Observational Monitoring of Biological Control vs. Herbicide to Suppress Leafy Spurge (*Euphorbia esula*) for Eight Years

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Abstract

The effectiveness of *Aphthona* flea beetles (87 percent *A. lacertosa* Rosenhauer and *A. czwalinae* Weise, and 13 percent *A. nigriscutis* Foudras) as biological control agents of leafy spurge, *Ephorbia esula* L. was compared with a single application of herbicide (picloram) and untreated plots for a period of 8 years. Percentage of cover of leafy spurge, grasses; and flea beetle numbers were measured each year from 2000 through 2007. Cover of leafy spurge on *Aphthona* biological control plots exhibited annual declines until 2005. In 2006, these plots showed a temporary rebound in leafy spurge coverage followed by a decline in 2007. Spurge cover increased on the herbicide-treated plots and remained unchanged on the untreated check plots from 2000 through 2003. In 2003, the flea beetles began to emigrate from the release points within the biological control plots and dispersed throughout much of the surrounding leafy spurge infested area including the herbicide treated and check plots. This dispersal and colonization caused a subsequent decline in spurge cover on the herbicide-treated and control plots from 2004 through 2007.
Keywords: Biological control; *Aphthona*; Leafy spurge; Weed management; Invasive weeds

Introduction

Leafy spurge, *Ephorbia esula* L. is a deep-rooted perennial weed with erect stems 40 to 80 cm tall (Hansen 2004, Stevens 1963). The weed reproduces by vegetative buds and seeds. A native of Europe and Asia, leafy spurge was first reported in North America in Massachusetts in 1827 (Noble et al. 1979). The plant is now well established on 2 million ha throughout 35 states and in the southern edges of most Canadian provinces. Leafy spurge is primarily a grasslands problem for ranchers and public land managers (Anderson et al. 2003).

Chemical controls are often prohibitively expensive to apply over extensive grazing lands characterized by low productivity (Bangsund et al. 1996). Leafy spurge cannot be eradicated with a single chemical treatment. The seed bank of leafy spurge remains viable in the soil for more than 8 years (Bowes and Thomas 1978). Eradication with herbicides may be possible, but the land manager must be committed to being more persistent than the weed. Unfortunately, it would probably require 5 to10 consecutive years of herbicide treatment to eradicate an established stand (Lym and Messersmith 1985). As a result, a strong emphasis has been placed on developing biological control agents for managing leafy spurge.

It is estimated that eventually 60 to 70 percent of all leafy spurge infestations could be managed with biological control agents (Bangsund et al. 1999) such as *Aphthona* spp. (Coleoptera: Chrysomelidae) flea beetles, currently the most successful insects on leafy spurge. Six root-feeding flea beetles, *Aphthona cyparissiae* Koch, *Aphthona flava* Guill, *Aphthona czwalinae* Weise, *Aphthona lacertosa* Rosenhauer, *Aphthona abdominalis* Duftschmid, and *Aphthona nigriscutis* Foudras, have been introduced into North America (Hansen et al. 1997, Lym and Carlson 2002). However, there is limited information on the impact of *Aphthona* spp. on leafy spurge and the associated plant community (Bangsund et al. 1999), and even less information comparing the efficiency of flea beetles with herbicide control. The objective of this study was a long term comparison of the efficacy of *Aphthona* flea beetles with an herbicide treatment for control of leafy spurge and their effect on grass and forb coverage.

Methods and Materials

The study was conducted from 2000 to 2007 on an area of approximately 50 ha of contiguous leafy spurge infestation in south central Idaho along the South Fork of the Boise River in the Sawtooth National Forest (elev. 1,524 m). The study area has a south-facing aspect, ranges between 5 to10 percent slope and received an average of 55.80 cm of precipitation per year. For the purpose of this study the infestation was divided into three equally sized blocks and each assigned one of three treatments: release of *Aphthona* flea beetles, herbicide treatment, or untreated control.

In 2000, we established six replicated plots in each of the three treatments. Eighteen, 30.5 m radius study plots were established by erecting a steel fence post in the center of each. Treatments were established as follows: (1) Six plots in an area treated with picloram (Tordon 22K liquid concentrate) at the rate of 3.2 kg/ha in 1999, (2) six plots in an area where flea beetles (approximately 1,000 beetles each, comprising 87 percent *A. lacertosa* and *A. czwalinae* and 13 percent *A. nigriscutis*) were released in 2000, and (3) six plots in an area without herbicide application or biological control agent treatments to be used for comparison. Individual plots were separated by at least 100 m from each other and the perimeter of the treatment areas. Plots were surveyed by establishing 30.5m line transects in each cardinal direction from the steel fence post. At 3m intervals along each transect using 0.10 m^2 sampling frames (quadrats) (Daubenmire 1959), leafy spurge canopy cover and grass cover were ocularly measured to the nearest 5 percent. We also completed five sweeps with a standard 38cm diameter sweep net along the transect adjacent to each quadrat sample (Southwood 1978) to survey for *Aphthona* flea beetles. Sampling was usually conducted in late June or early July during peak *Aphthona* activity.

