

Biological control of parthenium weed: field collection and redistribution of established biological control agents

Jason T. Callander and Kunjithapatham Dhileepan

Biosecurity Queensland, Department of Agriculture and Fisheries, Ecosciences Precinct,
GPO Box 267, Brisbane, Queensland 4001, Australia
(jason.callander@daf.qld.gov.au)

Summary Parthenium (*Parthenium hysterophorus* L.), a noxious weed of grazing areas in Queensland (Qld), is a Weed of National Significance in Australia. 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 Qld.

Parthenium is spreading further into southern Qld, where many of the widespread and effective biological control agents in central Qld are not present. Hence, a program to redistribute these agents from central Qld to the south and south east of the state has been initiated. The seed-feeding weevil (*Smicronyx lutulentus* Dietz), the stem-boring weevil (*Listronotus setosipennis* (Hustache)), and the root-boring moth (*Carmentia* nr. *ithacae* Beutenmüller), the winter rust (*Puccinia abrupta* var. *partheniicola* Dietel & Holway), and the summer rust (*Puccinia xanthii* var. *parthenii-hysterophorae* Seier, Evans & Romero) have been identified as priority agents for redistribution.

So far, field collected winter rust, the *Listronotus* weevil, the *Smicronyx* weevil, the *Carmentia* moth and the leaf-feeding beetle (*Zygogramma bicolorata* Pallister) have been field released at ten sites in south and south east Qld. Field releases of the winter rust from glasshouse cultures were also made at several sites. So far there is evidence of field establishment of the winter rust and the *Smicronyx* weevil in some of the release sites.

Cultures of the summer rust and *Listronotus* weevil have recently been established at the Ecosciences Precinct for future mass rearing and field releases. Redistribution of field collected and glasshouse cultured biological control agents and monitoring their establishment status in the field will continue over the next three years.

Keywords *Parthenium hysterophorus*, biological control, redistribution, Queensland, Australia.

INTRODUCTION

Parthenium hysterophorus L. (Asteraceae), commonly known as parthenium, is a Weed of National Significance in Australia (Dhileepan and McFadyen 2012). The noxious weed predominately occurs in Queensland (Qld) affecting 17 million hectares of grazing land and reducing pasture production by as much as \$16.5 million dollars (AUD) annually (Chippendale and Panetta 1994).

Parthenium is an annual herb, which has the ability to germinate and grow year-round, provided it receives adequate rainfall. Like many weeds, parthenium is a prolific seed producer, with a single mature plant capable of generating in excess of 150,000 seeds (Dhileepan 2012).

Biological control of parthenium in Australia was first initiated in 1977. Since then, 11 agents have been released in parthenium infested areas of central and northern Qld including nine insect species, the seed-feeding weevil (*Smicronyx lutulentus* Dietz), the stem-boring weevil (*Listronotus setosipennis* Hustache), the root-boring moth (*Carmentia* nr. *ithacae* Beutenmüller), the leaf-feeding beetle (*Zygogramma bicolorata* Pallister), the sap-feeding plant-hopper (*Stobaera concinna* (Stål)), the leaf-mining moth (*Bucculatrix parthenica* Bradley), two stem-boring moths (*Epiblema strenuana* Walker) and (*Platphalonidia mystica* Razowski & Becker) and the stem-boring weevil (*Conotrachelus albocinereus* Fiedler) and two rust pathogens, the winter rust (*Puccinia abrupta* Diet. & Holw. var. *partheniicola* Jackson Parmelee), and the summer rust (*Puccinia xanthii* var. *parthenii-hysterophorae* Seier, Evans & Romero). Most of these agents have established in central Qld and most have proven effective against the weed there (Dhileepan and McFadyen 2012).

Parthenium is spreading into southern Qld and northern New South Wales, where many of the widespread and effective biological control agents, established in central Qld, have not yet extended. On this basis, the seed-feeding weevil, the stem-boring weevil, and the root-boring moth, the winter rust, and the summer rust have been identified as agents for redistribution into southern Qld.

