Population Cycles of the Larkspur Mirid (Heteroptera: Miridae)[1]

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Abstract The larkspur mirid, *Hoplomachus affiguratus* Uhler, has been proposed as a biological control agent to damage tall larkspur, *Delphinium barbeyi* (L.) Huth, to prevent cattle from grazing it and becoming poisoned. The objective of this study was to monitor mirid populations and feeding damage to larkspur over time and determine if its population cycles are related to specific weather patterns. Individual larkspur plants were marked and the extent of damage estimated at 5 locations on 3 National Forests in Utah and Colorado. In years when mirid populations were high, damage to larkspur leaves ranged from 50 to 100% and greater than 75% of flowering heads aborted. In years and locations when its population was down, damage was minimal. The amount of larkspur damage was negatively correlated with the previous year's total precipitation and the previous September precipitation ($r = -0.68$ to -83) and was positively correlated with July and August temperature the previous year ($r = 0.61$ to 0.75). When mirid populations are high, damage levels appear to be sufficient to deter cattle grazing, but low levels of damage at the bottom of the cycle will likely not deter grazing.

Key Words Larkspur mirid, *Hoplomachus affiguratus,* population cycle, tall larkspur, *Delphinium barbeyi,* poisonous plant, cattle poisoning

Tall larkspur, *Delphinium barbeyi* (L.) Huth, is a serious poisonous plant that kills 4 to 15 percent of cattle grazing in larkspur-infested areas on mountain rangelands throughout the western U.S. (Pfister et al. 1993). It is a native pristine species in the tall forb community and occurs in patches on snowdrift sites in subalpine areas and under aspen canopy above 2600 m elevation. It is a large robust plant averaging 40 stems/plant (ranging up to 150/plant) and grows to a height of 1-2m. The larkspur mirid, *Hoplomachus affiguratus* Uhler, is host-specific to tall larkspur (Uhler 1895, Fitz 1972) and has been proposed as a biological agent to damage the weed and prevent cattle from eating larkspur. The larkspur mirid feeds on larkspur leaves and flowering heads, causing the flowering heads to abort and the leaves to become necrotic, turn brown and desiccate. Cattle will not eat the damaged plants (Ralphs et al. 1997), thus poisoning can be prevented. Because the larkspur mirid is a native insect that co-evolved with larkspur, it is unlikely to be successful as a classical biological control agent in the sense of killing or suppressing larkspur populations. However, its role in damaging larkspur to prevent consumption by cattle may be a novel biological tool in reducing the risk of poisoning.

The larkspur mirid is present in most tall larkspur populations. However, dense natural populations of the larkspur mirid were observed on the Routt National Forest

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near Yampa, CO, in 1988 (Peterson and Clementson 1989) and in central Utah near Ferron Reservoir on the Wasatch Plateau and in Salina Canyon on the Fishlake National Forest in 1992 (Ralphs, pers. obser.). Cattle and sheep refused to graze these mirid-damaged larkspur plants. Research confirmed that cattle will not eat mirid damaged plants (Ralphs et al. 1997). Mirid damage may also lower the toxic alkaloid concentration (Ralphs et al. 1998).

Success in transferring mirids to new plants and other larkspur populations has been mixed (Jones et al. 1998). Transferring second through fourth instars resulted in significant damage the year of transfer. In subsequent years, the mirid population grew and spread throughout the patch at some locations, but the mirids remained only on the plants to which they were transferred at other locations. Female mirids deposit eggs singly in the mature stems in late summer. As the stems senesce, they collapse and are buried beneath the snow during the winter. In the early spring, nymphs hatch from the old stems and crawl onto the new emerging larkspur shoots. Fall transfer of senescent stems containing mirid eggs is logistically more practical, but resulted in 50% success rate in establishing new populations. This method of harvesting larkspur stems from infested populations and transferring them to new larkspur patches was more successful in western Colorado (Kent Mower, pers. comm.).

In larkspur patches where mirid populations are high and the majority of plants are significantly damaged, the mirid has the potential of preventing cattle from eating larkspur and becoming poisoned. However, mirid populations tend to cycle, and the high level of damage may not be maintained naturally. The objective of this study was to indirectly monitor mirid populations over time to describe their population cycles, and to investigate the role of specific weather events (precipitation and temperature) in these cycles.

Materials and Methods

Mirids are difficult to count in a nondestructive manner. However, the extent of their damage is readily observable and can be reliably estimated. Individual larkspur plants were marked, and the extent of mirid damage was estimated at 5 locations on 3 National Forests in Utah and Colorado. We counted the number of aborted reproductive heads in relation to the total number of mature stalks and made an ocular estimate of the percentage of leaf biomass that was damaged on each plant. These estimates were made on the same plants each year as an indirect measure of the larkspur mirid densities and evidence of year-to-year variation in population levels.