The herbicide treatment was applied operationally in 1999 the year before sampling began, with a truck-mounted-boom sprayer. The herbicide was applied to the entire treatment block and not randomly to the individual plots, therefore the plots could not be randomized and the data were not analyzed statistically. The mean values for each parameter for all quadrats within the plots were calculated and averaged for each treatment. Raw cover class data (Daubenmire 1959, Southwood 1978) were converted to percentage of cover by averaging the midpoint for each category over the six replicates. The plot means (n = 6) and standard errors for each variable were calculated by year and treatment (SAS 1989) and presented graphically.

Results

At the beginning of the study in 2000, one year after the herbicide treatment, leafy spurge canopy cover averaged 6 percent on the herbicide treated plots, 38 percent on the control plots, and 65 percent on the plots where *Aphthona* biological control agents were released (Figure 1A). From 2000 to 2003, leafy spurge cover increased on the herbicide treated plots to 37 percent but declined to 39 percent on the plots where *Aphthona* were released. On plots treated with *Aphthona* beetles, leafy spurge cover declined further to a low of 5 percent in 2005, after which it resurged to 21 percent in 2006 then decreased to17 percent in 2007. In 2003, a few *Aphthona* beetles were beginning to be caught in sweep net samples conducted on the check and herbicide treated plots indicating emigration from the biological control plots had begun. By 2005 the beetles had dispersed throughout the study area and were pervasive throughout most of our plots (Figure 2). In 2004, leafy spurge coverage began to decline on both the check plots and on the herbicide-treated plots. This trend continued through

2007. Coverage of leafy spurge was similar among the three treatments in 2006 and 2007.

At the start of this study in 2000, grass cover was similar on the check (14 percent), herbicide treated plots (15 percent), and plots containing flea beetles (10 percent) (Figure 1B). In 2003, grass cover was 11 percent on the check plots, 13 percent on the herbicide plots and 21 percent on the plots treated with flea beetles. In 2007, grass cover was similar among treatments: flea beetles (23 percent); check plots (20 percent); herbicide plots (21 percent).

Discussion

Over the long-term, the coverage of leafy spurge on the biological control plots declined from 65% to 17%; beetles emigrating from the biological control plots also most likely reduced the cover of leafy spurge on the adjacent untreated check and herbicide treated plots. Few studies have compared the efficiency of biological control agents and chemical herbicides on leafy spurge in the same design. In our study, one year after its application the herbicide (picloram) reduced foliar cover of leafy spurge to less than 6 percent; however, leafy spurge cover rebounded, increasing each year for the next 3 years, then declined in each subsequent year through 2007. The check plots exhibited a similar pattern of decline in leafy spurge cover from 2003 through 2007 (Figure 1A).

Aphthona flea beetles were found almost exclusively on plots where they were released from 2000 through 2004 (Figure 2). In 2003, the beetles began to disperse from the biological control plots and by 2005 were found in the surrounding areas where no *Aphthona* were originally released, containing the check and herbicide plots (Figure 2). This emigration most likely caused the observed continual decline in the coverage of leafy spurge in these areas in the following years. In the *Aphthona* treated plots, it is likely that leafy spurge coverage was reduced by beetle feeding to the extent that they were forced to disperse into the surrounding area. This reduction of the coverage of leafy spurge to 5 percent in 2005 followed by a rebound in the coverage of leafy spurge to 21 percent in 2006 supports the hypothesis that the beetle emigrated in search of more sustenance. Butler et al. (2006) also noted an increase in the cover and density of leafy spurge the year following peak control by flea beetles while beetle abundance declined. They hypothesized that the resurge in leafy spurge cover may have been from developing seedlings or young plants that lack a sufficiently developed root system to support *Aphthona* larva (Fornasari 1996).