MATERIALS AND METHODS

Identification of central Queensland collection sites Based on ten years of survey data, sixteen sites, historically shown to harbour parthenium biological control agents, were identified as potential collection sites in central Qld. Sites were visually surveyed for the presence of biological control agents and collections were made in November and December 2015 and in February/March and March/April 2016.

Stem and root boring agents were collected as larvae-infested stem and root material. Affected parthenium plants were uprooted and excess soil around the roots, leaves and flowers were removed and the plants were cut into 20 cm pieces before being placed upon a 2 cm layer of sand inside ventilated plastic containers. Cut plant pieces were covered with moistened paper towel to help keep plant material fresh to sustain the growth of larvae inside. Containers were transferred to the laboratory for emergence of adults.

Adult seed-feeding weevils were collected from maturing parthenium plants. Plants were visually inspected for weevils and occupied flower stems were removed and placed into ventilated cylindrical containers lined with moistened paper towel.

Glasshouse culturing A culture of the winter rust was established at the Ecosciences Precinct (ESP) shade house in autumn/winter of 2015 from rust infected leaf material collected at Helidon Spa. Six medium/large parthenium rosettes were placed into an inoculation chamber (50 × 50 × 50 cm, aluminium frame covered with plastic). Rust infected leaves were suspended, on a wire grid, above the healthy parthenium rosettes. The inside of the inoculation chamber was sprayed with a light mist of water and then sealed for 48 hours. Plants were removed from the chamber and grown at 15–23°C for about ten days, until rust pustules were observed. Rusty leaves were harvested three weeks post inoculation, when rust pustules were ripe, and used to inoculate new parthenium rosettes.

Glasshouse cultures of the stem-boring weevil and the summer rust were recently established at ESP following collections made in March/April 2016.

The stem-boring *Listronotus* adults were collected from emergence containers and transferred to oviposition cages (50 × 90 × 100 cm aluminium frame, covered with gauze) containing six parthenium plants, at pre-flowering stage, for one week. Adult weevils burrow into the soil during daylight hours and thus are hard to recover when exchanging old plants for new ones. To circumvent losing adults in this way, a pot tray was fitted around each potted parthenium plant, lined with gauze and filled with sand. Plants were inspected for oviposition, adults recovered from trays

around pots, and exchanged with new plants weekly. Infested plants were kept inside the glasshouse at 27°C for 4–6 weeks before being uprooted, trimmed and placed in emergence containers (as described above). Fresh parthenium leaves were placed on top of the moistened paper towelling as a food source for emerging adults, making it easier to collect them from the emergence containers.

Summer rust was collected from the Burdekin River in northern Qld in May 2016 and sent to ESP for establishment of a glasshouse culture. The summer rust was cultured using the same method as described above for the winter rust, except inoculation and growing of the infested plants was done in a temperature controlled glasshouse at 27°C.

Field release sites in southern Queensland Selection criteria were formulated for the identification of potential biological control release sites in south and southeast Qld. Sites were required to have at least a moderate infestation of parthenium, which was temporally persistent. Sites were not to be subjected to insecticide and herbicide sprays and accessible for the duration of the project, and therefore were in localities where eradication was not possible or where chemical control was not feasible.

RESULTS

Biological control agents in southern Queensland Preliminary surveys in parthenium infested sites in south Qld (e.g. Ceder Vale, Kamorooka, Womillia Creek, Bowood and Amby-Springfield Road) and in south east Qld (e.g. Kilcoy, Junction View, Helidon Spa, Summerset and Biggenden) indicated the presence of only the *Zygogramma* beetle, the *Epiblema* moth and the leaf-mining *Bucculatrix* moth. There was no evidence of other agents including the seed-feeding *Smicronyx* weevil, the stem-boring *Listronotus* weevil, the root-boring *Carmenta* moth and the summer rust. The winter rust, however, was found to be already established at Helidon Spa.

