Feeding Impacts of a Leafy Spurge (Euphorbia Esula) Biological Control Agent on a Native Plant, Euphorbia Robusta

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Feeding Impacts of a Leafy Spurge (*Euphorbia esula*) Biological Control Agent on a Native Plant, *Euphorbia robusta*

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The biological control agent *Aphthona nigriscutis* Foudras (Chrysomelidae) established in Fremont County, WY since 1992 on leafy spurge was released into a mixed stand a native plant *Euphorbia robusta* Engelm. During host range testing, *E. robusta* was a likely host for *A. nigriscutis* under laboratory conditions. In 1999, *A. nigriscutis* was observed feeding on both *E. esula* and 31 of 36 *E. robusta* plants present on about 2 ha (5 ac) where the visually estimated *E. esula* canopy cover was 50%. By August 2001, *E. esula* cover had declined to less than 5% and *E. robusta* plants had increased to 450 plants with 26 (5.8%) showing feeding damage. In 2006 *Euphorbia esula* ground cover was 2% and of 598 *E. robusta* plants originally marked, 391 could be located and four of these had damage consistent with *A. nigriscutis* feeding. For the 8-yr period, *E. esula* ground cover was inversely correlated to *E. robusta* density and positively correlated to *A. nigriscutis* feeding damage on *E. robusta*. This study shows that while also acceptable to *A. nigriscutis* in the field, feeding on *E. robusta* declined with declining densities of the target weed while *E. robusta* population densities increased. It seems that some risk in this regard is acceptable in light of the damage from the target weed and the generally high level of selectivity provided by biological control agents.

Nomenclature: Leafy spurge, *Euphorbia esula* L. EPHES; *Apthona nigriscutis* Foudras.

Key words: Non-target feeding.

Early host range testing of potential weed biological control agents was designed to demonstrate that new biocontrol of weeds agents would not attack economically valuable crop species. In recent years, concern has shifted toward the impacts, both direct and indirect, that biological agents might cause to native species. *Rhinocyllus conicus*, a biological control agent for musk thistle (*Carduus nutans* L.) has been found to attack a wide variety of native thistles, some endangered (Gassmann and Louda 2001). Increased concern has stimulated a call for greater risk assessment of new biological control agents, more thorough study of the target species prior to release, and postrelease tracking of host range under field conditions (Waage 2001). This has lead to a complex screening process, very large test plant lists, rejection of potential biological control of weeds agents for relatively minor nontarget feeding, and a long, drawn-out permitting process in the United States. There seems to be limited consideration of the benefits of biological control of weeds, however, such as lower costs and more permanent control costs and the costs of doing nothing. Other weed control measures applicable to large infestations are far less selective and more environmentally damaging.

Early in the leafy spurge (*E. esula*) biocontrol program, *E. robusta* had been identified as a native species sympatric and closely related to *E. esula*; as a perennial it should support the full life cycle of *Aphthona* beetles, but it was never actually tested (Pemberton 1985). A number of small discrete populations of *E. robusta* are located in Fremont County, WY, particularly in the Lander area. *Euphorbia robusta* blooms in May and sets seed by early June. Plants vary in size from single stems a few centimeters tall to large plants with as many as ten stems and standing 25 cm (10 in) tall. The typical plant has four to six stems and is 10 cm (4 in) tall with a well-developed tap root. Typically, *E. robusta* is found sparsely growing in narrow strips along rocky, windswept ridges of red sandstone. Bare ground typically represents more than 50% of such communities and most of the plants in the community are less the 25 cm (10 in) due to the harsh environment. Many *E. robusta* populations in the Lander area are located within hundreds of meters of *E. esula* infestations.

Aphthona nigriscutis was released in Fremont County, WY in 1990 for the control of *E. esula*, and was well established by 1993. A major redistribution effort led to