After leafy spurge, graminoids (grass and grass-like plants) were the dominant cover type on all study plots. Graminoids increased in coverage each year following treatment on the *Aphthona*treated plots from 10 percent in 2000 to more than 30 percent in 2005 and 23 percent in 2007 (Figure 1B). Butler et al. (2006) also showed a more rapid and larger response in graminoids following the decline of leafy spurge

In summary, we began with three disparate covers of leafy spurge among our treatments. The plots where *Aphthona* beetles were released had the highest coverage of leafy spurge at the beginning of the study, followed by the untreated check plots, and finally the herbicide (picloram) plots. Through the following 8 year period the *Aphthona* biological control agents caused a decline in the cover of leafy spurge from 65 percent to less than 5 percent on the treated plots. With insufficient leafy spurge to adequately support the flea beetle population on biological control plots, *Aphthona* emigrated throughout the area occupied by leafy spurge including the plots containing the check and herbicide treatments. Interestingly, as beetles dispersed, the cover of leafy spurge on the biological control plots rebounded from 5 percent to 21 percent from 2005 to 2006. This may be the initiation of a cycle of increasing leafy spurge cover followed by an increase in flea beetles causing a subsequent decline in leafy spurge. As leafy spurge becomes naturalized into the indigenous plant population, this cycle will most likely decline in amplitude.

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References

Anderson, G.L., Delfosse, E.S., Spencer, N.R., Prosser, C.W., & Richard, R.D. (2003) Lesson in developing successful invasive weed control programs. Journal of Range Management **56**, 1–12.

Bangsund, D.A., Leitch, J.A., & Leistritz, F.L. (1996) Economics of herbicide control of leafy spurge (*Ephorbia esula* L.). Journal of Agriculture and Res. Economics **21**, 381–395.

Bangsund, D.A., Leistritz, F.L., & Leitch, J.A. (1999) Assessing economic impacts of biological control of weeds: The case of leafy spurge in the northern Great Plains of the United States. Journal of Environmental Management **56**, 35–43.

Bowes G.G. & Thomas, A.G. (1978) Longevity of leafy spurge seeds in the soil following various control programs. Journal of Range Management **31**, 137–140.

Butler, J.L., Parks, M.S., & Murphy, J.T. (2006) Efficience of flea beetle control of leafy spurge in Montana and South Dakota. Rangeland Ecology and Management **59**, 453–461.

Daubenmire, R.F. (1959) A canopy-coverage method. Northwest Science **33**, 43–64.

Fornasari, L. (1996) Biology and ethnology of *Aphthona* spp. (Coleoptera: Chrysomelidae, Alticinae) associated with *Euphorbia* spp. (Euphorbiaceae). In Chrysomelidae Biology (eds Jolivet, P.H.A. & Cox, M.L.) pp. 293–313. Academic Publishing, Amsterdam, Netherlands.

Gunderson-Izurieta, S., Markin, G.P., Reedy, N., & Frieberg, B. (2009) Southern Idaho student "bug crews": Weeds, youth, and biocontrol in the rangelands of Idaho. Rangelands **31**, 36–40.

Hansen, R.W., Richard, R.D. Parker, P.E., & Wendel, L.E. (1997) Distribution of biological control agents of leafy spurge (*Euphorbia esula* L.) in the United States: 1988-1996. Biological Control **10**, 129–142.

Hansen, R.W. (2004) *Aphthona spp.* In Biological Control of Invasive Plants in the United States (eds Coombs, E.M., Clark, J.K., Piper, G.L., & Cofrancesco, A.F., Jr.) p. 467. OSU Press, Corvallis, Oregon.

Lym, R.G. & Messersmith, C.C. (1985) Leafy spurge control with herbicides in North Dakota: 20-year summary. Journal of Range Management **38**, 149–153.

Lym, R.G. & Carlson, R.B. (2002) Effect of leafy spurge (*Ephorbia* esula) genotype on feeding damage and reproduction of *Aphthona* spp.: implications for biological weed control. Biological Control **23**, 127–133.

Noble, D.L., Dunn, P.H., & Andres, L.A. (1979) The leafy spurge problem In Proceedings of the Leafy Spurge Symposium June 26-27, pp. 8–15. Bismarck, North Dakota.

SAS Institute, Inc. (1989) SAS/STAT User's Guide, Version 6, 4th ed., Volume 2. Cary, North Carolina.

Southwood, T.R.E. (1978) Ecological Methods. Chapman and Hall, New York. 524p.

Stevens, O.A. (1963) Handbook of North Dakota Plants. North Dakota Institute of Regional Studies p. 197. Fargo, North Dakota, 324p.

