Colonisation of agricultural regions in Western Australia by *Conyza bonariensis*

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Summary *Conyza bonariensis* is common throughout the wheat-belt of Western Australia (WA), as a weed of wastelands, but has the capacity to invade cropping systems. The feasibility of slowing the rate of invasion depends on the rate of short distance seed dispersal and colonisation (establishment of seedlings). This was investigated in 2008/2009, at the Department of Agriculture and Food WA Merredin Research Station. The Station, and all farms and road verges within a 2 km radius of the Station, were checked for *C. bonariensis* plants from winter to summer 2007, but no plants were discovered. *Conyza bonariensis* seed were subsequently planted in a 4 m^2 plot, on the Station, in December 2007. Of the emerging cohort, a single plant survived to produce an estimated 5965 seeds in April and May 2008, which were allowed to naturally disperse. Monitoring of the Station and surrounding area continued until March 2009, to find and destroy the resulting fleabane rosettes (359 in total). Rosettes were found a maximum of 1842 m from the Parent Plant. Close monitoring of spring, summer and autumn weed growth to prevent seed set of *C. bonariensis* would be required to delay the spread of this weed on individual farms.

Keywords *Conyza bonariensis*, flaxleaf fleabane, dispersal, colonisation.

INTRODUCTION

Conyza bonariensis (L.) Cronquist (flaxleaf fleabane) is a common weed in Australia. It is widespread in the eastern States and the south of WA, and successfully competes with a range of crop species (Wu 2007). *Conyza bonariensis* is found throughout the wheat-belt (broad scale grain and pasture region) of WA, but is more commonly a weed of wastelands, roadsides and towns, rather than cropping fields (Hussey *et al.* 1997). The capacity of *C. bonariensis* to infest agricultural areas in the central wheatbelt is unknown, and will depend on the colonisation rates of this species in agricultural ecosystems.

Various studies have examined *C. bonariensis* demography and dispersal in other agricultural environments (reviewed by Wu 2007). *Conyza bonariensis* seeds emerge several days after sowing (assuming adequate moisture availability). Seedling growth is slow, active growth (bolting and flowering) commences in spring and summer, and seed head production occurs over several weeks or months. The number of seeds produced has been estimated at 290–400 per head.

Dispersal of *C. bonariensis* is likely to be widespread, as seeds have low terminal velocity; allowing for broad scale seed dispersal (Wu 2007). Shields *et al*. (2006) used atmospheric seed sampling techniques to indicate that *C. canadensis* seeds likely travel up to 500 km. It is highly probable that *C. bonariensis* achieves similar broad scale seed dispersal. However, dispersal distance does not indicate how well *C. bonariensis* can establish or colonise an area, i.e. how many seeds actually establish following dispersal. Colonisation rates of *C. bonariensis* within a farming landscape have not been investigated, but will affect invasion rates of this species into new areas and spread of herbicide resistant genes through existing populations (Hanson *et al.* 2009).

This research aimed to assess the potential of *C. bonariensis* to become a weed of farms in the central WA wheatbelt, by examining colonisation rates within the farming system.

MATERIALS AND METHODS

Seed source A population of *C. bonariensis* plants was identified in Merredin WA during January 2007. The plants were spread in remnant vegetation (−31.474, 118.281).

Colonisation An un-grazed annual ryegrass pasture field was identified, at the Department of Agriculture and Food WA Merredin Research Station (hereafter referred to as the Research Station) on Great Eastern Hwy (–31.504, 118.226). The Research Station, and all farms and road verges within a 2 km radius of the Research Station, were searched for *C. bonariensis* plants or other species of the *Conyza* genus during September and November 2007 and January 2008. No plants were discovered.

One hundred seeds (20 from five individual plants) were collected from the Merredin population, in December 2007. Seeds were evenly spread over a 4 m^2 area, on 14 December 2007, in the centre of the pasture field. A cohort of eight seedlings emerged in January. A single plant (Parent Plant) survived to produce 21 seed heads. Seeds were released from the seed heads via wind mediated dispersal, in April and May 2008. Seed production by subsequent cohorts at this site was prevented.

Following seed release, establishment of *C. bonariensis* plants on the Research Station and surrounding farms was monitored at intervals of 3 months, from September 2007 to March 2009. Monitoring occurred after major rainfall events, when germination was likely to have occurred. Plants were identified at the seedling or rosette stage, location was marked and plants were removed.

Location of rosettes was mapped and direction of each rosette from Parent Plant was subject to circular data (CDESCRIBE) analysis (GENSTAT Version 12.1 2009). Daily maximum wind speed and direction at the time of seed release from Parent Plant was obtained from the Merredin Research Station automatic weather station (Department of Agriculture and Food Western Australia 2009) and likewise subject to a CDESCRIBE analysis.

