A. glabra*. Non-target species tested for the *Mimosa* sub-project (to reduce the incidence of false positives being detected from samples collected from the field) included *Acacia bidwillii*, *Acacia complanata*, *Acacia fimbriata*, *Acacia glaucocarpa*, *Acacia mearnsii*, *Acacia nilotica*, *Acacia podalyriifolia*, *Acacia salicina*, *Adenanthera pavonina*, *Albizia lebbeck*, *Albizia procera*, *Caesalpinia ferrea*, *Erythrina vespertilio*, *Leucaena leucocephala*, *Mimosa pudica*, *Neptunia dimorphantha*, *Neptunia gracilis*, *Neptunia major* and *Pultenaea lophantha*. Non-target species tested for the *Annona* sub-project included *A. squamosa*, *A. diversifolia*, *A. reticulata*, *A. cherimola*, *A. mucosa*, *A. atemoya*, *A. muricata*, *A. cherimola x squamosa*, *Rollinia deliciosa* and *Duguetia uniflora*.

Collaborators

- Mackay Reef Catchments
- Local governments
- Biosecurity officers, including Stacey Harris, Helen Haapakoski, Michelle Smith and Shane Haack

Key publication

Vitelli, JS, Oakey, J, Madigan, BA, Driver, L, Chamberlain, AA & Heard, TA 2011, 'Molecular tools help determine the origins of *Mimosa pigra* infestations in Queensland, Western Australia and the Northern Territory', *Proceedings of the 11th Queensland weed symposium*, The Weed Society of Queensland, Mackay, pp. 65–68.

20. Control packages for statewide weed eradication targets

Project dates

July 2008 – June 2018

Project team

Joseph Vitelli, Annerose Chamberlain 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 (currently 53 eradication target species are naturalised). Research includes investigating control options and collecting basic ecological data (e.g. time to reproductive maturity and soil seed-bank persistence). The project has a statewide focus (bridging both aquatic and terrestrial environments) and combines field, glasshouse and laboratory studies. Red witchweed and alligator weed were the main species investigated in 2015–16.

In a screening trial at the Ecosciences Precinct, the herbicide that controlled above-ground alligator weed biomass most effectively was the application of picloram granules. To confirm plant mortality, alligator weed pots are in the process of being sieved to determine below-ground biomass and root viability. In a field trial at Miram Vale, no regrowth was found on alligator weed treated with picloram 58 months earlier (August 2011).

An integrated control study has been established near Mackay to investigate 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. Packets of red witchweed seed are buried at various depths and then retrieved over time following treatment to assess control efficacy. Six months after treatment, the data are showing encouraging trends. As seed burial depth increases from the surface to 50 cm deep, seed viability increases from 61% to 69%. Treatments utilising herbicides (81% seed viability) do not significantly differ from the control (maintaining bare ground) treatment (77%). The catch crop, sorghum (17%), is having the biggest reduction in seed viability, followed by the fumigants, dazomat (38%) and ethylene (39%).

Collaborators

- Brisbane City Council
- Capricorn Pest Management Group
- Logan City Council
- Seqwater
- Brett Cawthray, Gladstone Regional Council
- Juliet Musgrave, Fraser Coast Regional Council
- Local governments
- Tony Dugdale, Department of Economic Development, Jobs, Transport and Resources (Victoria)
- Biosecurity officers, including Peter Austin, Dan Stampa, Michael Graham, Lyn Willsher, John Reeve, Stacey Harris, Dan McCudden, Helen Haapakoski, Michelle Smith, Shane Haack and Duncan Swan

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.

Falconia intermedia damage to pink flowering lantana, Atherton Tablelands

Rubber vine herbicide trial testing foliar and splatter gun applications

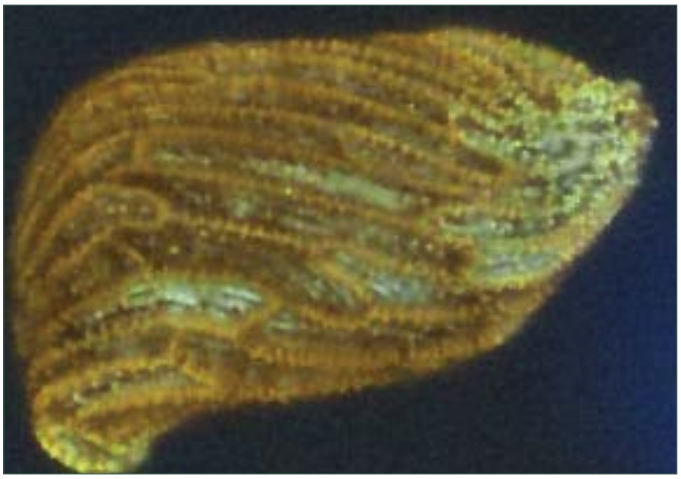
Mikania micrantha age-to-maturity pot trial, December 2015, Tropical Weeds Research Centre

Mikania micrantha age-to-maturity pot trial, April 2016, Tropical Weeds Research Centre

Seed longevity and seedling emergence trial, Tropical Weeds Research Centre

Stevia ovata low-volume splatter gun herbicide trial

Anna Williams and Natasha Riding burying red witchweed seed packets



Microscopic red witchweed seed

Bellyache bush biocontrol agent *Sciota divisella*

Dactylopius tomentosus biotype effective against *Cylindropuntia fulgida*

Jason Callander collecting parthenium biocontrol agents, Clermont

Field establishment of parthenium winter rust, Junction View, south-east Queensland

