Home on the Range: Establishment of a Canada Thistle Biocontrol Agent

By Deirdre A. Prischmann-Voldseth, Greta Gramig, and Erin E. Burns

Invasive weeds are one of the worst scourges within rangelands, and it is often difficult to control them using conventional approaches such as herbicides or mowing. But all is not lost—insect allies can help us combat these noxious plants! We are talking about insect biocontrol agents, or plant-eating bugs that feed on weeds. However, there are hurdles these insects must overcome to successfully control weed populations; the first is establishing a viable population after being released. In this article we focus on one such ecological drama, which is the biocontrol of Canada thistle in North Dakota with a stem-mining weevil.

The Setting: North Dakota–The Peace Garden State

Environmental conditions can have dramatic impacts on insect–plant interactions and insect biology (e.g., mortality, reproductive rates, developmental times, overwintering capabilities). North Dakota is one of the most rural states in the United States, with 13.5 million acres of rangeland and 22 million acres of harvested cropland.[1,2] This large state is well known for harsh, cold winters, with average annual temperatures ranging from 37°F in the northeast region of the state to 43°F along the southern border.[3] Average winter temperatures are 11–15°F higher in the southwest corner of the state than the northeast corner because of warming effects of Chinook winds. The average number of days with freezing air temperatures (32°F) range from 180 in southwest North Dakota to 210 in areas along the Canadian border. Soil temperature data are scant, but along the eastern border in Fargo the lowest average soil temperature was 8.2°F at a 0.25-inch soil depth (data from the mid-1960s).[3] Average depth of frost penetration into the soil ranges from 4 to 4.5 ft. The freezing depth of soil depends on air temperature, soil type, soil moisture content, and insulation from vegetation and snow cover. In general, drier soils freeze more quickly and to a greater depth than moisture-laden soils. North Dakota receives an average of 20 inches of annual precipitation in the southeast to 13 inches in the northwest. Typically annual precipitation increases from west to east, but because of topographic uplift, one area in the southwest receives more than 16 inches of precipitation annually, which is substantially greater than the surrounding area.[3]

The Antagonist: Canada (a.k.a. Creeping) Thistle–The Ultimate Invasive Weed

Noxious perennial weeds are a constant problem plaguing the vast stretches of rangeland in North Dakota. Canada thistle (*Cirsium arvense* L.; Fig. 1) is the number one noxious weed in the state, with approximately one million acres currently infested. This weed species is an invasive perennial that thrives in disturbed or moist habitats.[4] Canada thistle causes several ecological problems, including native plant displacement, a reduction in the quality of grazing land, and lower crop yields.[4] This weed is particularly difficult to manage on low-lying moist sites such as those associated with riparian areas.[5] Canada thistle spreads via seeds and shoots that sprout from an extensive, creeping root system. Current management programs often rely on herbicide applications, mowing, tillage, and crop rotation. However, many of these tactics can be costly and labor intensive, and many herbicides cannot be used in environmentally sensitive areas (e.g., near water). Thus, there is a need for alternative control measures.

The Protagonist: *Hadroplontus litura*–A Stem-Mining Weevil

Biological control can be an important component of an integrated approach to weed management, and several natural enemies have been investigated with regard to Canada thistle.[6] In general, these insect biocontrol agents have either failed to establish or have had minimal impacts on thistle populations.[6] However, some land managers and scientists believe that in some cases *Hadroplontus* (formerly *Ceutorhynchus*) *litura* Fabricius, a stem-mining weevil native to Europe (Fig. 2), may contribute to Canada thistle suppression.[7,8]

Adult weevils overwinter in the soil and begin feeding on Canada thistle rosettes once they emerge in the spring. After several weeks, females deposit eggs within holes chewed into plant tissue. Larvae cause the majority of damage when they