Seed production per head A total of 15 flower heads (three heads per plant from five plants) were removed from both the Merredin population and the Research Station population during March and April 2009. The selected heads were fully formed but only partially open (to ensure no seeds had been lost due to dispersal). Seeds on each head were counted manually under a dissecting microscope.

ANOVA was used to investigate variation in seed production per head between the two populations. Population was the factor, plant number and seed head number were the blocking factors and seed number per head was the response (GENSTAT Version 12.1 2009).

RESULTS

Seed production per head Seed production ranged from 189 to 385 per head, with a mean and standard error of 284 ± 13.8. Average seed production per head by plants at the Merredin and Research Station populations was not significantly different ($P = 0.191$).

Colonisation From the average number of seeds per head and the number of seed heads produced by Parent Plant, an estimated 5965 seeds were released onto the Research Station in April/May 2008. In the following year, 366 rosettes were found growing on the Research Station. No rosettes were found on the farms/roads adjoining the Research Station. As a result, it was assumed that all rosettes found on the Research Station originated from seed produced by Parent Plant. Given this assumption, established rosettes only accounted for 6.02% of the estimated 5965 seeds. The largest proportion of rosettes was found within 20 m of Parent Plant (64 plants). The maximum distance a rosette was found from Parent Plant was 1842 m (Figure 1).

The likelihood of a seed successfully establishing (colonisation probability) varied in different areas of the Research Station (Figure 2). While some rosettes were randomly distributed within fields, rosettes were more often clustered around fence lines or roadsides. There are two large clusters of rosettes to the north-east of Parent Plant, both to the north and south of the Great Eastern Highway. Summer weed control through herbicide use or cultivation did not occur at these sites and stubble was standing not burnt (both sites were the trial sites of other research projects). However, it is important to note that there were several other trial sites where summer weed control did not occur on the Research Station and stubble was un-burnt, to the north-west and south of the trial site (although no other sites to the north-east of Parent Plant). No rosettes were found in remnant patches of native vegetation (Figure 2). Obviously, it is more difficult to find rosettes in native vegetation (as opposed to open fields under a summer fallow). However, native vegetation in Merredin has a sparse understory and so any *C. bonariensis* plants would have been found when they reached maturity, if not at the rosette stage.

The mean direction of rosettes from Parent Plant was 0.3 degrees, or N. The kernel density estimate indicated that rosettes were predominately found in three different directions from parent plant, NNE, SE and WNW (Bandwidth: 1). Rosette location appeared to be related to wind direction, as mean direction of the strongest daily wind events that occurred during April to May 2008 (i.e. when Parent Plant shed seed) was 14.11 degrees, or NNE. The kernel density estimate indicated that wind most frequently blew towards the NNE and NW (Bandwidth: 1). Further, the highest wind speeds (over 8 m s^{-1}) predominately occurred when the wind blew towards the NNE or NNW and WNW.

DISCUSSION

The main conclusion from these results is that *C. bonariensis* will spread to and successfully colonise farming systems in WA (within fields, roadsides and fence lines), given the successful spread of this species over the Research Station over 1 year.

It was assumed that wind was the primary dispersal mechanism, as has been found for other species

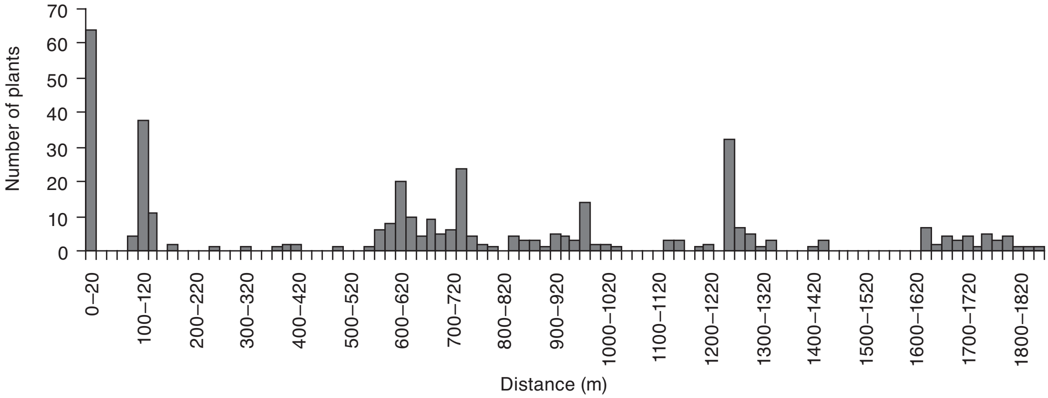

Figure 1. The number of plants that established within a set radius (0–1860 m) of Parent Plant. Establishment was monitored from May 2008 to March 2009, following the release of an estimated 5965 seeds during April and May 2008.