Jatropha leaf-webber larvae *Sciota divisella*, India

Jatropha rust field assessment trial, Trinidad

Juvenile prickly acacia plant severely infested with thrips galls

Prickly acacia scale insect field choice trial, Institute of Forest Gene

Testing herbicide application rates on various aquatic plant species—zero days after treatment

Testing herbicide application rates on various aquatic plant species—28 days after treatment

Chital deer, Charters Towers region, north Queensland

Cluster fence boundary, Tambo

Feral cat feeding on a macropod carcass

Mature chital stag with tracking collar, Charters Towers region, north Queensland

Setting a foot-hold trap for wild dogs

Wild dog with a tracking collar

Part 2: Pest animal management

21. Impacts of rabbits on vegetation dynamics in southern Queensland

Project dates

July 2013 – December 2015

Project team

Joe Scanlan, Michael Brennan and Peter Elsworth

Project summary

All grazing has the potential to influence pasture condition. Rabbits can exert considerable pressure on pasture from grazing, comparable to that of domestic livestock (Scanlan & Berman 1999). The pasture growth model GRASP now has the capability to simulate changes in pasture condition (Scanlan et al. 2014) as a result of changes in pasture utilisation (i.e. the amount of forage consumed as a proportion of amount produced). Utilisation depends on seasonal growing conditions (giving a particular amount of growth) and the number of grazing, domestic, native and feral animals (giving the amount of forage consumed).

Grazed and exclosed treatments were applied to areas with and without rabbits in the Stanthorpe area in 2007. Simulations based on the field data indicate that rabbit populations would have to be much higher and/or growing conditions much poorer than experienced during this trial work for rabbits to negatively impact on pasture or livestock production. The percentage of perennial grasses in the pasture improved in all treatments, whether grazed or exclosed from all grazing. The lack of any impact of rabbit grazing precluded any analysis of the economic benefit from grazing by rabbits. The approach outlined in Scanlan et al. (2013) could be followed if we used a conversion factor of rabbits to cattle in terms of their adult equivalents. A number of 100 rabbits per adult cattle equivalent has been proposed and used in previous work (Scanlan & Berman 1999).

Collaborator

- D Berman, Queensland Murray–Darling Committee

Key publications

Scanlan, JC & Berman, DMcK 1999, 'Determining the impact of the rabbit as a grazing animal in Queensland', *People and rangelands, building the future—proceedings of the 6th international rangeland congress*, pp. 520–521.

Scanlan JC, Berman, DM & Grant, WE 2006, 'Population dynamics of the European rabbit (*Oryctolagus cuniculus*) in north eastern Australia: simulated responses to control', *Ecological Modelling*, vol. 196(1), pp. 221–236.

Scanlan, JC, MacLeod, ND & O'Reagain, PJ 2013, 'Scaling results up from a plot and paddock scale to a property—a case study from a long-term grazing experiment in northern Australia', *The Rangeland Journal*, vol. 35(2), pp. 193–200.

Scanlan, JC, McIvor, JG, Bray, SG, Cowley, RA, Hunt, LP, Pahl, LI, Macleod, ND & Whish, GL 2014, 'Resting pastures to improve land condition in northern Australia: guidelines based on the literature and simulation modelling', *The Rangeland Journal*, vol. 36(5), pp. 429–443.

22. Rabbits in north Queensland

Project dates

July 2013 – June 2016

Project team

Peter Elsworth, Michael Brennan and Joe Scanlan

Project summary

Rabbits have traditionally been in low numbers in north 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 north Queensland to assess if and how they are increasing in number.

In southern and western parts of Queensland, the biology of rabbits is well known, and the corresponding control techniques to manage them are well known. This is not the case in north Queensland, where temperatures are generally higher than what is considered tolerable for successful breeding (Cooke 1977). Rabbits are, however, persisting in this region and so must be successfully breeding. Initial surveys have shown that rabbits are using hollow logs and bushes as harbour rather than constructing warrens. Breeding appears to be attempted year-round with reduced litter sizes. Further surveys will help identify the successful breeding periods and the environmental conditions that support successful breeding.

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 Austrwalia*, vol. 10, pp.113–120.

23. RHD Boost monitoring

Project dates

April 2014 – June 2017

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 resistance (Elsworth et al. 2012) and the presence of non-pathogenic rabbit calicivirus (RCV-A1) that provides partial protection against RHDV (Strive et al. 2009; Strive et al. 2013)

has led to the search for an additional strain of RHDV to be imported into Australia for release. This national project (RHD Boost) has completed laboratory testing and identified the best strain for release.

To assess its success in the wild, field sites are being established throughout Australia. In Queensland, two sites are being monitored to assess rabbit populations prior to and following the release of the RHD Boost strain. If successful, this new strain will help further reduce rabbit numbers, allowing for integrated control methods to be more effective. Additionally, communities will participate in the release of RHD Boost (RHDV-K5), which will require those groups to undertake monitoring pre- and post-release at additional sites in autumn 2017. Releasing RHDV-K5 at a number of sites across Queensland will increase the immediate impact on rabbit numbers and allow a greater opportunity for the virus to persist and spread in the wild.

Collaborators

- Invasive Animals Cooperative Research Centre
- CSIRO
- NSW Department of Primary Industries
- South Australia Biosecurity
- Shane Lampard, Somerset Regional Council
- Craig Magnussen and Peter Rouen, 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.