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Interpretive Summary

It has been demonstrated that although relatively host specific, several *Aphthona* sp. will feed and occasionally reproduce on a North American native spurge, *Euphorbia robusta*. Host specificity testing is relied upon heavily to assess safety of proposed agents for weed biological control, and a great deal of concern is voiced about impacts on nontarget species. We observed that when leafy spurge populations are high and *Aphthona nigriscutis* develops to epidemic population levels, some feeding on *Euphorbia robusta* does occur in the field. We also observed that as leafy spurge ground cover declined, the *Aphthona nigriscutis* populations also declined, and nontarget feeding stopped. This suggests that *Aphthona nigriscutis* did not move from the leafy spurge onto the nontarget species in the field, even though it is possible to show that potential under laboratory conditions. We also observed the *Euphorbia robusta* population increased to partially fill the void created by the retreating leafy spurge, indicating that the earlier-observed nontarget feeding had no population level detrimental effect. Taken with other similar reports where nontarget feeding by weed agents has been related to high densities of the target weed and epidemic outbreaks of the biological control agent, it is not unreasonable to conclude that reasonably host-specific agents used in biological control of weeds pose little long term threat to native species that occur in low density. Requirements that proposed weed biological control agents feed on no other species in the laboratory are overrestrictive and unnecessarily eliminate many good agents from consideration for release in the United States.

hundreds of releases during the next few years. Each release of 1,000 adult beetles was marked by a steel post and monitored annually to assess establishment. In 1998, while monitoring release sites in a mixed stand of *E. esula* and *E. robusta*, we observed and marked some *E. robusta* plants with feeding scars on the leaves and occasionally saw *A. nigriscutis* feeding on the plants. The next year the marked plants had disappeared and a study was initiated to quantify the impact of *A. nigriscutis* feeding on *E. robusta* in the field.

Materials and Methods

Aphthona nigriscutis was first released at Site 1, located at N42.80121, W-108.79570, 5 km SW of Lander, WY, a mixed stand of *E. esula* and *E. robusta* on July 13, 1994. A study site boundary was established using three *A. nigriscutis* release locations marked with steel posts on the west and a road on the east with parallel north and south lines to enclose a rectangle of about 2 ha (5 ac). *E. robusta* was roughly distributed in two groups toward either side of the site; plants 1 to 19 on the west where *E. esula* ground cover was greater, and 20 to 36 on the east where *E. esula* ground cover was lower. The soil at the site was a red sandy loam, 50 to 150 cm (20-59 in) deep mixed with rocky outcrops. The site slopes 10 to 20 degrees to the northeast and average annual precipitation is 33 cm (13 in), although since 1998 rainfall has been 50 to 75 percent of normal.

In 1999, *Euphorbia esula* plants at the site averaged 58 cm (23 in) in height (10 randomly selected stems) and percent cover was visually estimated as declining from 90% to the west near the *A. nigriscutis* release sites to < 10% to the east. Between May and August 1999, 36 *E. robusta* plants were located, marked with a numbered wooden stake driven into the ground (the stake was placed 60 cm [23.6 in] north of the plant to avoid shading the plant or injuring the root), and photographed.

From August 1999 until 2006, *E. robusta* plants were checked annually. The plants that had disappeared were recorded and new plants were marked across the site. Each *E. robusta* plant was visited in July 1999 at the peak of *A. nigriscutis* emergence to check for feeding damage and annually thereafter until 2006. The percent of leaves with feeding scars on each stem was estimated and damage classed as follows: heavy, > 50% of leaves on and > 50% of stems with feeding scars; medium, between 25 to 50% of leaves on and 25 to 50% of stems with feeding scars; light, < 25% of leaves on and stems with feeding scars; or zero, with no apparent feeding.

For comparison to Site 1, a second population of *E. robusta* was selected far from either *E. esula* infestations or *A. nigriscutis* releases. Site 2, located 33 km SE of Lander, WY at N42.62169, W-108.45184, was carefully surveyed, the *E. robusta* population delimited, and individual plants marked were counted in 2000, 2001, and 2007.

At Site 1, from 2000 until 2006, annual assessments were made of *Euphorbia* densities. *Euphorbia esula* density for the whole site was estimated across a grid 15 m apart set up using a GPS unit. At each grid point a meter square frame was randomly dropped in 2000 and then permanently marked; thereafter the number of *E. esula* and *E. robusta* stems in it were counted. From 2001, percent cover of both species was also estimated in each frame with a point frame (Levy and Madden 1933), and the first contact only for each wire in the frame was recorded.

Following dissection of some *E. esula* plants in 2000 at Site 1, the next year, on May 25, 2001, 12 *E. robusta* plants were dug up to examine the roots for presence of *A. nigriscutis* larvae and feeding damage. On April 17, 2003, 30 *E. robusta* and 30 *E. esula* were dug up using a 10 cm (4 in) cup cutter to keep soil intact around the roots of the plants. These plants were kept alive in a greenhouse and bagged to monitor insect emergence. After adult emergence was complete, the soil was sifted for pupa and dead adults. The roots were examined for feeding damage and presence of larvae.

