

Feasibility of biological control of silverleaf nightshade in Australia

Raelene M. Kwong^{1,2}, Jean Louis Sagliocco¹, John Weiss^{1,2}, Trevor Hunt¹ and Tereso Morfe¹

¹Department of Primary Industries, PO Box 40, Frankston, Victoria 3199, Australia

²CRC for Australian Weed Management

Email: Rae.Kwong@dpi.vic.gov.au

Summary Silverleaf nightshade, *Solanum elaeagnifolium* Cav. is a significant weed in the cropping/pasture and perennial pasture zones of temperate Australia. The extensive and deep perennial root system makes this plant extremely competitive, and the limited control techniques currently available are uneconomical for the treatment of large, dense infestations. Biological control is considered a highly desirable option to reduce the impact of existing infestations and slow rates of spread.

This study aimed to determine the feasibility of commencing a biological control program for silverleaf nightshade based on a review of natural enemies associated with this species in the native range and an assessment of the organisms' potential for biological control.

Keywords Silverleaf nightshade, *Solanum elaeagnifolium*, feasibility study, biological control.

INTRODUCTION

Silverleaf nightshade, *Solanum elaeagnifolium* Cav. is a major agronomic weed in Australia and throughout the world.

In the report 'Weeds of significance to the grazing industries of Australia' by Grice (2002), silverleaf nightshade is identified as a Priority Weed of cropping/pasture zones of temperate rangelands and recommends biological control as a 'high priority research and development need'.

However, before embarking on an expensive and lengthy program, a critical assessment of the need for biological control and the prospects for success should be conducted.

The following criteria are often used when considering the commencement of a biological control program: (1) the weed has become widespread and causes significant agricultural and/or environmental damage, (2) ongoing control costs are high enough to warrant the research effort into biological control, (3) the weed has no or little economic or social value, (4) the potential of finding natural enemies that develop upon and damage only the target weed (i.e. are host specific), and (5) the likelihood of selected agents being able to establish in the introduced range and cause substantial levels of suppression.

This paper reviews the need for biological control and summarises the findings of a feasibility study on

the prospects of undertaking a biological control program for silverleaf nightshade in Australia.

IS BIOLOGICAL CONTROL WARRANTED?

Distribution and impact Silverleaf nightshade in Australia is estimated to infest approximately 140,000 ha and is particularly problematic in South Australia, New South Wales and Victoria. A weed risk assessment analysis indicated that silverleaf nightshade is a 'highly invasive weed', (scoring 0.668 out of a maximum potential score of 1), and has the potential to invade up to 398 million ha across Australia (Kwong *et al.* 2006). In comparison to six other important temperate pasture weeds, silverleaf nightshade ranked second. The rank order (from highest to lowest priority) was: (1) serrated tussock, (2) silverleaf nightshade, (3) prairie ground cherry and cape tulip, (4) spear thistle, (5) St John's wort and (6) Bathurst burr.

Silverleaf nightshade competes strongly with other vegetation. Cereal yield reductions of up to 77% have been recorded in South Australia (Heap and Carter 1999), where silverleaf nightshade infests over 40,000 ha in cereal growing areas. Silverleaf nightshade competes directly with summer-growing pastures such as lucerne, lowering production and leading to reduced carrying capacity.

On average, silverleaf nightshade costs affected farmers \$1730 per year in control costs and \$7786 per year in production losses (McLaren *et al.* 2004). In South Australia alone, silverleaf nightshade has been estimated to cost producers more than \$10 million per year.

Control The extensive and deep root system makes silverleaf nightshade a difficult weed to control. Repeated application of herbicides is often required to achieve successful control, while cultivation and slashing is largely ineffective and can exacerbate weed spread. Currently, there are no effective and affordable treatments for the control of large, dense infestations.

Benefit cost analysis A standard benefit-cost analysis was conducted to estimate the impact of a hypothetical biological control program against silverleaf nightshade to Australian agricultural industries (mainly cropping and grazing).

The analysis estimated that savings of close to \$140 million in future control costs would accrue over a 30 year period at a 10% discount rate, providing a benefit to cost ratio of 59 to 1 (Kwong *et al.* 2006).

PROSPECTS FOR BIOLOGICAL CONTROL

Potential biocontrol agents A literature review of organisms associated with *S. elaeagnifolium* was conducted utilising electronic databases (CAB Abstracts (1910–2005) and Agricola (1979–2006)), compiling the scientific literature published in the last 95 years. As extensive surveys had been conducted by USA, South African and Australian scientists between the 1960s to the 1980s, much information about the arthropod fauna associated with silverleaf nightshade in the Americas was readily available in the literature.

The feasibility study assessed a total of 30 organisms, (1 fungus, 1 nematode, 3 mites and 25 insects). Each species was assessed for its potential as a biocontrol agent based on three criteria: (1) its known host range, (2) the nature and level of impact on silverleaf nightshade and (3) the likelihood of the organism becoming established in targeted areas of Australia.

Host range As there are many Australian native and economically important plant species closely related to silverleaf nightshade, a high degree of host specificity is of utmost importance in considering the potential of organisms for biocontrol. Of the 30 organisms assessed, 11 were considered to have no biocontrol potential because of their known broad host range.

