

A new biological control project against stemless thistle (*Onopordum acaulon*) in Western Australia

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Summary Stemless thistle (*Onopordum acaulon*) is a weed of warm temperate areas that receive less than 450 mm of rainfall per annum. In Western Australia, infestations have plant densities of up to 67 plants m⁻² with up to 84% of plants remaining vegetative during the spring/summer reproductive period. Infestations are maintained by high seed rains of up to 15,900 seeds m⁻² which supply a long-lived soil seed bank. A unique opportunity exists to implement the biological control of this species with agents that have been selected for and successfully established on *Onopordum acanthium* and *O. illyricum* in eastern Australia. To date the CRC for Australian Weed Management has released two species of agent in Western Australia, the seed head weevil *Larinus latus* and the petiole moth *Eublemma amoena*. Factors effecting their establishment are discussed.

Keywords *Onopordum acaulon*, *Larinus latus*, *Eublemma amoena*, biological control.

INTRODUCTION

Stemless thistle (*Onopordum acaulon* L.) is a prostrate, herbaceous plant originating from the Iberian Peninsula and North Africa (Amaral Franco 1976). Since its introduction into Australia in 1844, it has spread widely in South Australia, Victoria and New South Wales, where it is considered a weed of warm temperate areas that receive less than 450 mm of rainfall per annum (Parsons and Cuthbertson 1992). The thistle forms at times dense populations across an estimated 1.6 million hectares in these areas (Parsons and Cuthbertson 1992). There is no published information on the ecology of this weed in Australia.

Onopordum acaulon is a more recent invader of Western Australia (first recorded in 1955), and occupies a much smaller area of several thousand hectares in a similar climatic zone (Briese *et al.* 1990). However, while current herbicide-based control procedures have kept infestations small, they have not prevented the spread of the weed (Briese *et al.* 1990). Biological control therefore offers an additional management option that might prevent this thistle from becoming a more serious weed problem, such as occurs in eastern Australia.

The taxonomic affinity with the stemmed *Onopordum* species, *O. illyricum* L. and *O. acanthium* L., has

provided a unique opportunity to implement biological control on stemless thistle with insects that were selected primarily for the control of the stemmed species (Briese *et al.* 2002). Of the six species of insect selected for and released on the stemmed species, three have been identified as being immediately suitable for release on *O. acaulon*. They are the seed weevil (*Larinus latus* L.), the petiole moth (*Eublemma amoena* Hbn.) and the crown weevil (*Trichosirocalus briesei* Alonso-Zarazaga and Sanchez-Ruiz). The stem borer, (*Lixus cardui* ol.) was not considered suitable as the plant does not have the necessary phenology to support its larval development. The seed fly (*Urophora terebrans* Loew) and the rosette fly (*Botanophila spinosa* Rondani) may be considered for release on stemless thistle if they establish and impact on the stemmed *Onopordum* thistles in the future.

In this paper we report preliminary data on the demography of *O. acaulon* in Western Australia, necessary for the subsequent evaluation of biological control agent impact, as well as presenting results for the initial releases of two of these agents, *L. latus* and *E. amoena*, in Western Australia.

MATERIALS AND METHODS

The CRC for Australian Weed Management release project was set up with two main objectives: 1) release and establish available agents, and 2) gain insights into *O. acaulon* population dynamics and flowering phenology/seed production.

The first agent released in Western Australia was *L. latus*. The species was selected for two reasons: 1) it is having a significant impact on the seed production of the stemmed *Onopordum* species and 2) large field populations have built up in NSW, making the collection of large numbers of *L. latus* inexpensive and simple. While accessing insects for release has been easy, there has been a major technical hurdle to overcome in synchronising the oviposition period of *L. latus* with the flowering period of *O. acaulon*. Stemmed *Onopordum* thistles flower from late November until February (see Pettit and Briese 2000), while stemless thistle was observed to flower from September until December. In an attempt to resynchronise the oviposition period, insects were shipped to Perth at the end of summer 2001, so that they could over winter in

conditions closer to those that they would encounter upon release in the field. They were then given a natural Perth winter in a shade house. By the beginning of September 2001, *L. latus* was observed to be feeding on the *O. acaulon* rosettes provided in the cage in Perth. At this time, immature (green) capitula needed by *L. latus* for oviposition were becoming available in the field around Lake Grace and Salmon Gums and Grass Patch near Esperance. Between 50 and 95 adult weevils were subsequently free released into a thistle infestation free from stock-grazing at each of 21 sites during the last week of September.