24. Assessing impact of rabbits on horticulture

Project dates

July 2013 – December 2016

Project team

Peter Elsworth, Michael Brennan and Joe Scanlan

Project summary

The economic cost of rabbits to agricultural industries in Australia is currently estimated at approximately $200 million per year (Gong et al. 2009). These figures, however, are produced from estimated losses to the beef and wool industries as a result of competition and loss of feed for cattle and sheep.

Very little is known about the impact that rabbits have on horticultural crops, although it has long been known that crops are eaten (Rowley 1963).

Queensland produces one-third of the nation's fruit and vegetable produce and is worth more than $2 billion per year (figures from Growcom). Many of the growing areas are in regions of high rabbit numbers or regions of rabbit expansion. Using controlled experiments, the damage of rabbits to certain horticultural crops is being determined. This will enable land users to make better management decisions regarding control of rabbits. Rabbits are using creeks and farm sheds as habitat in the Lockyer Valley and are damaging adjoining crops. Pen trials have shown that damage is most significant at the seedling stage, during which the entire plant can be destroyed. After this stage, crop damage becomes superficial and there is no loss to yield.

Collaborators

- The University of Queensland (Gatton)
- Growcom
- Somerset Regional Council
- Southern Downs Regional Council
- Darling Downs Moreton Rabbit Board
- Rugby Farms Pty Ltd

Key publication

Rowley, I 1963, 'Bait materials for poisoning rabbits. I. Studies on the acceptance of bait materials by caged rabbits', *Wildlife Research*, vol. 8, pp. 56–61.

25. Influence of type of harbour (warren vs above ground) on population viability

Project dates

January 2013 – December 2015

Project team

Joe Scanlan

Project summary

Based on data from the Cottonvale site near Stanthorpe, the mortality rate of rabbits that live in above-ground harbour is much higher than for rabbits that live in warrens. It is possible that rabbits that only live above-ground harbour may be unable to sustain a population. An individual-based model of rabbits in the region has been developed using NetLogo software. The model allows comparison of the effects of different habitat suitability (specifically the amount of harbour) on population dynamics and the impact of predation.

With reproductive and mortality rates observed during the trial at Cottonvale and other similar work, rabbits could survive in good, fair and poor habitat suitability in the absence of predation and with harbour. However, a modest amount of predation limited survival overall and prevented survival in the poor habitat. Survival of the population is very sensitive to the level of predation. A dynamic sub-model of predation pressure would provide better insight into rabbit

survival in this environment. Similarly, removal of harbour also reduced the likelihood of long-term survival. A feature not yet included in the model is predation being linked to rabbit populations (and therefore habitat suitability). Such a model could contribute to the regional scale modelling work done by Murray et al. (2014).

The general applicability of this model in Queensland may be limited. Initial results from a field study in north Queensland indicates that rabbits can survive (albeit at a low population) in areas with only above-ground harbour. To represent these situations, different reproductive and mortality parameters are required. While these could be estimated from the field results, it is inherently difficult to parameterise a model with two unknown rates that act in opposition. In this situation, there are many possible parameter sets that can produce the same observations.

Key publications

Murray, JV, Berman, DM & van Klinken, RD 2014, 'Predictive modelling to aid the regional-scale management of a vertebrate pest', *Biological Invasions*, vol. 16, pp. 2403–2425.

Ramsey, DSL, McPhee, SR, Forsyth, DM, Stuart, IG, Scroggie, MP, Lindeman, M & Matthews, J 2014, 'Recolonisation of rabbit warrens following coordinated ripping programs in Victoria, south-eastern Australia', *Wildlife Research*, vol. 41, pp. 46–55.

Scanlan JC, Berman, DM & Grant, WE 2006, 'Population dynamics of the European rabbit (*Oryctolagus cuniculus*) in north eastern Australia: simulated responses to control', *Ecological Modelling*, vol. 196(1), pp. 221–236.

26. Adaptive management of peri-urban deer in south-east 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-east Queensland have grown to a size where they are now considered serious pests. Their impacts range from agricultural production losses (crop and forestry damage, competition with livestock), browsing and grazing damage in conservation areas, to collisions with vehicles.

Deer populations appear to be growing, requiring management plans for current populations to consider the future by not just controlling current impacts but, ideally, containing populations and developing capability for future control. There has been limited control effort in south-east Queensland, but control is frustrated by few effective control tools, community opposition and concern over public safety and non-target injury when applying lethal control.

The project is focused on deer hotspots (primarily red and rusa) in northern Brisbane and, in particular, within the Noosa, Sunshine Coast and Moreton Bay regional council areas. These councils are monitoring deer species and conducting some control activities.

The project will assess the cost-effectiveness of removing deer through trapping and shooting, and the effectiveness of using radio-collared 'Judas' animals. Seasonal movements of deer will also be examined using radio telemetry. Community views on deer and their management will be canvassed to identify acceptable management action.

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. A toxin-delivery device has been built and deployed in a non-toxic trial, following success in New South Wales.

Collaborators

- Richard Mylan, Phil Herrington and Ken English, Noosa Shire Council
- Mark Kimber and Anthony Cathcart, Sunshine Coast Regional Council
- Rob Hunt, National Parks and Wildlife Service (New South Wales)
- Troy Crittle, Biosecurity, NSW Department of Primary Industries
- Biosecurity officers, Duncan Swan, Matt Ryan and Lyn Willsher
- 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.

