Flea Beetle (*Altica* spp.) Herbivory on a Threatened Plant, F.E. Warren Air Force Base, Wyoming

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RESEARCH NOTE

Flea Beetle (*Altica* spp.) Herbivory on a Threatened Plant, F.E. Warren Air Force Base, Wyoming

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ABSTRACT: Colorado butterfly plant (*Oenothera coloradensis* (Rydb.) W.L. Wagner & Hoch ssp. *coloradensis* [syn. *Gaura neomexicana* Woot. ssp. *coloradensis* (Rydb.) Raven & Gregory]) in the *Onagraceae*; Primrose family) is a Threatened plant whose population declined in a protected area in southeastern Wyoming in 2007-2008, setting record low numbers in 23 years of the annual population census. This trend was accompanied by pervasive flea beetle herbivory (*Altica* spp.) in 2007. The most frequent flea beetle species collected in 2008-2009 was *Altica foliaceae* LeConte, a native species. *Altica foliaceae* favors members of *Onagraceae*, and *A. foliaceae* adults were collected on browsed *Oenothera* plants. The *Oenothera* population returned to pre-infestation numbers in 2009-2010, evidence that it survived by vegetative plants and seed bank. Results point to the importance of repeated long-term monitoring, without which this event could have been interpreted as a disaster or have gone unnoticed. It also documents an event that can inform population viability analysis.

Index terms: Altica, herbivory, long-term monitoring, *Oenothera*, Threatened plant

INTRODUCTION

Colorado butterfly plant (*Oenothera coloradensis* (Rydb.) W.L. Wagner & Hoch ssp. *coloradensis* [syn. *Gaura neomexicana* Woot. ssp. *coloradensis* (Rydb.) Raven & Gregory]) was listed as Threatened under the Endangered Species Act in 2000 due to limited distribution and threatened habitat (USDI FWS 2000). F.E. Warren Air Force Base (WAFB) contains one of the largest populations of *Oenothera* and the only one protected on federal land. Complete population census of *Oenothera* was initiated on WAFB in 1986 and conducted annually from 1988-2010 to determine if the population was being maintained (Marriott, unpubl. data; Fertig, unpubl. data; Heidel et al. unpubl. data; Wepprich et al., unpubl. data). It represents the only long-term census of an *Oenothera* population, and the only one at regular annual intervals. Unprecedented declines in *Oenothera* population numbers took place in 2007-2008 across WAFB. Thus, we sought to determine the cause of this event.

Oenothera is a monocarpic biennial or short-lived perennial that has a cluster of basal leaves in the vegetative stage and a flowering stalk 50-80 cm tall in the reproductive stage (Fertig et al. 1994; Floyd and Ranker 1998). It is restricted to mesic floodplains and drainages in northeast Colorado, southwest Nebraska, and southeast Wyoming (Fertig et al. 1994; USDI FWS 2000).

WAFB is located immediately west of Cheyenne (41° 07'N 104° 52'W) in Laramie County, Wyoming. WAFB has the only Oenothera population located on federal land, and it has the only population with long-term monitoring (Grunau et al., unpubl. data). *Oenothera* occupies riparian habitat along three streams of contrasting settings on WAFB, at 1862-1887 m elevation.

METHODS

Plant population trends and herbivory patterns

Complete population census of *Oenothera* population on WAFB was conducted in 1986 and annually from 1988-2010 to determine whether goals of maintaining the population were being met. Information on herbivory frequency, extent, and patterns on *Oenothera* plants was sought concurrently during population census of *Oenothera* in August 2007-2010. Photographs were taken of herbivory patterns and flea beetle larvae in 2009 to document the herbivory phenomenon.

Insect collections

Insect collections were made in early- and mid-summer in the 2008-2009 growing seasons on or near *Oenothera* plants to identify the 2007 outbreak agent. In 2008, sweep net collections of adult flea beetles (*Altica* spp.) were made among *Oenothera* plants on two of three WAFB streams (23 June, 21 July, 6 August, 29 August, and 3 September). In 2009, larvae and adult flea beetles were collected by hand directly from *Oenothera* plants on all three WAFB streams (July 29). The 2009 flea beetles were identified to family by Scott Schell and to species by Charles Staines. The 2008 specimens were identified to family