Collection sites in central Queensland Of the sixteen sites visited between November 2015 and April 2016 (Figure 1), only eight sites consistently had abundant biological control agents for collection and redistribution in southern Qld (Table 1). At Lotus Creek, Clermont and Old Orion Road the *Smicronyx* weevil was particularly plentiful; the *Zygogramma* beetle was collected in high numbers from Clermont in November 2015 but was found sparsely in subsequent collections; the *Carmenta* moth was recovered in high numbers from Sandhurst Bridge, Lotus Creek and Mooliyember Creek; the *Listronotus* weevil was the

Table 1. Parthenium biological control agents (SW = *Smicronyx* weevil; EM = *Epiblema* moth; LW = *Listronotus* weevil; CM = *Carmentia* moth; ZB = *Zygogramma* beetle; PM = *Platphalonidia* moth) present at collection sites in central Queensland surveyed in 2015/16.

Collection sites	Times surveyed	Agents present
Gracemere	3	SW, EM
Mount Hay	3	SW, EM
Wycarbah	3	SW, EM
Apis Creek	2	LW, SW
Lotus Creek	4	CM, LW, SW, EM
Carfax yard	1	SW
Clermont	4	CM, SW, EM, ZB
Morebridge	1	SW
Gaylong	3	EM
Gordon Road	3	
Sandhurst Bridge	4	CM, LW, SW, EM
Wyntoon	4	CM, LW, SW, EM
Old Orion Road	4	CM, SW, EM
Rolleston	4	CM, LW, SW, EM, PM
Mooliyember Creek	4	CM, LW, SW, EM, PM
Hutton Creek	3	CM, LW, SW, EM, PM

dominant agent collected from Mooliyember Creek; the *Epiblema* moth was present at most sites in high numbers; the *Platphalonidia* moth was recovered from sites south of Emerald and only at the end of the season. No biological control agents were recovered from parthenium at Carfax yard, Morebridge, Gaylong and Gordon Road sites in 2015–16.

Field releases of agents to date In consultation and collaboration with community and regional council groups, ten release sites were identified which met the above criteria (Figure 1).

Approximately 3000 field collected *Smicronyx* weevils were released across five sites and about 400 *Listronotus* and *Carmentia* infested plants (collect from central Qld) were supplied and distributed at three sites in southern Qld between November 2015 and March 2016 (Table 2).

Winter rust was released at eight sites in southern Qld. Forty-five potted, winter rust infected parthenium rosettes were planted in the Mitchel region at Ceder Vale (n = 5), Kamorooka, Womillia Creek, Bowood and along the Amby-Springfield road (n = 10 at each site). In addition, 100 winter rust infected parthenium leaves, collected from Helidon Spa, were scattered directly onto suitable parthenium rosettes at each of the abovementioned sites, as well as sites at Kilcoy, Summerset and Junction View.

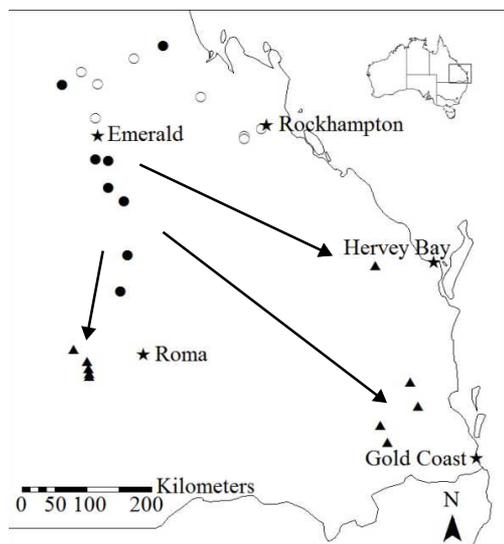


Figure 1. Map of central Queensland collection sites (circles indicate all collection sites, solid circles indicate key collecting sites) and southern Queensland release sites (solid triangles). Stars indicate nearby major cities or townships.

Table 2. Parthenium biological control agents released at each site (WR = Winter rust; SW = *Smicronyx* weevil; LW = *Listronotus* weevil; CM = *Carmentia* moth; ZB = *Zygogramma* beetle) in south and south east Queensland in 2015/16.

Region	Sites	Agents supplied/ released
South Qld	Ceder Vale	WR
	Kamorooka	WR, LW, CM, SW
	Womillia Creek	WR, LW, CM, SW, ZB
	Bowood	WR
	Amby-Springfield Road	WR
South East Qld	Kilcoy	WR, SW, ZB
	Junction View	WR
	Helidon Spa	SW
	Summerset	WR
	Biggenden	LW, CM, SW

To date, the winter rust appears to have established at both Summerset and Ceder Vale sites and the *Smicronyx* weevil has established at both Helidon Spa and Kilcoy sites. Monitoring of the other release sites will continue.