27. Ecology and management of chital deer in north Queensland

Project dates

July 2014 – December 2017

Project team

Tony Pople, Mike Brennan, Matt Amos and Joe Scanlan

Project summary

Chital deer became established in north Queensland in the late 1800s. Over the past 20 years, they have increased in abundance and spread from their historic range. A landholder survey is documenting the timing and extent of this spread, and the view of chital deer as pests that compete with cattle. Some control is being undertaken, primarily ground shooting plus some interest in trapping, but it is uncoordinated and only done on some properties. Chital deer also provide income to landholders and safari hunting operators, and there is some potential for a game meat harvest. Thus, there are potentially conflicting objectives for deer management.

Over the past two years, the abundance of chital deer has declined on two intensively monitored properties based on vehicle spotlight counts. This decline coincides with two particularly dry years north of Charters Towers and has been mirrored by a decline in body condition. In March 2016, following good wet season rains and with most animals in above-average body condition, few mature females were reproducing (i.e. either pregnant or lactating), further highlighting the importance of food as a limiting factor and driving the population's dynamics.

A masters study has so far found a high proportion of grass in the diet of chital, which appears to increase during the wet season. A range of grass, forb and browse species are eaten. Near infrared reflectance spectroscopy is being used to broadly compare the diet of chital with cattle, and to determine whether deer faeces can adequately represent the diet of chital.

During the late dry season of 2015, camera traps set along 10 km transects on seven properties sampled a reported declining gradient of chital density away from homesteads. The cameras also detected wild dogs, feral pigs and macropods. The relationship among these species, homesteads and distance to water (dams, troughs) is being analysed. Chital are present in a high proportion (› 40%) of wild dog scats and make up about half of those scats, suggesting that predation is also an important influence on the population's dynamics.

A trial of a device that delivers non-toxic bait to deer (Hunt et al. 2014) and excludes non-target species is being undertaken on one property. Deer have so far shown little interest in feeding at the device, despite the dry conditions and a range of food types offered.

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)
- Neal Finch, Department of Environment and Heritage Protection
- Lauren O'Bryan and Rodney Stevenson, Biosecurity Queensland
- Ashley Blokland, Charters Towers Regional Council

Key publications

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.

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.

28. Peri-urban wild dog research

Project dates

June 2012 – June 2016

Project team

Matt Gentle, James Speed and Lee Allen

Project summary

This project aims to improve our understanding of wild dog ecology, impacts and management in peri-urban areas (where wild dogs are notoriously difficult to manage). Almost two-thirds of the funding is from the Invasive Animals Cooperative Research Centre.

The movement ecology of wild dogs was studied using satellite collars in the Sunshine Coast, Moreton, Gold Coast and Townsville local government areas. Thirty-seven collars were deployed and continuously monitored every 30 minutes for 11–394 days. Wild dogs were typically nocturnal and travelled an average of 6.9 km per day. The overall mean home range size was 17.47 km^2, and appeared to be constrained to suitable vegetation fragments. Wild dogs were residing within several hundred metres of urban residences and regularly travelled into suburban areas at night. Diet analysis indicated that peri-urban wild dogs are not reliant upon human-sourced foods, and so limiting access to these foods is unlikely to influence their abundance. Genetic data showed that most wild dogs in these areas are hybrid dingo/domestic dogs.

Resident reports indicate that wild dogs can maim and kill domestic pets and livestock, and occasionally harass but rarely attack people. The threat of actual and potential impacts can result in fear, distress and loss of amenity to residents. Wildlife attacks, including on koalas, are not uncommon and predation levels can be significant. We have also confirmed that wild dogs carry a variety of diseases and pathogens, and their proximity to people, pets and stock offer some potential for transmission.

The degradation rate of PAPP (a new toxin for wild dogs) in commercially manufactured baits was assessed in the Sunshine Coast hinterland. Buried baits degraded at a faster rate than surface-laid baits, but both retained dog-lethal doses of PAPP for considerable periods. This longevity will be potentially advantageous to target wild dogs colonising areas following baiting campaigns, but suggests caution is needed when determining safe withholding periods to protect working and domestic dogs. Ejectors may provide a suitable means to target wild dogs, but interference from people and pets will limit application in peri-urban areas. Baiting records show uneven spatial and temporal coverage, and highlight the difficulty in obtaining population-level control with baiting in peri-urban areas.

Overall, this project has highlighted that wild dog management strategies are constrained in peri-urban areas where it is difficult to apply control at scales suitable for holding wild dogs at low numbers. Control objectives may need to focus more on specific individuals, groups or impacts to ensure wild dogs responsible for impacts are targeted.

Collaborators

- Invasive Animals Cooperative Research Centre
- NSW Department of Primary Industries
- Meat and Livestock Australia
- Brisbane City Council
- City of Gold Coast
- Logan City Council
- Moreton Bay Regional Council
- Somerset Regional Council
- Sunshine Coast Regional Council
- Tweed Shire Council
- University of New South Wales
- Lana Harriott, Erin Carmelito, Alice McNeill and Marina Cursino, The University of Queensland
- Jane Oakey, Biosecurity Queensland (Coopers Plains)
- Ben Allen, University of Southern Queensland

Key publications

Allen, BL, Goullet, M, Allen, LR, Lisle, A & Leung, LKP 2013, 'Dingoes at the doorstep: preliminary data on the ecology of dingoes in urban areas', *Landscape and Urban Planning*, vol. 119, pp. 131–135.

Gentle, M, Allen, B, Speed, J & Allen, L 2014, 'The impacts and management of peri-urban wild dogs', *Program and abstracts 16th Australasian vertebrate pest conference*, Brisbane, p. 110.