A sub sample of release sites was then visited during the last week of November, to record plant density (10–20 42 × 42 cm quadrats per site), size (rosette diameter) and reproductive status. A random sample of mature capitula was taken to assess seed production and *L. latus* attack. In order to simplify the future calculation of seed production for the species a relationship between the size of the capitulum and the number of seeds produced was determined by regressing the numbers of seeds in individual capitula against their surface area in mm².

To date there have been two releases of *E. amoena* near Esperance. A caged release of 300 pupae of *E. amoena* was made in August 2000 and a release of 2000 final instar larvae was also made during November 2001. The mature larvae were transferred onto rosettes where they tunnelled into the plant tissue to complete feeding and pupate.

RESULTS

Onopordum acaulon demography Demographic data collected from three of the release sites from 2000 to 2002 showed that *O. acaulon* populations fluctuated in plant density between years, reaching levels of between 22 plants m⁻² and 67 plants m⁻² over the two years sampled (Figure 1).

Plants within these populations were quite variable in size (Figure 2). Moreover, as rosette size increased, an increasing percentage of plants eventually flowered and subsequently senesced (13, 16 and 47% in the increasing size categories, respectively) (Figure 2). The population entering summer, however, was dominated by plants which had remained vegetative (82%), rather than become reproductive (18%).

The linear regression model shown in Figure 3 explained 89% of the variance in seed produced by individual capitula. Seed production may therefore be estimated for *O. acaulon* by measuring the area of the capitulum and applying the equation:

$$y = 0.373x + 17.2$$

(where x = capitulum area in mm² and y = the number of seed produced).

Based on the plant density, proportion of plants flowering and the data used to derive this regression, the annual seed rain was estimated to vary from 240 seeds to 15,882 seeds m⁻² at the three sites.

Biological control Five of the 21 *L. latus* release sites were surveyed for insect development during November 2002. *L. latus* was found to be developing in capitula at four of those sites. A further sample of capitula taken from the Lake Grace site in late December indicated that 31 out of 52 (59%) of *L. latus* eggs laid developed through to adults emerging from capitula

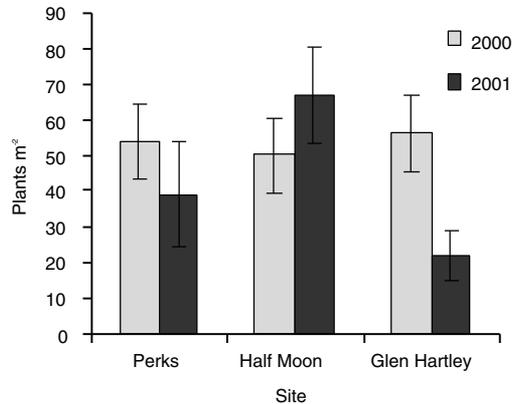


Figure 1. *O. acaulon* plant densities at three *L. latus* release sites in 2000–2001 and 2001–2002.

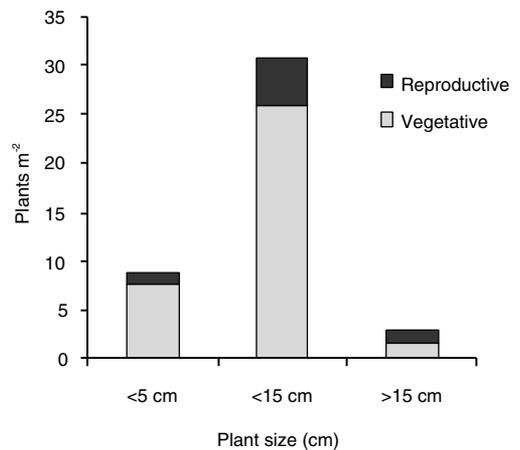


Figure 2. The mean numbers of *O. acaulon* plants across three size (rosette diameter cm) classes that flowered or remained vegetative at three sites during 2001.

(Table 1). The remaining 41% of observed individuals died before completing development.

Data for capitula damaged by *L. latus* indicate that the weevil is capable of having a significant impact on the seed production of *O. acaulon*, reducing the numbers of viable seed in individual capitula by up to 100% (see also Figure 3).

