HORIZONTAL SEED DISPERSION PATTERNS OF CALIFORNIAN THISTLE (*CIRSIMUM ARVENSE*)

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ABSTRACT

Few Californian thistle seeds find their way to the soil seed bank raising a question about their dispersal and fate. The horizontal seed distributions around ten Californian thistle patches were studied on two farms. Thirteen seed traps were placed on the ground in four directions around each patch, seven of these were downwind (prevailing wind direction) at different distances from the patches. Seed traps were left for 48 h and trapping was repeated three times. The highest numbers of seeds were collected at the edge of a patch, with numbers declining exponentially as distance from the patch increased. The horizontal seed distribution was significantly affected by landscape type and/or landscape objects. Relatively more seeds were captured away from a patch that had trees growing a short distance upwind than from patches on flat land. A similar pattern of disturbance was observed for patches located in a gully.

Keywords: Californian thistle, *Cirsium arvense*, pappus, pasture, seed dispersal.

INTRODUCTION

Californian thistle (*Cirsium arvense*) is an introduced perennial herb and is one of the most common thistle species in New Zealand. It was first noticed in New Zealand in 1887 and is described by Roy et al. (2003) as New Zealand's most pernicious weed. It is native to South Eastern Europe and the Eastern Mediterranean, Western Asia and North Africa (Moore 1975). Holm et al. (1977) and Gustavsson (1997) name it as "one of the world's worst weeds".

The majority of research until now has focused on the asexual nature of Californian thistle. However, Heimann & Cussans (1995) concluded that the contribution made by sexual reproduction to the survival and spread of this species has been underestimated, partly owing to an inadequate number of studies. Seed dissemination occurs 2-3 weeks after pollination. Each seed is equipped with a pappus, which allows wind dispersal. Seeds are retained by the capitulum until the wind speed is sufficiently large to detach them. However, the pappus breaks off easily from its seed, often leaving seeds in the capitulum (Sheldon & Burrows 1973). The efficiency of seed dispersal is an important determinant of rate of spread, and knowledge of both average and maximum dispersal distances is important for understanding population expansion (Cronk & Fuller 1995).

The aim of the present research was to elucidate the effectiveness of Californian thistle seed dispersal and to determine how far away from the patch the seeds travel. This research is part of a wider study in which temporal changes in the soil seed bank and the impact of pasture gap size on Californian thistle seedling establishment are also being examined.

MATERIALS AND METHODS

Ten clearly distinguishable patches (individual populations) of Californian thistles were selected on two commercial farms, one at Walton and one at Tirau in the Waikato.

Populations were selected if they met the following criteria: (1) at least 2 m from paddock boundary fence, (2) at least 2 m from any adjacent patch, (3) at least 6 m in diameter and (4) accessibility to a 100 m transect along main axis of prevailing wind. Where more than five sites met the above rules on one farm, patches were randomly selected. Four of the patches consisted of predominantly or exclusively male plants, located at Tirau, and six predominantly or exclusively female. Six of the patches were located on flat land, one near trees and three in gully basins.

Thirteen seed traps were positioned around each patch. The traps were placed at ground level at different distances and in four directions from each of the ten Californian thistle patches. Seven traps were placed downwind (westerly was the prevailing wind direction) from the patch and were located at the edge of the patch and at 2.5, 5, 10, 20, 50 and 100 m from the edge of the patch. In three further compass directions traps were located at 2.5 and 10 m from the edge of the patch. This was conducted over December 2004 to January 2005 at Walton and throughout February 2005 at Tirau.

Seed traps measured 400 x 250 mm and consisted of a stiff base with removable sticky sheets of plastic (fly control adhesive film, Garrick trading Co). The traps were laid flat on the ground and left in the field for 48 h. The sheets of plastic were then removed to count the number of seeds, pappus with seed attached and pappus only (collectively termed seed/pappus) on each trap. New sheets of sticky plastic then replaced the original plastic so that each trap was sampled three times. There was a gap of at least one week between the removal of and replacement of new sheets of plastic. General weather conditions (wind direction and precipitation) were noted. To ensure that only seeds from the target patch were counted, thistles outside the target population were removed. A pink dye was applied by a knapsack sprayer to the target population where removal of the non-target thistles was not possible. Landform and nearby features were also noted; for one patch, trees were positioned about 50 m away from that patch. Fifteen flower heads from each patch were dissected and seed counted.

The spline and its 95% confidence interval were estimated using a Bayesian smoothing technique (Upsdell 1994), with the error distribution set as Poisson but employing an identity link.