Harriott, L, Gentle, M, Traub, R, Soares-Magalhaes, R & Cobbold, R 2014, 'Disease prevalence and public health risks of peri-urban wild dogs', *Program and abstracts 16th Australasian vertebrate pest conference*, Brisbane, p. 108.

29. 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, which would allow the removal of wild dogs and control of kangaroo and other pest populations inside the fenced area by denying immigration. With growing interest in, and public funding and construction of, exclusion/cluster fences in Queensland, there is a need to evaluate different pest management approaches and assess longer term benefits of cluster fences on livestock production, land condition and biodiversity. 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 biomass and condition 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 cluster with that of properties outside. Ultimately, the success of cluster fencing will be determined by the extent to which livestock production 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. This project will assist with the collection and analysis of relevant data for this determination to be made in the future.

There is a wide range of pasture/land types within the Morven cluster and in neighbouring areas. Ninety-six sites have been inspected, with most of these being recorded at least four times over the last 18 months. Both within and outside the cluster, pasture condition has varied over time, with no consistent trends evident at this stage. It will take many years before any differences between inside and outside the cluster can be detected.

Results from monitoring wild dog activity have shown autumn seasonal peaks during mating season and troughs during whelping and pup rearing on properties outside the cluster. Inside the cluster fence, wild dogs are now scarce due to the effort and resources put into controlling them. Kangaroo activity has steadily declined in the Morven cluster since the start of observations in November 2013. Monitoring of pest animal activity in the Tambo cluster has commenced.

Collaborators

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

Key publications

Allen, L, Engeman, R & Krupa, H 1996, 'Evaluation of three relative abundance indices for assessing dingo populations', *Wildlife Research*, vol. 23, pp. 197–206.

Allen, L & Engeman, R 2015, 'Evaluating and validating abundance monitoring methods in the absence of populations of known size: review and application to a passive tracking index'. *Environmental Science and Pollution Research*, vol. 22, pp. 2907–2915.

30. Non-target impacts of 1080 pig baits

Project dates

June 2014 – June 2018

Project team

Matthew Gentle, Peter Cremasco, Cameron Wilson and James Speed

Project summary

This project examines two feral pig 1080 baiting practices—aerial application of meat baits and the use of baits prepared from fruit and vegetable materials. These practices 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 on non-target species impacts for these methods. However, they have agreed to permit continued legacy use while studies are undertaken to collect and collate relevant data.

We reviewed the literature and other available data to define the issue and the appropriate research questions. We then designed and completed field studies in north Queensland, where baiting feral pigs with fruit containing 1080 is common. Baiting campaigns using fruit (primarily bananas and mangoes) were monitored for indicators of non-target risk, including visitation and consumption of bait material, non-target species deaths and changes in abundance of selected species. Preliminary results indicate minimal interference and uptake of fruit bait material by non-target species during best-practice pig baiting campaigns. 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 of feral pigs.

Collaborators

- Hinchinbrook Shire Council
- Herbert Cane Productivity Services

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.

31. Feral pig movements—individual and population-scale

Project dates

July 2014 – June 2017

Project team

Matthew Gentle and Joe Scanlan

Project summary

Biosecurity Queensland is assisting the Queensland Murray–Darling Committee (QMDC) to assess the movements of feral pigs (using GPS tracking) in an agricultural landscape of southern Queensland. This will improve our knowledge of feral pig movements and 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 will be sought to complete the DNA analysis.

The work is part of a professional doctorate (University of New England, Australia, and Penn State University, United States) study by a QMDC officer. This study aims to foster community engagement through scientific research. QMDC 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) has been delayed until late 2016 to fit in with other project milestones. Field sites have been approved and initial stakeholder workshops completed to implement the pre-treatment community engagement component.

Collaborators

- Queensland Murray–Darling Committee
- Origin Energy
- Queensland Gas Corporation
- SANTOS
- Various landholders, comprising farmers and graziers

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. 37, 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 2015, 'Integrating human dimensions and ecological research: improving feral pig management by fostering innovative community engagement', *Australian Wildlife Management Society 28th annual conference: wildlife management in a changing environment, Perth*, p. 72.

32. Feral cat ecology and management

Project dates

June 2014 – June 2018

Project team

Matthew Gentle, James Speed and Bronwyn Fancourt

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 National Parks and Wildlife Service management program. Laboratory methods have been identified and samples from core areas have been selected for initial 'proof of concept' testing. If initial tests are successful, we plan to increase the sample size and scope of this study to better determine population boundaries of feral cats in western Queensland.

Improving feral cat management techniques

Intensive control (such as that undertaken in the 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.

Alternatively, other means of presenting poison to cats may be applicable. For example, there is a device that sprays a toxin onto the coat of the cat, which then ingests the toxin during normal grooming behaviour. This can be used in combination with new technologies to improve target-specificity (e.g. cameras or other means to identify the target species).

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.

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)
- Sam Richards, University of Central Queensland
- Jane Oakey, Biosecurity Queensland (Coopers Plains)
- Diana Fisher, The University of Queensland

Key publication

Rich, M, Nolan, B, Speed, J & Gentle, M 2014, 'Lessons in feral cat control—can adaptive management provide the solution?', *Program and abstracts 16th Australasian vertebrate pest conference*, Brisbane, p. 43.

Part 3: Research services

33. Chemical registration—providing tools for invasive pest control

Project dates

July 2012 – June 2018

Project team

Joseph Vitelli and David Holdom

Project summary

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

Eleven new permits were issued to Biosecurity Queensland during 2015–16 by the Australian Pesticides and Veterinary Medicines Authority (APVMA). Eight permits related to weeds (African boxthorn, African Lovegrass, bitter weed, hymenachne, Kahili ginger, rubber vine, sagittaria, sicklepod, white ginger and yellow ginger), one permit related to an aquatic adjuvant and two permits related to pest animals (exotic birds, foxes and wild dogs).