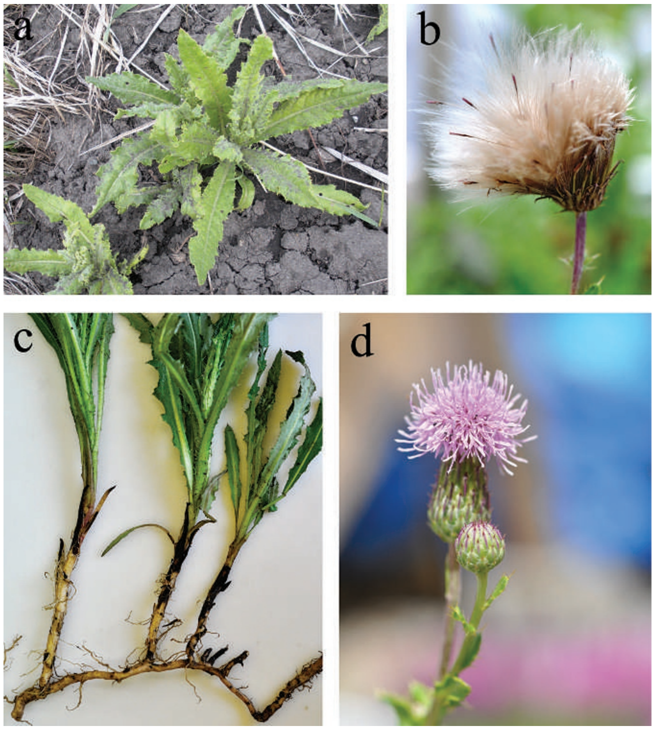

Figure 1. Canada thistle (*C. arvense*). **a,** early-season rosettes; **b,** reproductive flower with seeds and papus; **c,** clonal vegetative stems; **d,** early-season flower and bud. Photos by Erin Burns.

tunnel into plant stems to feed on the pith. Larval feeding can make plants more susceptible to pathogens and adverse environmental conditions.[8] However, larvae do not damage vascular bundles, and plants often compensate for reductions in vigor and root carbohydrates after larvae stop feeding and pupate in midsummer.[9] Overall, most scientific literature indicates that these weevils have a minor impact on reducing the spread or distribution of nonstressed thistle populations.[6] Therefore, current research is focusing on integrating this weevil species with other management tactics, such as herbicides, pathogens, and/or plant competition[10,11]

The Conflict

Evaluating the establishment and performance of introduced biological control agents is an integral part of weed biocontrol programs. After insects are released into a new environment, they must survive, reproduce, and maintain a viable population before they can negatively impact the target weed. Criteria for confirming establishment vary but generally involve recovering insects two or more years following their initial release. Several factors can influence the establishment and success of weed biocontrol agents, including number of insects released, number of releases, environmental conditions, biology and behavior of the biocontrol agent, and weed density and biology.[12,13] Although monitoring the performance of introduced biocontrol agents and the suppression of target weeds is essential to developing effective weed management programs, scientists rarely perform these types of assessments.