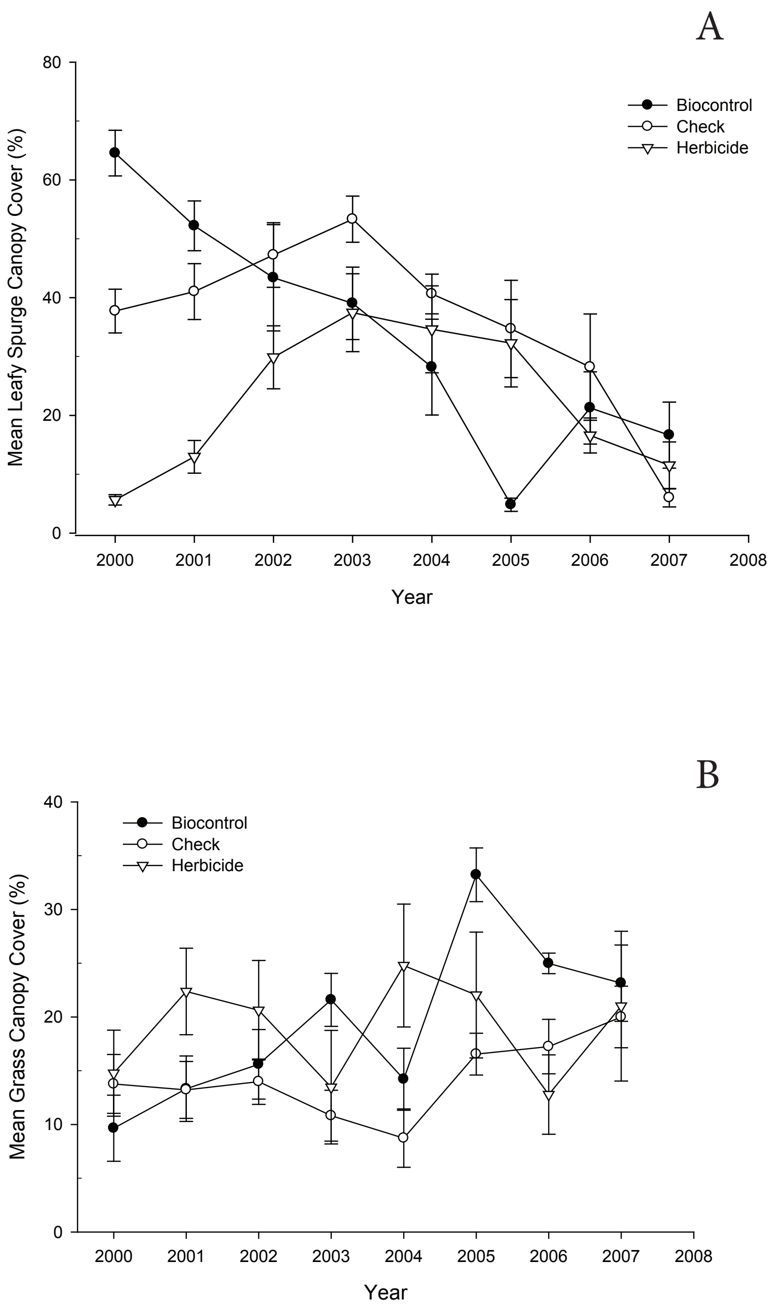

Figure 1. Change in canopy cover from 2000 to 2007. (A) Leafy spurge, (B) Grasses.

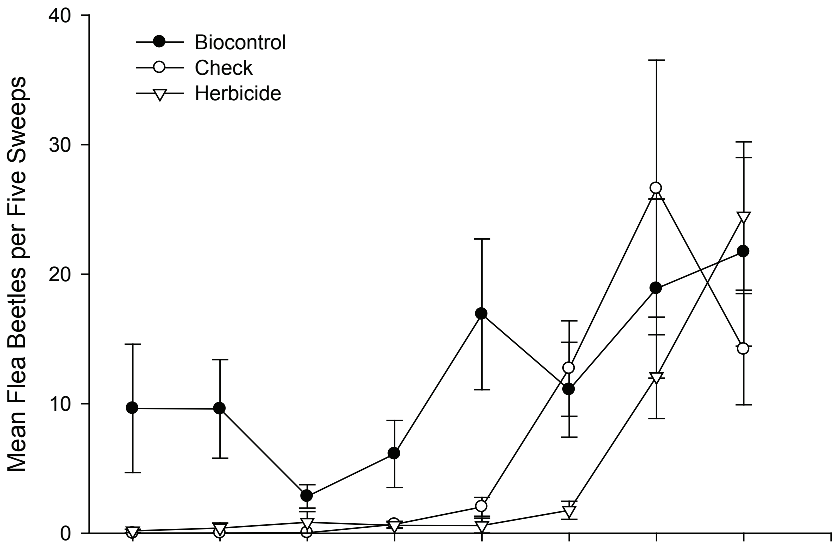

Figure 2. The average number of *Aphthona* flea beetles caught in plots for each of the three treatments.