Queensland was added as a jurisdiction to a minor use permit for the control of Madeira vine and cat's claw creeper growing in riparian zones, submitted by the NSW Department of Primary Industries. A further five permits (calotrope, feral cats, prickly acacia, salvinia and sodium hypochlorite) have also 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 officers, including Sonia Jordan, Steve Csurhes, Corey Bell, Craig Hunter, Michael Graham, Lyn Willsher, John Reeves, Stacey Harris, Michelle Smith and Duncan Swan

Key publications

Eleven new permits were issued by APVMA to Biosecurity Queensland during the 2015–16 financial year:

1. Permit (PER82158) Triclopyr/picloram/aminopyralid/Sicklepod, expires 31 March 2021, ‹http://permits.apvma.gov.au/PER82158.PDF›.
2. Permit (PER82156) Triclopyr/picloram/aminopyralid/Rubber vine, expires 31 March 2021, ‹http://permits.apvma.gov.au/PER82156.PDF›.
3. Permit (PER81752) Glyphosate/African boxthorn, expires 31 March 2019, ‹http://permits.apvma.gov.au/PER81752.PDF›.
4. Permit (PER81236) Nufarm Bonus Adjuvant/Surfactant/Herbicides, expires 30 June 2020, ‹http://permits.apvma.gov.au/PER81236.PDF›.
5. Permit (PER80964) Glyphosate/Artificial ponds, irrigation and natural waterways/Sagittaria, expires 30 September 2020, ‹http://permits.apvma.gov.au/PER80934.PDF›.
6. Permit (PER81265) Haloxyfop/Hymenachne, expires 30 June 2018, ‹http://permits.apvma.gov.au/PER81265.PDF›.
7. Permit (PER14004) Strychnine/Wild dogs and foxes, expires 31 March 2019, ‹http://permits.apvma.gov.au/PER14004.PDF›.
8. Permit (PER12745) Alphachloralose/Exotic birds, expires 30 June 2021, ‹http://permits.apvma.gov.au/PER12745.PDF›.
9. Permit (PER81084) Flupropanate/Pasture and non-crop situations/African lovegrass, expires 30 September 2018, ‹http://permits.apvma.gov.au/PER81084.PDF›.
10. Permit (PER12436) Metsulfuron-methyl, triclopyr, imazapyr and picloram/Various situations/Kahili ginger, white ginger and yellow ginger, expires 31 October 2020, ‹http://permits.apvma.gov.au/PER12436.PDF›.
11. Permit (PER12520) Various product/Non-cultivated areas of native and other vegetation/Bitter weed, expires 31 Janurary 2021, ‹http://permits.apvma.gov.au/PER12520.PDF›.

Queensland was also added to:

NSW permit (PER13914(v2)), Control of madeira vine and cats claw creeper in riparian zones, expires 31 March 2026, ‹http://permits.apvma.gov.au/PER13914.PDF›.

34. 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, Coopers Plains, Brisbane.

Forensic toxicology

Over the year, our laboratory performed more than 50 investigations into possible animal poisonings—34 for sodium fluoroacetate, eight for strychnine and 15 for anticoagulants. While most investigations related to domestic dogs and cats, some involved livestock.

Formulation chemistry

During the year, our formulation facility produced 1480 L of 1080 36 g/L pig bait solution in accordance with upcoming registration of the formulation with the Australian Pesticides and Veterinary Medicines Authority. New safety data sheets for several formulations were written to keep them updated and in the new required format. Testing of post-preparation sodium fluoroacetate solutions and meat baits continued throughout the year.

External funding

Research and development contracts

Project/research area	Funding body	Funds ($)
Weed biocontrol in Papua New Guinea	AusAID	48 000
Biological control of bellyache bush	Meat and Livestock Australia	105 000
Biological control of prickly acacia	Meat and Livestock Australia	19 000
Controlling calotrope in northern Australia	Meat and Livestock Australia	8 000
DNA sampling of pond apple	Reef Catchments	11 000
Biological control of Cylindropuntia cactus	Meat and Livestock Australia Rural R&D for Profit Program	7 000
Aquatic weed herbicide evaluation	Sumitomo	5 000
Peri-urban wild dog control	Invasive Animals Cooperative Research Centre	183 000
TOTAL		**386 000**

Rural Land Protection Fund

Project/research area	Funds ($)
Weed seed dynamics	14 000
Herbicide application research	146 000
Biological control of bellyache bush	117 000
Biological control of prickly acacia	86 000
Biological control of cat's claw creeper	123 000
Biological control of cactus	189 000
Biological control of lantana	64 000
Biological control of mother of millions	1 000
Rearing and release of weed biological control agents	196 000
Biocontrol evaluation	207 000
Water weed ecology and management research	146 000
Wet tropics best-practice research	13 000
Feral deer best-practice research	167 000
Wild dog best-practice research	120 000
Rabbit best-practice research	254 000
Non-target impacts of 1080 feral pig baits	67 000
Pesticide authorities	61 000
Pest management chemistry and chemical registration	98 000
TOTAL	**2 069 000**

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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, pp. 1–8.

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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, 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.

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Dhileepan, K, Lockett, CJ, Murugesan, M, Balu, A, Perovic, D & Taylor, DBJ 2015, 'Life cycle and host range of *Phycita* sp. rejected for biological control of prickly acacia in Australia', *Journal of Applied Entomology*, vol. 139, pp. 800–812.