RESULTS

General weather conditions were hot sunny days with light breezes, predominately from the prevailing direction. Intermittent breezes from other directions did occur. However, for one repeat on one farm, strong winds and drizzle were noted.

Virtually all pappus, with or without seed attached, were captured downwind from the patch. Only occasional seed/pappus were collected on the traps placed in any of the three other directions. The high variability combined with the low numbers made a meaningful analysis of these traps impossible and from here on only the traps placed in a downwind direction from the patch are discussed.

Early in the season (December-January), the first catches were low. On average less than one seed/pappus was caught per sticky trap from the four male populations. Early seed/pappus numbers were higher, but also variable, for the female than the male populations with an average of 5.5 seed/pappus caught per trap. Seed/pappus numbers increased with the second (1.5 and 14.4 seed/pappus per trap for male and female populations respectively) and third catches (1.1 and 13.9 seed/pappus per trap for male and female populations respectively). The low number of seed/pappus caught on the traps around the male populations indicates that they make a minimal contribution to the total seed dispersal. Close analysis of dissected seedheads showed much lower seed numbers in the male compared to the female seedheads (data not shown).

Most pappus attached to seed travelled only a short distance and were captured either at the edge or at 2.5 m distance from the patch. Overall, pappus with seed attached declined exponentially as distance from the parent patch increased (Fig. 1). Similarly pappus that had separated from the seed was also predominantly captured at either the edge or the closest traps. However, the decline in numbers of pappus only over distance

was not as steep as for pappus with seed attached (Fig. 1). Pappus only travelled 1 to 2 times further than pappus with seed attached.

FIGURE 1: Average number of pappus with seed attached and pappus only captured plotted against log downwind distance (m) from six female Californian thistle parent patches. The data analysed were at seven positions (0, 2.5, 5, 10, 20, 50 and 100 m) on three occasions and the patches were from two farms.

The horizontal pappus (with seed attached) distribution results showed a generally exponential decline with increasing distance away from the patch on flat land (Fig. 2). However, varied landforms (gullies) and interference from trees caused variations to this exponential decline (Fig. 2), with a higher proportion of pappus with seed attached being deposited at a greater distance from the patch than on flat land. For the patches located in a gully, peak pappus with seed attached capture was not at the edge of the patch but at 2.5 m away from the patch. The decline in pappus with seed attached number over distance was also more gradual for patches located in gullies than what was observed for patches on flat land (Fig. 2).

FIGURE 2: Proportion of the total pappus with seed attached that was caught at set distances from female Californian thistle parent patches. Data are the mean for three repeats and are presented for patches located on flatland with no close obstructions (n=6), flatland with large trees 50 m away (n=1) and in a gully (n=3).

DISCUSSION

This study has shown that Californian thistle has effective dispersal of seed from the parent population, with seed deposition highest closest to the source and gradually declining as distance increases. The typical exponential decline was mirrored for soil seed bank counts at similar distances, with counts of 679 Californian thistle seeds/m² at the edge, 36 seeds/m² at 2.5 m, 32 seeds/m² at 5 m and 9 seeds/m² at 20 m (I.A. Wallace, unpubl. data). Clumping of seed occurs at different distances when wind currents are influenced by the landscape and/or objects on the landscape. However, seed dispersal is just one variable linking seed production and seedling establishment (Sheldon & Burrows 1973). These results suggest that the poor correlation between the number of seedlings and seed production is not because of limitations in horizontal seed dispersal in the New Zealand pastoral setting.

Many factors govern the effectiveness of pappus dispersal including pappus structure, height of seed release and the environmental factors of the habitat (Sheldon & Burrows 1973). Landscape type (e.g. gullies or hills) and objects on the landscape (e.g. trees or buildings) have a significant effect on wind current and direction. This was demonstrated in seed dispersal from patches located on variable landscapes or those near trees. Steady winds increase dispersal distance, whereas turbulence may either curtail or prolong transportation (Sheldon & Burrows 1973). When there is a lack of suitable wind velocities at the habitat, dispersal may be severely reduced, which explains clumping of seed near the parent patch.

These findings have direct relevance to pasture management and Californian thistle control strategies. Although seed dispersal is working effectively, most seeds are shown to be deposited either on the edge or close to the edge of the patch. As Californian thistle is allelopathic to its own seedlings (Bendall 1975) this may explain why most seeds fail to establish. Future research will attempt to address this issue by focussing on aspects of seedling establishment.

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