Damage and potential impact on silverleaf nightshade Organisms that cause repeated defoliation or reduce the vigour of silverleaf nightshade plants were considered promising agents. Those organisms causing cosmetic or minimal damage were considered a low priority. Of the 30 organisms assessed, nine species were considered to have low potential because their impact on silverleaf nightshade was considered to be minor.

Likelihood of agent establishing in Australia Theoretically, organisms from similar climates are more likely to be pre-adapted to conditions in the introduced environment. In this study, a climate analysis of the distribution of silverleaf nightshade in southeastern Australia (Figure 1) compared with climates within the native ranges of the weed indicated that the most comparable climates were in the central regions of Argentina and Chile (Figure 2).

Organisms originating from Argentina were therefore considered more promising than those from

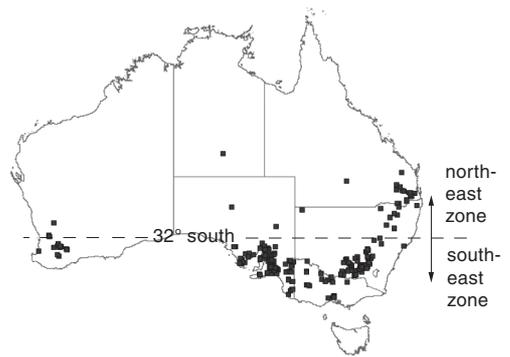


Figure 1. Silverleaf nightshade locations in south eastern Australia used for climate match predictions. Due to the broad distribution of silverleaf nightshade and the variation in climate across this range, the climate match predictions were refined by separating the Australian locations into two zones (north east and south east).

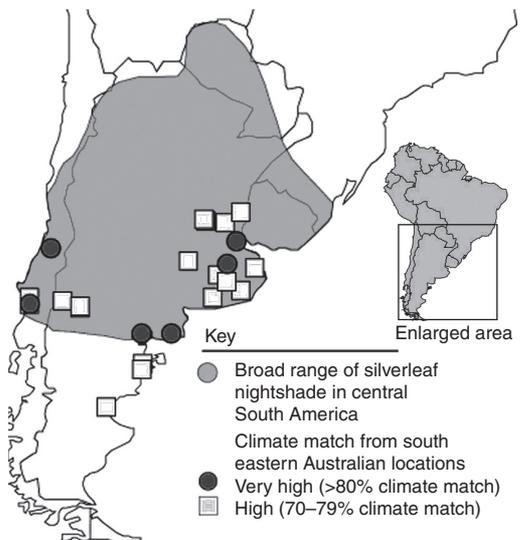


Figure 2. Climate match prediction (using CLIMATE software) of silverleaf nightshade infestations in southeastern Australia to South America overlaid with known silverleaf nightshade locations in central South America. Closed circles indicate locations with a very high (>80%) climate match comparable to silverleaf nightshade locations in southeastern Australia (occurring south of 32°).

Mexico, Texas and Arizona. A CLIMATE comparison of the Monterrey region of Mexico, where many biocontrol agents had been sourced for release on to silverleaf nightshade in South Africa, indicated that Monterrey had a climate comparable to the subtropical regions of Northern NSW and Queensland. Hence organisms from Monterrey were considered less likely to establish in the summer-drought climates of South Australia, Victoria and southern New South Wales where silverleaf nightshade is problematic. Of the 11 species originating from Argentina, there was little information available on their biology, host range and impact on the host plant, making it difficult to adequately assess their biological control potential. Only one species, the gelechiid moth *Symmetrischema ardeola* (Meyr) was considered the most promising because preliminary tests in Argentina suggested that it might be specific to silverleaf nightshade. The larvae of *S. ardeola* feed on flower buds, stamens and pistils and thus could reduce seed production.

Knowledge gaps Despite our thorough review of the literature our ability to adequately assess the potential of finding suitable biocontrol agents for use in Australia was hampered by insufficient information on: 1) the origins of silverleaf nightshade populations in Australia compared with the native range, and 2) the natural enemy fauna associated with silverleaf nightshade in regions of comparable climate.

Silverleaf nightshade is native to the Americas, with geographically separate distributions occurring in southwestern USA/central America compared to South America (Argentina/Chile). Despite morphological differences existing in populations between these two ranges, little information is available on the taxonomic relationships and genetic variation within and between these populations. In addition, the origins of Australian populations and the degree of genetic variation within Australian populations are not known. Mismatches between biotypes of the host plant in the native range and the target weed in the introduced range can affect the establishment success or effectiveness of biocontrol agents, particularly for highly host-specific agents such as fungal pathogens

and eriophyid mites. Hence, an understanding of the origins of Australian populations is instructive as it will assist in prioritising silverleaf nightshade populations in the native range from which potential agents might be sourced.

As previously discussed, preference for the selection of potential agents for Australia should be given to those occurring in central Argentina, particularly the Buenos Aires and Pampa provinces, and in the central regions of Chile (around Santiago). However, these areas have never been specifically surveyed. Hence, the natural enemies associated with silverleaf nightshade within the regions of comparable climates to targeted regions of Australia, is poorly understood. A strong argument for undertaking survey work in this region is the proximity of a highly experienced biological control laboratory (USDA SABCL) in Buenos Aires.

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