Results and Discussion

By 2000 *E. esula* dramatically declined to 12% cover and there were many new *E. robusta* plants to be recorded and

Table 1. Percent survival of *Euphorbia robusta* in 2006 by year of discovery.

Year of discovery	1999	2000	2001	2002	2003	2004	2005
Percent surviving in 2006	52	61	67	65	95	76	75
New plants marked	36	198	258	63	19	21	4

evaluated. Five of the 36 marked *E. robusta* plants were not present in 2000 and all had been fed on heavily in 1999. However, nine other plants also had heavy feeding in 1999, one was dug up in 2001 and 6 (43%) survived until 2007. Three of the five plants missing in 2000 reappeared and were evaluated in 2007. In 1999, 17 *E. robusta* plants had light feeding, and all were alive in 2000; one was dug up in 2001, and 9 (53%) survived until 2007. A 450% increase in the *E. robusta* population took place between 1999 and 2000 at the same time *E. esula* had declined. By 2007, over 600 *E. robusta* plants have been recorded and monitored at Site #1.

In contrast to the change in *E. esula* ground cover, stem density was variable over time, with 12 stems/m^2 in 2000, and 7, 9, 14, 25, 10, and 6 stems/m^2 through 2006. The change in *E. esula* ground cover was not the result of fewer stems, but rather a reduction of size of *E. esula* plants by *A. nigriscutis.* Plant size was reduced from an average height of 58 cm (23 in) in 1994 to unbranched, non-flowering stems 10 to 15 cm (4-6 in) tall in 2006. These smaller plants now are part of the mix of plant species rather than a dominant canopy overshadowing the smaller native vegetation. Density of *E. esula* stems is not related to the decline in feeding damage to *E. robusta*, but the decline in ground cover is.

At Site #2, there were 81 marked *E. robusta* plants in 2000; that number increased to 101 plants in 2001. By 2007, 76 plants remained, including 26 of the original plants. We estimated 54 of the 81 (66%) survived until 2007, which was similar to Site 1 (see Table 1). Our census data suggested *E. robusta* is a short-lived perennial with regular mortality and recruitment of new plants.

No larvae were found among the dug-up plants in 2001. However, in 2003, *Aphthona nigriscutis* feeding damage was present and adults emerged from *E. esula*, but neither feeding damage nor adults were seen with *E. robusta*. *E. robusta* root material was not examined when the beetle population was high in 2000 so we could not verify whether larval feeding on the roots took place at high beetle density. Nonetheless beetles were present in subsequent years and had the opportunity to attack adjacent *E. robusta* (Wacker and Butler 2006).

During the host specificity testing, the host range of *A. nigriscutis* was found to be within the subgenus *Esula* in the genus *Euphorbia*, which includes *E. robusta* (Pemberton 1986, 1987, 1989). Pemberton's conclusion in the petition to release *A. nigriscutis* was that *E. robusta* was likely to be attacked even though it was not tested. In contrast, Wacker and Butler (2006) suggested that *E. robusta* might be a poor host for *Aphthona* spp. because its smaller taproot would be unable to provide a food source comparable to the heavy rhizomatous root system of *E. esula*. They reported that when large numbers of *Aphthona* were released onto isolated populations of *E. robusta*,