Despite parthenium being able to grow all year round, provided adequate rainfall, the peak growing season for the weed is between spring and autumn. For this reason, neither the *Listronotus* weevil nor the summer rust, cultured at ESP, have been field released during winter. While both these agents have mechanisms that enable them to persist over winter, the colder winter temperatures and sporadic frosts that occur in southern Qld are not conducive to the development and thus establishment of either agent. Cultures will continue through winter and then be ramped up to mass-rearing with releases planned for November 2016.

DISCUSSION

With the growing presence of parthenium weed in southern Qld and the absence of many effective agents, there was a need to expedite the spread of the highly effective agents from central Qld. Field collection and subsequent release of collected agents allows for a rapid and efficient means to get some of these more effective agents from central Qld down into parthenium infested areas of southern Qld. However, field collection alone will not be adequate to meet this challenge due to variability in the availability of parthenium and its biological control agents between central and southern Qld.

For example, due to a very dry spring, collections in November of 2015 were made of a very small range of agents which were present in low numbers. By December this had improved, and by February/March a greater variety of agents were collected and in greater numbers, although mainly between Emerald and Injune. Sites between Rockhampton and Emerald did not receive as much spring rainfall as areas south of Emerald, delaying the growth of the weed and ultimately delaying the buildup of agents in those sites (Table 1). Both the Lotus Creek and the Clermont collection sites situated were on the fringes of damns, and thus had their own source of water, minimizing their reliance on local rainfall.

By February/March many of the parthenium plants in southern Qld had matured (largely due to limited rainfall and dry conditions). Ideally the best time to release the insect agents and the summer rust into southern Qld is early in the growing season (from spring onwards), when parthenium grows vigorously,

and these agents have the best conditions to establish. This also allows time for the agents to complete several generations and prepare for winter (i.e. winter diapause). Unfortunately the optimal time to collect insect agents is later in the season once they have had time to build in numbers. The winter rust is, however, adapted to thrive during winter conditions and thus releases of this agent are best suited to the cooler months.

This necessitates the need for the establishment and mass rearing of one or more agents, to supplement the field release program. Although the summer rust was not present at any of the collection sites in central Qld, it is believed that the climatic conditions in southern Qld may be a better match for this agent. Future efforts will focus on the mass rearing and releasing of the summer rust and the *Listronotus* weevil in southern Qld between spring and autumn. During winter, the collection and redistribution of the winter rust will be the focus of work, as this is the only agent active then.

ACKNOWLEDGMENTS

The study was funded by the Rural Research and Development for Profit Program of the Australian Government (Department of Agriculture and Water Resources), the Meat & Livestock Australia and the Queensland Government (Department of Agriculture and Fisheries). We thank Queensland Murray Darling Committee (QMDC), South East Queensland Catchments, Junction View Pest Management Group and North Burnette Regional Council for their continued assistance in identifying potential release sites in southern Queensland. In particular we thank Tom Garrett (QMDC) and Glenn Proctor (North Burnette regional council) for their aid in the releasing biological control agents in their areas. We also thank Rachel McFadyen for her expertise and assistance with field collections and releases and Di Taylor and Boyang Shi for their technical support.

REFERENCES

- Chippendale, J.F. and Panetta, F.D. (1994). The cost of parthenium weed to the Qld cattle industry. *Plant Protection Quarterly* 9, 73-6.
- Dhileepan, K. (2012). Reproductive variation in naturally occurring populations of the weed *Parthenium hysterophorus* (Asteraceae) in Australia. *Weed Science* 60, 571-6.
- Dhileepan, K. and McFadyen, R.C. (2012). *Parthenium hysterophorus* L. – Parthenium. In 'Biological control of weeds in Australia: 1960–2010', eds M. Julien, R.E. McFadyen and J. Cullen, pp. 648. (CSIRO Publishing, Melbourne).