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Mainali, K, Dhileepan, K, Warren, D, McConnachie, A, Strathie, L, Hassan, G, Karki, D, Shrestha, BB & Parmesan, C 2015, 'Projecting future expansion of invasive species: comparing and improving methodologies', *Global Change Biology*, vol. 12, pp. 4464–4480.

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Pople, T 2015, 'Requirements of tools to control feral cats', *National feral cat management workshop proceedings: University of Canberra*, Department of the Environment, Invasive Animals Cooperative Research Centre/PestSmart, Canberra, 21–22 April, pp. 67–73.

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Posters

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Bickel TO 2015, *Aquatic plant management research*, NQ Dry Tropics and local catchment volunteers, Townsville, September.

Bickel TO 2015, *Make it snappy speed talk: mosquito breeding in aquatic weeds?*, ESP science community, Brisbane, 20 August.

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Brooks, SJ 2015, *Research update and* C. hirta *impacts*, National Tropical Weeds Eradication Program Management Committee, 8 August.

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Campbell, SD 2016, *Neem tree impacts*, ecology and control, Lower Burdekin Landcare Committee meeting, Ayr, 14 June.

Campbell, SD 2016, *Seed longevity*, *splatter gun and cactus research*, Tropical Weeds Research Centre & Prior Street Department of Agriculture and Fisheries staff 'get together', Tropical Weeds Research Centre, Charters Towers, 11 February.

Campbell, SD 2016, *Weed research update*, Breeder nutrition and management and weed control workshop, Collinsville, 27 May.

Campbell, SD 2016, *Weed research update*, Burdekin Dry Tropics NRM Regional Pest Management Group meeting, Charters Towers, 10 February.

Carlos, E 2015, *Prickly acacia seed and pod maturity update*, WoWW Advisory Group meeting, Winton, 2–3 December.

Day, MD 2015, Increasing Pacific weed biocontrol collaboration workshop, New Zealand Landcare Research Ltd, Waikoloa, Hawaii, United States, 25 September.

Day, MD 2015, *Removing barriers to invasive species management in the production and protection forests in Southeast Asia*, International Steering Committee of UNEP/GEF, Bali, Indonesia, 9–12 December.

Day, MD 2015, *Weed biological control in Indonesia*, Forest Research and Development Center, Bogor, Indonesia, 16 December.

Day, MD 2016, *Acacia, Senegalia* and *Vachellia* taxonomy, phylogenetics and biocontrol workshop, Queensland Herbarium, Brisbane, 2 February.

Dhileepan, K 2015, *Malarial vector–parthenium weed interactions: to target weeds or vectors?*, Malaria vector–invasive weeds workshop (organised by Bill and Melinda Gates Foundation & CABI), Naivasha, Kenya, 2–4 December.

Dhileepan, K 2015, *Parthenium biological control in southeast Queensland*, South East Queensland Pest Advisory Forum meeting, Caboolture, 22 July.

Dhileepan, K 2015, *Parthenium biological control in south Qld*, South region meeting, 11 September.

Dhileepan, K 2015, *Weed biological control*, presentation to Korean visitors, Ecosciences Precinct, Boggo Road, Brisbane, 20 July.

Dhileepan, K 2016, *Field collection and redistribution of parthenium biocontrol agents*, Parthenium biocontrol workshop (organised by Mitchell Landcare & QMDC), Upper Maranoa River Catchment, Tooloombilla, Injune, 22 March.

Elsworth, PG, Minns, S, Rusli, M, Stienke, L, Wang, R & Leung, L 2015, Lockyer Valley Rabbit Group meeting, landholders and Lockyer Valley Regional Council, Gatton, 31 March.

Gentle, M 2015, *Peri-urban wild dog research—an update*, South-east Queensland Pest Advisory Forum, Gold Coast, Queensland, 24 November.

Gentle, M & Allen, B 2015, *Peri-urban wild dog research*, Wild dog theme meeting, Invasive Animals Cooperative Research Centre, Armidale, New South Wales, 11–13 November.

Gentle, M & Allen, B 2016, *Peri-urban wild dog research*, Wild dog theme meeting, Invasive Animals Cooperative Research Centre, Armidale, New South Wales, 23–25 February.

Jones, PK & Day, MD 2015, Hudson pear taskforce, Castlereagh Macquarie County Council, Lightning Ridge, 29 October.

Jones, PK & Day, MD 2016, Southern Inland Queensland Rural Lands Management Group meeting, Bulloo Shire Council, Thargomindah, 18–19 May.

Pukallus, K, 2016, *Biological control overview at TWRC*, Tropical Weeds Research Centre & Prior Street Department of Agriculture and Fisheries staff 'get together', Tropical Weeds Research Centre, Charters Towers, Australia, 11 February.

Pukallus, K, 2016, *Tour of TWRC biological control rearing facilities and project overview*, NQ Dry Tropics and Traditional owners (NQ), Tropical Weeds Research Centre, Charters Towers, 1 June.

Pukallus, K & Clark, J 2015, *Biological control overview and tour of TWRC facilities and UU release sites*, CSIRO research staff and visiting Korean scientists, Tropical Weeds Research Centre, Charters Towers, 21 July.

Snow, E 2016, *Biological control of cat's claw creeper in Qld*, Pest and Invasives Reference Group meeting, Brisbane City Council, Green Square, Fortitude Valley, 23 February.