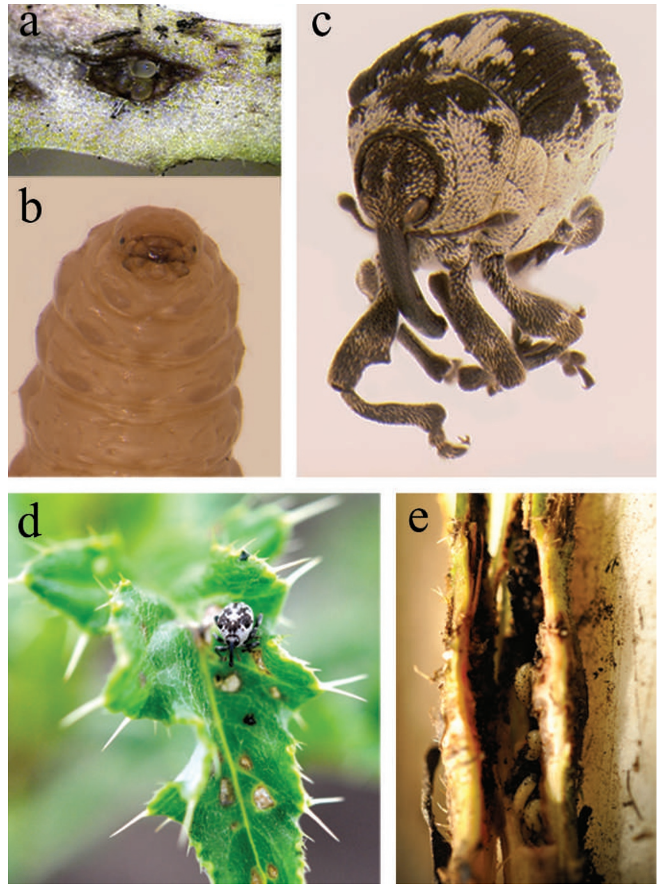

Figure. 2. The stem-mining weevil, *H. litura*. **a,** eggs laid in leaf tissue; **b,** ventral field of larva; **c,** adult weevil; **d,** adult weevil and associated windowpaning damage to thistle leaves; **e,** weevil larvae and associated stem-mining damage. Photos by Deirdre Prischmann-Voldseth (a–c) and Erin Burns (d–e).

Hunting for Our Hero

In 2004 North Dakota Department of Agriculture (NDDA) personnel released *H. litura* at 102 sites in 34 counties within North Dakota. Release sites spanned a wide range of habitats varying in climate, soil type, and native vegetation. The NDDA purchased weevils from a commercial supplier (Integrated Weed Control, Bozeman, MT), who field-collected them in Montana. At each site, NDDA personnel released approximately 1,000 adult weevils (combination of males and females) at one point near the edge of the thistle patch. They marked the exact release point with a metal fence post and recorded its GPS coordinates.

In June and July 2008, teams organized by the NDDA assessed all but seven release sites. Twenty sites had experienced major disturbance (e.g., cultivation, flooding, and pesticide application) and were considered failures. At the other 75 sites, workers randomly sampled 20 thistles from within 20 feet of the release point (i.e., where weevils were initially released in 2004). They determined the presence or absence of *H. litura* by splitting open thistle stems and looking for weevil larvae, stem damage, and/or weevil frass.

During July 2009, NDDA personnel and researchers from North Dakota State University (NDSU) revisited 46 of the release sites that had been sampled in 2008. Prior to sampling, NDSU workers established permanent transects at all sites so that samples could be systematically collected (Fig. 3). Three 52-ft-long transects extended out from the point where weevils were originally released and fanned out away from linear patch edges. These linear boundaries were primarily caused by anthropomorphic activity (i.e., were roads or field edges). Workers harvested 20 thistle stems at each site—five from each of four inter-transect spaces. They cut thistles 2.5 inches below the soil surface, which they then bagged and placed in ice chests for transport back to the lab. Workers processed plants in the lab, which involved using a scalpel to split open stems and assessing the presence of weevil larvae and/or severity of larval mining damage.

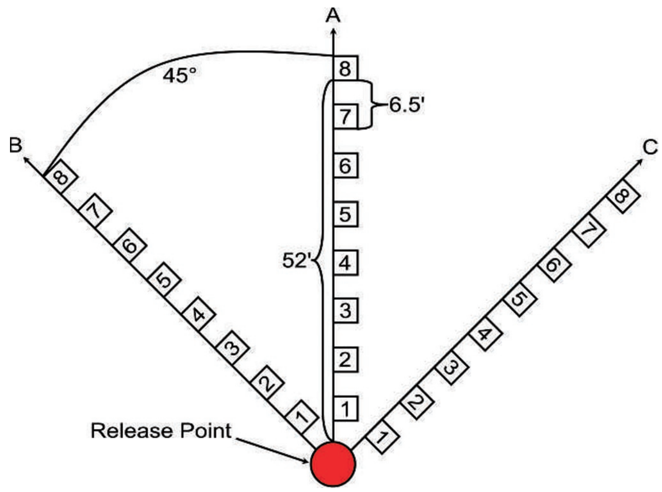

Figure. 3. Diagram of weevil release point and permanent transects with quadrats (2.7 ft^2) used to assess weevil and thistle densities.