To date there is no evidence that the pupal release of *E. amoena* made in 2000 has established, this has been attributed to weather conditions at the time of the release and post-release drought. Immediately following the release, cold and wet conditions were experienced, which we believe reduced the number of adults emerging. The already reduced population of moths was then impacted upon by a prolonged spring/summer/autumn drought that reduced plant quality for larval development. The 2001 larval release was made at a separate site and at this stage it is too early to assess survival.

DISCUSSION

Onopordum acaulon ecology Parsons and Cuthbertson (1992) suggest that most *O. acaulon* rosettes that germinate during the growing season die with the onset

of summer drought, with some surviving the summer to become biennial under favourable conditions. The data presented here indicate that the flowering strategy of *O. acaulon* is more complex. Only 18% of plants flowered in this study, with plant size having a strong influence on the propensity to flower; 47% of the largest size category flowering compared to 13 and 16% of plants in the smaller categories. This suggests that *O. acaulon* behaves more as a facultative perennial than a true biennial, as size may also be considered a function of age. Importantly, the fact that 82% of the population remain vegetative during the summer has implications for control options.

Biological control prospects The petiole moth *E. amoena* produces two to three generations of adults on the over summering rosette population of stemmed *Onopordum*, with peak impact occurring during February/March as the larval population reaches its maximum for the season (Swirepik pers. obs.). If *E. amoena* establishes on *O. acaulon*, there is great potential for it to reduce the survival of over summering rosettes and/or reduce the size of those that survive attack. It is therefore important to make a concerted effort at establishing this species.

The impact of *E. amoena* may also be complemented by the successful release and establishment of the crown weevil *T. briesei*. This species attacks stemmed *Onopordum* rosettes from April until September in eastern Australia, causing plant death and/or a reduction in plant size during the growing season. Reducing plant size before the onset of flowering may also lower the proportion of flowering plants, exposing the remaining non-flowering plants to additional *E. amoena* attack and the stress of summer drought. This would lead to further mortality of plants prior to the onset of flowering (Rees *et al.* 1999), thus increasing the reliance of *O. acaulon* on its seed bank for the maintenance of populations. With time, and the reduced input due to pre-dispersal seed destruction by *L. latus*, this seed bank should be depleted, leading to control of the weed.

Larinus latus was found developing in heads at four of the five sites surveyed one year after release and 59% of eggs laid at Lake Grace led to adult emergence. This indicates that the resynchronisation of the species has at least been partially successful. These results compare favourably with egg to adult survivorship of *L. latus* on stemmed *Onopordum* in eastern Australia (Pettit and Briese 2000), where it has been recorded destroying over 90% of seed produced (Swirepik and Smyth 2002). This bodes well for the establishment of the species on *O. acaulon*, though it will be essential to determine whether there is differential attack by

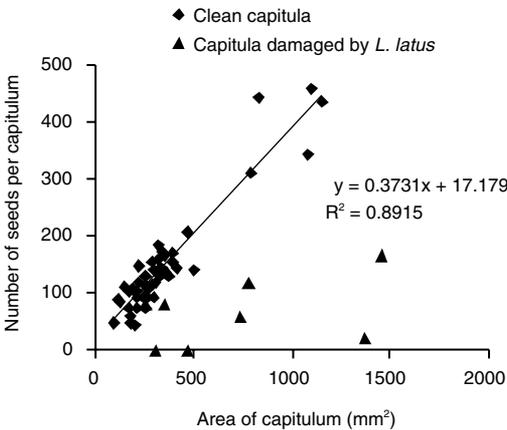


Figure 3. The relationship between capitulum area and the number of seed produced for *O. acaulon* from capitulum collected at three study sites (with and without *L. latus*).

Table 1. Survival of *L. latus* to different life-stages in capitula collected at Lake Grace, December 2001.

	Life stage			
	Eggs	Larvae	Pupae	Adult
% reaching life stage	100	80	67	59

the weevils on earlier vs later developing capitula of stemless thistle, as this will impact on the efficacy of *L. latus* as a biocontrol agent.

Activity to date in the biocontrol of *O. acaulon* is a clear example of value adding to existing biological control projects, and was made possible by the CRC for Australian Weed Management. However, the project is still in its early stages. Further work is required on plant population ecology and a full release program for *E. amoena* and *T. briesei* needs to commence. There is also a need for ongoing monitoring of the outcomes of these releases, so that measured agent impact can be related to any changes in plant population dynamics and the full contribution of the agents to the control of *O. acaulon* assessed.

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