Snow, E 2016, *Update on the biological control of cat's claw creeper*, SEQ Catchments Canopy Killer Forum, Beenleigh Events Centre, Beenleigh, 10 February.

Speed, J 2015, *Ejectors in peri-urban areas—research findings*, South-east Queensland Pest Advisory Forum, Gold Coast, Queensland, 24 November.

Vitelli, JS 2016, *RWW eradication response (efficacy) trial progress*, update on RWW management to the sugar cane industry and infested owners forum, Canegrowers boardroom, Mackay, 7 April.

Vogler, W 2015, *Prickly acacia control and farm biosecurity*, Dry Tropics Pest Advisory Forum, Kilcummin, 21 October.

Vogler, W 2015, *Prickly acacia research update*, WoWW Advisory Group meeting, Winton, 2–3 December.

Vogler, W 2016, *Invasive grasses*, Mareeba Shire Council Pest Advisory Committee meeting, Mareeba, 14 June.

Vogler, W 2016, *Prickly acacia seed passage through cattle*, Shire Rural Lands Officer Group meeting, Julia Creek, 31 March.

Vogler, W & Carlos, E 2016, *Visual cues and the impact of drying on seed germination*, Shire Rural Lands Officer Group meeting, Julia Creek, 31 March.

Lectures and seminars

Bickel, TO 2016, *Aquatic plant ecology and management*, School of Agriculture and Food Sciences, The University of Queensland, Gatton, 20 April.

Brooks, SJ 2015, *Research on eradication target species*, University of Queensland students, Charters Towers, 15 July.

Callander, J 2015, *Parthenium biological control in south and south east Queensland*, Entomology Society of Queensland, Ecosciences Precinct, 14 June.

Campbell, SD 2015, *Introduction to the Tropical Weeds Research Centre*, University of Queensland students, Charters Towers, 15 July.

Campbell, SD 2015, *Weed control*, School of Distance Education students, 'Red Bluff', Charters Towers, 15 September.

Day, MD 2015, *Biological control of weeds in Queensland*, Korean scientist delegation, Brisbane, 17 July.

Day, MD 2016, *Protecting ourselves from invasive plants with biological control*, Palau International Coral Reef Center, Koror, Palau, 8 June.

Elsworth, PG 2016, *Biological control—animal applications*, The University of Queensland, Animal and Plant Biosecurity, Gatton, Queensland, 4 May.

Pukallus, K 2015, *Biological control overview and TWRC projects*, University of Queensland students, Tropical Weeds Research Centre, Charters Towers, Australia, 15 July.

Vitelli, JS 2016, *Past, present and proposed GRT research*, Gympie Regional Council's giant rat's tail grass information day, Woolooga Hall, Queensland, 16 April.

Vitelli, JS 2016, *Proposed GRT research and other 'stuff'*, Gympie Regional Council's giant rat's tail grass information day, Woolooga Hall, Queensland, 15 April.

Field days

Brennan, M 2016, *Chital deer research*, Burdekin Regional Pest Management Group meeting, NQ Dry Tropics, Townsville, 10 May.

Campbell, SD 2016, *Best practice weed management for small blocks*, Dalrymple Landcare small block holders day, 'Leahton Park', Charters Towers, 7 May.

Campbell, SD 2016, *TWRC display*, Northern Beef Producers Expo, Charters Towers Showgrounds, 4 March.

Gentle, M 2015, *Feral cat research and management*, Predator control day, Gatton, 27 June.

Gentle, M 2016, *Vertebrate pests—overview and control strategies*, Veterinary School, The University of Queensland, Gatton, 9 March.

Pople, A & Brennan, M 2015, *Ecology and management of chital deer*, Chital deer management field day, Dalrymple Landcare, Gainsford station, Charters Towers, 10 September.

Pople, A & Brennan, M 2016, *History of spread, distribution and population dynamics*, Chital deer management field day, Dalrymple Landcare, Feldspar station, Charters Towers, 13 May.

Pukallus, K 2016, *TWRC biological control display and information*, Northern Beef Producers Expo, Charters Towers Showgrounds, 4 March.

Setter, MJ 2015, Stevia ovata *research update*, Tablelands Regional Council Stevia Task Force, Ravenshoe, 2 July.

Vogler W 2015, *Prickly acacia control and farm biosecurity*, NQ Dry Tropics woody weed field day, Bowen, 14 October.

Vogler, W 2016, *Navua sedge ecology and management*, Nufarm Navua sedge field day, El Arish, 6 April.

Vogler, W 2016, *WoWW prickly acacia and bellyache bush biological control*, Southern Gulf NRM innovation field day, Richmond, 27 April.

Vogler, W 2016, *WoWW prickly acacia seed and pod maturity*, Southern Gulf NRM innovation field day, Richmond, 27 April.

Vogler, W 2016, *WoWW prickly acacia seed passage through cattle*, Southern Gulf NRM innovation field day, Richmond, 27 April.

Vogler, W 2016, *WoWW prickly acacia spray misting*, Southern Gulf NRM innovation field day, Richmond, 27 April.

Vogler, W & Hosking, K 2016, *Rubber vine control using a splatter gun*, Southern Gulf NRM innovation field day, Richmond, 27 April.

Scientists in School program

Pukallus, K 2015–16, ***Scientists in School program***, Millchester State School, Charters Towers.

Pukallus, K 2015, *Science activities*, National Science Week, Millchester State School, Charters Towers.

Pukallus, K 2016, *DAF Hermitage plant science competition*, year 2/3, Millchester State School, Charters Towers.

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