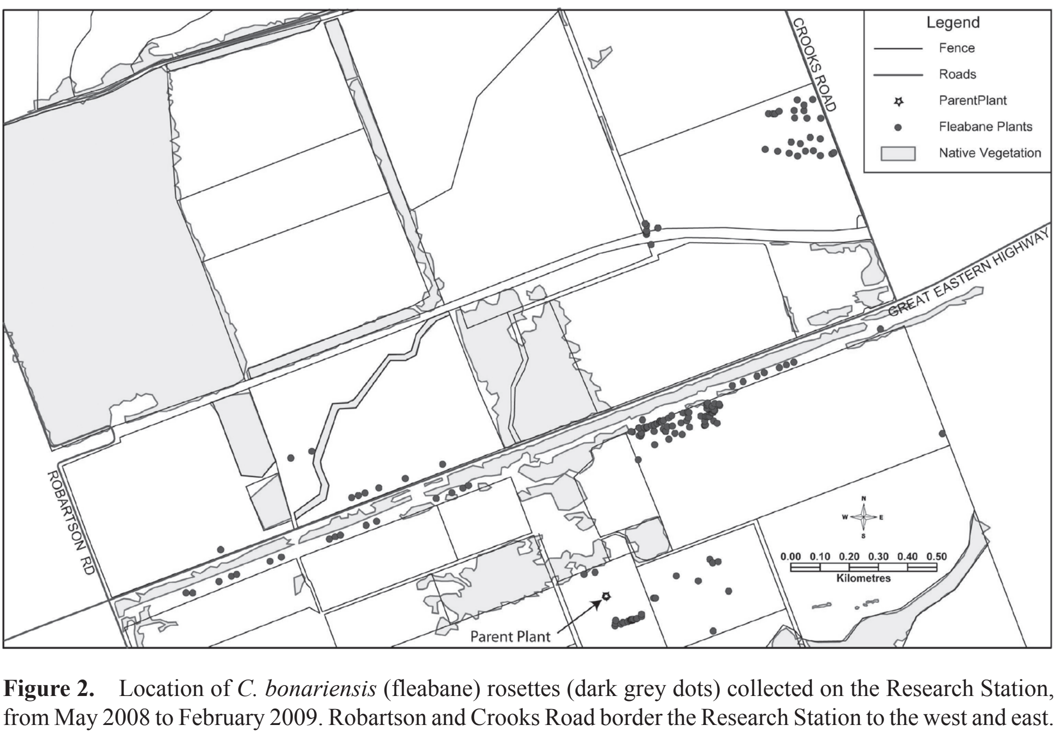

Figure 2. Location of *C. bonariensis* (fleabane) rosettes (dark grey dots) collected on the Research Station, from May 2008 to February 2009. Robartson and Crooks Road border the Research Station to the west and east. The legend indicates the location of Parent Plant, roads, fences and areas of native vegetation.

of the *Conyza* genus (Shields *et al.* 2006). However, vehicle movement may also have influenced dispersal (particularly along the roadsides). The current work examines colonisation rather than dispersal, and so does not give an accurate impression of total seed dispersal (due to variation in colonisation probabilities). However, this work found a maximum dispersal distance of 1842 m. Further, 298 rosettes were found more than 100 m from Parent Plant, accounting for 5% of the released seed. Many traditional models of dispersal indicate that 99% of seed lands within a few metres of the seed source, and few seeds achieve longer distance dispersal events (reviewed by Jongejans *et al.* 2008). In this study, at least 5% of seed (and possibly more) landed more than 100 m away from Parent Plant. Possibly seeds travelled further than suggested by other dispersal studies because they experienced secondary dispersal. The relatively bare, flat agricultural fields in Merredin (free of plants in the summer/autumn fallow) would allow secondary dispersal by wind. Vehicle movement (particularly along roadways) may also have influenced secondary dispersal. Alternatively, authors of other studies have argued that wind turbulence and abscission thresholds heavily influence maximum dispersal distances and have not been fully accounted for by dispersal studies, particularly those that have investigated artificial seed release (Schippers and Jongejans 2005, Skarpaas *et al.* 2006). In the current study, seeds experienced natural dispersal, i.e. presumably seeds were released due to the strongest wind events in turbulent conditions, and thus had opportunity to travel further than artificially released seeds.

As stated, colonisation probabilities were not equivalent. Obviously, sites with poor summer weed control were favourable for colonisation. Roadsides, fence lines and standing stubble were also favourable, possibly due to improved seed catching and retention (compared to bare ground). However, over the bulk of the Research Station, standard farm practices (including summer weed control) appeared to control plants. Therefore, thorough summer weed control (including fence lines) should successfully remove plants. Herbicides commonly used for summer weed control in WA are highly effective against young fleabane, and can also control mature plants (Wu *et al.* 2008). However, given the rate of dispersal, it is probably not possible to contain the spread of herbicide resistant populations, as has been found for *C. canadensis* (Hanson *et al.* 2009). This highlights the need to avoid herbicide resistance development in WA.

ACKNOWLEDGMENTS

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