Home on the Range

In 2008 there was evidence of larval weevil activity at 45 of the 75 sampled sites. Percent *H. litura* infestation ranged from 5% to 95% at the sites where the weevils were present (i.e., sites with larvae and/or mining damage within thistle stems; Fig. 4). In 2009 workers documented *H. litura* activity at 35 of the 46 revisited sites, with the percent of infested plants ranging from 5% to 70% (Fig. 4). Virtually all of the sites with weevils present in 2008 also had weevils in 2009, and 11 of sites without confirmed weevil activity in 2008 were found to have evidence of weevils the following year. Five years after being released, researchers documented the weevils at 55 of the original 75 nondisturbed sites, indicating that the biocontrol agent had established at 73.3% of sites where it was successfully released. Note that this establishment rate is based on limited sampling and is therefore a conservative estimate. In addition, workers found high stem infestation rates (> 50%) at sites throughout the state, both along N–S and E–W gradients, indicating that weevils were able to establish at sites with a range of environmental conditions.

Our results clearly demonstrate that the protagonist is surviving and thriving in North Dakota, even though air and soil temperatures in the winter can be extremely low. These positive findings parallel those from other northern locations. In Ontario, Canada, scientists field released *H. litura* in 1967 and considered it established after its recovery the following year.[14] In the 1970–1980s, researchers released *H. litura* in multiple locations throughout the United States (including Montana and South Dakota), and this species is now established in several states.[14]

Although *H. litura* is often considered the most effective agent for control of Canada thistle, results of previous research are mixed with regard to the performance of this biocontrol agent. Based on multiple field releases in several geographic locations, the general consensus is that by itself, *H. litura* is not an extremely effective biocontrol agent. Since

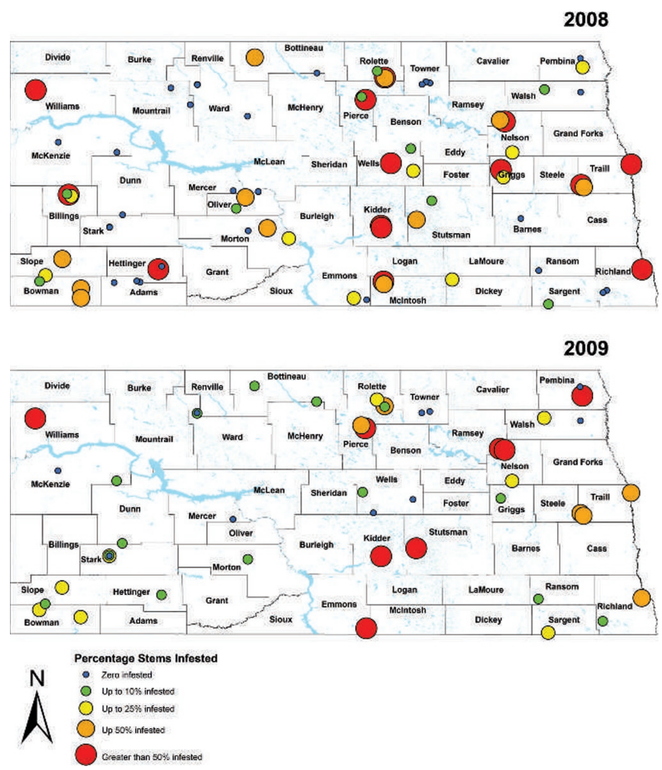

Figure. 4. Map of North Dakota showing weevil establishment data for release sites sampled in 2008 and 2009.

H. litura damage occurs relatively early in the season, thistle plants may or may not recover, depending on other stresses such as drought, pathogens, and plant competition.[8,11,15] An integrated weed management approach is likely to be the most successful way to control Canada thistle. Therefore, identifying environmental and biotic factors associated with improved performance of biocontrol agents is important, because multiple stressors may work additively or synergistically to enhance thistle suppression.

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