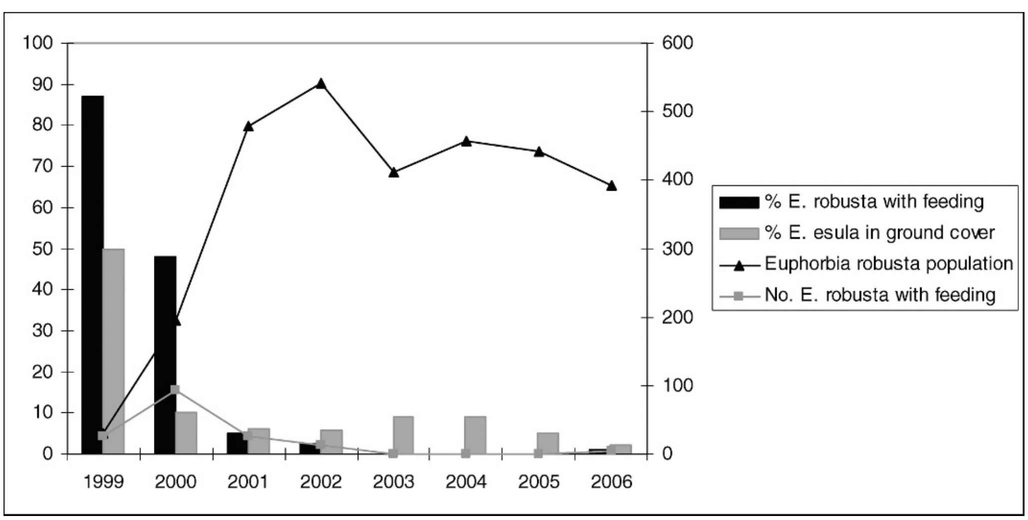

Figure 1. Time course for *E. esula* cover (%), and *E. robusta* population size, feeding incidence (%), and number of *E. robusta* with feeding.

temporary adult feeding was observed, but *Aphthona* populations did not persist.

Percent cover of *E. esula* at Site 1 during this study is presented in Figure 1. No difference was found between the random and permanent samples of percent cover used at Site 1. As the *E. robusta* population increased, the number of plants with feeding damage first increased, then decreased, and the percentage of plants fed upon declined annually over the period (Figure 1). There was a negative relationship between *E. esula* percent cover and *E. robusta* density (Figure 1) suggesting the *E. robusta* population might have been suppressed by *E. esula*. Feeding damage to *E. robusta* appears to lag a year behind the *E. esula* percent cover decline (Figure 1) suggesting that adult feeding by *A. nigriscutis* on *E. robusta* in 2000 is more closely related to *E. esula* ground cover in 1999 than in 2000. Changes in the abundances of both species might also be linked to a ten-year drought in the Lander area if *E. robusta* is more drought tolerant. Only 2005 had precipitation nearing the average for the previous ten years.

Observations at Site 1 suggest that *A. nigriscutis* only fed on *E. robusta* when its primary host, *E. esula,* was plentiful enough to support dense beetle populations. As *E. esula* cover declined, adult feeding by *A. nigriscutis* on *E. robusta* declined as well, even though the *E. robusta* population increased (Figure 1). Even with a 17-fold increase, however, *E. robusta* still did not replace the amount of *E. esula* cover and biomass present in 1999 and so could not have sustained the earlier high *Aphthona nigriscutis* densities.

Although we could not confirm whether *A. nigriscutis* can complete its life cycle on *E. robusta* in the field, the strong correlation between the declines in *E. esula* with the decline in beetle damage to *E. robusta* suggests that we observed only an adult feeding effect. If *E. robusta* was a good developmental host for beetle larvae, then it seems unlikely that adult feeding would decline. Adult feeding alone might not have had sufficient impact on *E. robusta* to affect population density of this perennial plant (R. W. Pemberton, personal communication). If so, then the observed morality of *E. robusta* was not caused by the beetle. This is supported by the comparative if rather crude survivorship data (Table 1).

Waage (2001) reports two parallel occurrences where weed biocontrol agents attacked nontarget species during the epidemic period of agent development when the host plants were superabundant. A lace bug, *Teleonemia scrupulosa*, released against largeleaf lantana (*Lantana camara* L.) in sesame crops in Uganda attacked the crop at peak populations (Davies and Greathead 1967), and a leaf beetle, *Zygogramma bicolorata*, released against ragweed parthenium (*Parthenium hysterophorus* L.) attacked sunflowers in India during population explosions (Jayanth et al. 1993). In both cases, a decline in host plant numbers resulted in a decline in the biological control agent and the nontarget feeding stopped (Davies and Greathead 1967; Jayanth et al. 1993).

Aphthona beetles are proving to be excellent biological control agents for *E. esula* in the United States (Nowierski and Pemberton 2002). Our study supports this by suggesting that damage to related *E. robusta* was only transient and appeared to be only adult feeding related to the density of the target at the same sites. This study helps to evaluate the nontarget risks identified during host–range testing in the field following release. No choice feeding during host specificity testing does not necessarily equate to nontarget damage in the field, especially when the nontarget species is at low density. This study presents another example that this is often the case and that nontarget feeding, even when observed, often falls to insignificant levels if the target is suppressed.

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