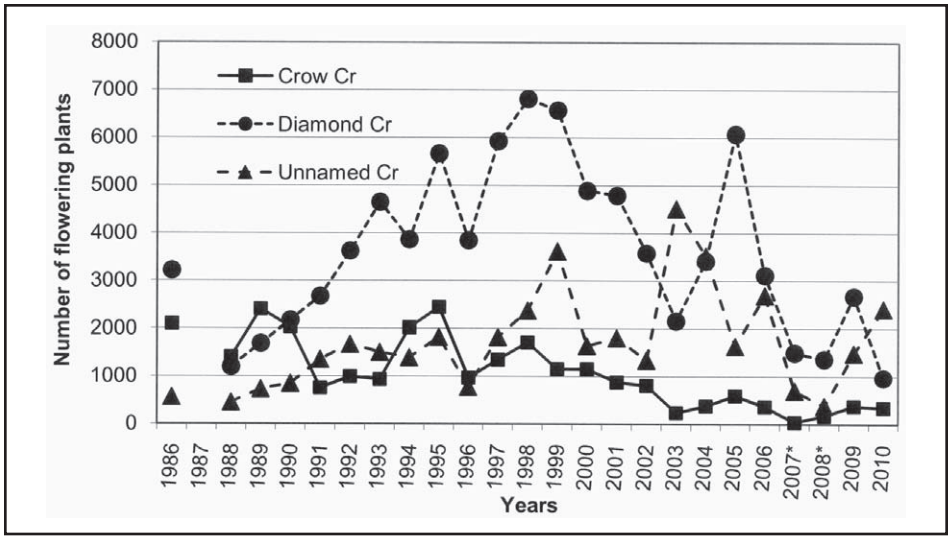

Figure 1. Colorado butterfly plant trends, WAFB (1986-2010).

by Lusha Tronstad and to species by Shawn Clark and Laurent LeSage.

RESULTS

Plant population trends and herbivory patterns

In 2007, all flowering *Oenothera* plants showed signs of heavy insect herbivory on WAFB, and the population reached a 20-year low (Figure 1). Numbers declined further in 2008, though there were no aboveground signs of herbivory. The associated population growth rates were interpreted as outliers of the previously observed growth rates, calculated as the natural logarithms of the two-year growth rates for all three streams, falling over two standard deviations below the average (Wepprich et al., unpubl. data).

In 2007, flowering plant leaves were covered by a perforated shot-hole pattern typical of adult flea beetles, representing loss of 50%-100% functional leaf area (S. Clark, Anthropod Collections Manager, BYU Bean Museum, pers. comm.; Figure 2). Stems and inflorescence branches were scarred and broken, buds eaten, and flowering/fruit production curtailed or greatly reduced on all plants, which is typical of flea beetle larvae damage (Figure 3). Some *Oenothera* plants died and dried before flowering. The damage to live inflorescences was heavy, such that intact flowers and fruits were scarce. Herbivory was found only on reproductive *Oenothera* plants, but not on vegetative plants inspected in September.

Signs of above-ground herbivory were not detected in 2008, and *Oenothera* plants appeared healthy. However, the total number of *Oenothera* plants in 2008 on WAFB was lower than in 2007 (B. Heidel 2009, unpubl. data). Synchronous declines took place in other *Oenothera* populations (J. McKee, Fish and Wildlife Biologist, U.S. Fish and Wildlife Service – Ecological Services, pers. comm.; C. Strouse, Natural Areas Technician, Ft. Collins, Colo., pers. comm.).

In 2009, nearly all *Oenothera* plants appeared healthy and the numbers of plants on WAFB rebounded (Heidel et al. 2010, unpubl. data). There were still low levels of herbivory observed throughout the population, with patterns corresponding to those from 2007 except in lower frequency and intensity. Few leaves were browsed.

Figure 2. Severe herbivory on a leaf of Colorado butterfly plant, July 2009. Photo by B. Heidel.

Figure 3. Severe foliage herbivory on a live Colorado butterfly plant, August 2009. Photo by B. Heidel.

Very few had almost all foliage consumed. Larvae were observed on a July 2009 visit (Figure 4). In 2010, none of the above herbivory patterns were detected over the course of the growing season, though numbers declined further in part of the population (Diamond Creek).

Insect collections

Five species of adult beetles in the tribe Alticini (Family Chrysomelidae) were identified from collections in 2008-2009 (Table 1). In 2008, *Altica foliaceae* LeConte was collected in each of five sweep net samples throughout the growing season at WAFB and on *Oenothera* plants. Two other flea beetle species were collected in the 2008 sweep net samples (*Chaetocnema ordinata* White and *Phyllotreta albonica* LeConte), but were not found directly on *Oenothera* plants. Thus, *Oenothera* may not be their preferred host plant. In 2009, *A. foliaceae* was collected by hand directly from *Oenothera* plants at WAFB. Two other flea beetle species were collected directly from *Oenothera* plants in 2009: *A. torquata* LeConte and an undescribed species of *Altica*, and *Oenothera* may be their preferred host. Larvae of flea beetles were also collected by hand from *Oenothera* plants in 2009, though it was not possible to identify larvae to species.

DISCUSSION

There are prior reports of Altica foliaceae herbivory on other species of Oenothera (Clark et al. 2004) but not on this one. Flea beetle herbivory has not been noted in prior monitoring on WAFB. All of the flea beetle species collected on or near *Oenothera* and identified are native. Both *Altica foliaceae* and *A. torquata* are recognized as having host plants in the Onagraceae. Only the former is recognized as having a closely-related species of butterfly plant among its host plants, namely *O. curtiflora* W. L. Wagner & Hoch (syn. *Gaura parvifolia* Dougl. ex Lehm) (Clark et al. 2004). However, herbivory was not observed on any other members of the Onagraceae at WAFB, including the sympatric *O. curtiflora*.

The affinity of *Altica foliaceae* to *Oenothera* and its frequency and ubiquity in ensuing years support the interpretation that *A. foliaceae* was a likely agent in the 2007 herbivory outbreak on *Oenothera*. The ubiquity of herbivory was consistent with reports that adults of *A. foliaceae* are strong fliers which disperse widely (Cranshaw 2010). The Chrysomelidae larvae that were observed damaging *Oenothera* plants at the same time as adults may have been *Altica* larvae of the same species, because larvae and adults overlap during summer (Barstow and Gittins 1971; Phillips 1977; Sangita et al. 1986; Nayek and Banerjee 1987; Michaud 1990). Larvae can be voracious herbivores that result in reduced flower mass, reduced seed mass, and lower annual increment of root weight of perennial host plants (Michaud 1991).

Altica densities can increase without warning and severely defoliate host plants (Woods 1917; Michaud 1990). Severe defoliation of host plants can hinder flowering (Michaud 1990), cause plant shoots to die (Atkins 1964), or kill the plant (Went 1973; Phillips 1977). *Altica* outbreaks have been reported in agricultural and natural settings in the past (e.g., Port and Guile 1986; Michaud 1989; Dosdall and Stevenson 2005; Hiiesaar et al. 2006). For example, fireweed (*Epilobium angustifolium* L.) is an important nectar plant in British Columbia for beekeepers. Sudden, unprecedented outbreaks of *Altica tombacina* Mannerheim have severely defoliated populations of their host plant, fireweed, resulting in much lower honey returns (Atkins 1964; Michaud 1989). Similarly, outbreaks of *Altica* spp. have severely defoliated heather (*Calluna vulgaris* (L.) Hull) in Britain (Phillips 1977), and outbreaks of *Altica bimarginata* Say have damaged alder (*Alnus* spp.) in the northeastern United States (Woods 1917). Often, the reasons for sudden increases in beetle densities are unknown (Woods 1917; Atkins 1964; Michaud 1990).

Figure 4. Photos of chyrsomelid larvae browsing buds and inflorescence branches of Colorado butterfly plants in July and August 2009. Photos by B. Heidel.

The further decline of the *Oenothera* population in 2008 when there were no signs of herbivory is unexplained unless there was underground herbivory or undetected herbivory on vegetative plants, possibly including the seedling stage. Flea beetle herbivory can be most devastating when the plants are young and becoming established (Sangita et al. 1986; Bach 1993).

The 2007-2008 decline of *Oenothera* on WAFB exhibited greater synchrony between the three stream subpopulations than at any other time during monitoring (Figure 1). The pattern was consistent with the ubiquity and severity of declines reported elsewhere in its range (J. McKee, Fish and Wildlife Biologist, U.S. Fish and Wildlife Service – Ecological Services, pers. comm.; C. Strouse, Natural Areas Technician, Ft. Collins, Colo., pers. comm.). This led us to pursue population viability analyses that included evaluation of the growth rates with and without the herbivory event, and for each stream subpopulation (Wepprich et al., unpubl. data).

The population rebounded in 2009, though low herbivory levels persisted. The population numbers dipped in 2010, though plants were healthy. Monitoring should continue at some level to determine whether herbivory outbreaks are recurring events. Analysis of the life history of *Altica foliaceae* is warranted if herbivory outbreaks repeat.

An unprecedented herbivory outbreak event for *Oenothera* in the 20th year of long-term monitoring is a reminder of the potential for ecological surprise in familiar systems (Doak et al. 2008). The results highlight the importance of repeated long-term monitoring, without which this event could have been interpreted as a disaster or gone completely unnoticed. Finally, it provides context for addressing herbivory outbreak events affecting the population viability and recovery of *Oenothera*.

ACKNOWLEDGMENTS

The hypothesis of flea beetle herbivory on *Oenothera* was first made by Jan

Table 1. Flea beetles collected in Colorado butterfly plant habitat on WAFB (2008-2009).

Species	2008	2009
Altica foliaceae LeConte	**X**	**X**
Altica torquata LeConte		**X**
Altica spp.		**X**
Chaetocnema ordinata R.E. White	**X**	
Phyllotreta albonica LeConte	**X**	

[1] The 2008 specimens were deposited at the Smithsonian Institution. The 2009 specimens were deposited at M. L. Bean Museum of Brigham Young University, University of Montreal, and University of Wyoming.

McKee (U.S. Fish and Wildlife Service – Ecological Services, Cheyenne, Wyo.) based on her work at other populations in 2007. Reports of herbivory outbreak on *Oenothera* in 2007 and trend observations in 2008 were provided by J. McKee and by Crystal Strouse (City of Fort Collins, Colo.). Insects were identified to family by Scott Schell (University of Wyoming Extension) and to species by Charles Staines (Smithsonian Institution) in 2008. Flea beetle determinations were made to species by Shawn Clark (M.L. Bean Museum, Brigham Young University) and Laurent LeSage (University of Montreal) in 2009. Review comments by Shawn Clark and Tyson Wepprich are gratefully acknowledged. This study was coordinated for WAFB by Lori Ford and Cathryn Pesenti, made possible through monitoring funds provided by U.S. Air Force – F.E. Warren Air Force Base in collaboration with the University of Wyoming.

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