Yampa, CO, Bull Park. This site was an open park in the Aspen zone (2600 m elevation) and supported a tall larkspur patch about 1 ha in size. Other vegetation in this tall forb community included current (*Rubes montigenum* McClatchie), western coneflower (*Rudbeckia occidentalis* Nutt.), saw senecio (*Senecio serra* Hook.), aster (*Aster engelmannii* (D.C. Eaton) Gray) and mountain brome (*Bromus carinatus* H.&A.). The larkspur mirid was observed in 1989 by Petersen and Clementson (1989), and 20 plants were marked with rebar stakes and monitored for height and vigor for 2 yrs. In 1992, mirid numbers were low and little damage was apparent. In 1996, three of the original plants were relocated and an additional 17 plants were marked to assess extent of leaf damage and proportion of aborted heads on each plant in 1996 and 1998.

Ferron, UT, Ferron Reservoir. This site was in the subalpine zone (3000 m elevation) with scattered subalpine fir pockets interspersed in the tall forb plant community dominated by tall larkspur, western coneflower, sweet cicely (*Osmorhiza occidentalis* (Nutt.) Torr.), western bluebell (*Mertensia oblongifolia* (Nutt.) G. Don), and mountain brome. In 1992, we marked 10 plants that were heavily infested with mirids, and 2 plants at the edge of the patch that originally were not infested. In 1995, we marked an additional 10 infested plants along a transect that traversed the entire length of the larkspur patch (1.5 ha).

Mayfield, UT, 12-Mile Flat. This site was 6 km west of Ferron Reservoir on the western side of the mountain at 3000 m elevation. The plant community was similar to that at Ferron Reservoir. Mirids infested all larkspur plants in a 0.75-ha patch on a flat, but were not on plants up the slope. We marked 5 plants on the flat that were infested and 5 plants extending up the slope that were not infested in 1996.

Skyline Drive, UT. The site, 4 km west of Ferron Reservoir at the top of the mountain (3200 m), was partially shaded by subalpine fir trees. We marked 5 plants in the open sunlight that were infested with mirids and 5 plants that were shaded in mornings that were not infested in 1996.

Salina, UT, Salina Reservoir. Elevation was about 2900 m; the plant community was dominated by larkspur and mountain brome, with scattered snowberry (*Symphoricarpos longiflorus* Gray) shrubs. Mirids infested a 1-ha larkspur patch above a road, but were not present on the slope below the road. In 1996 we marked 5 infested plants along transects in the infested area and 5 plants in the non-infested area.

Data analysis. Plant height at Yampa, CO, in 1989 and 1990 was compared between infested and non-infested plants. A visual estimate of vigor was made of infested plants. Yearly mean estimates of leaf damage and aborted heads and standard errors of the mean are presented for 1996 and 1998. Estimates of leaf damage and aborted flowering heads were graphed over years beginning in 1992 at Ferron. Comparisons of leaf damage and aborted heads between marked larkspur plants that were originally infested and those that were not infested at Ferron Reservoir, 12-Mile Flat, Skyline Drive, and Salina Reservoir, were made by analysis of variance in a General Linear Model (GLM) in a split-plot design over time.

Weather records were obtained from USDA Natural Resource Conservation Service SNOTEL weather monitoring sites near each of the study sites. Distance from the weather stations to the respective sites were: Ferron 3 km, Skyline 4 km, Mayfield 5 km, Salina 7 km. Data were summarized into total annual precipitation, winter precipitation, and monthly growing season precipitation (June through Sept.); and average monthly temperature during the growing season. Correlations of leaf damage and aborted heads with the current and previous years' weather parameters were conducted. Multiple stepwise regression was used to determine the relative influence of current and previous years' weather parameters on mirid populations.

Results and Discussion

Mirid damage to larkspur plants ranged from 0 to 100% on both leaves and flowering heads. Feeding damage to the flowering heads caused the flowers to abort and wither and prevented the raceme from elongating. Leaf damage varied greatly among plants, ranging from a few mottled spots to extensive damage which caused leaves to senesce, desiccate and shrivel up.

Some of the damage to larkspur could not be attributed entirely to the mirid. The green-bronze aphid, *Kakinia wahinkae* Hoffes, was present on some plants, and the larkspur maggot, *Hylemya laxiforms Huckett,* was present in the pods, but did little damage to the foliar parts. Also, some flowering heads aborted from drought, but their racemes continued to elongate with the aborted flower bracts intact and spread out. Mirid-damage was separated from drought damage by the short, non-elongated racemes with shriveled, aborted flowers clustered together.

Plants infested at the beginning of the study sustained significantly higher level of damage of both leaves and heads compared to the original non-infested plants (Table 1). There was some mirid damage on the original non-infested plants in subsequent years as the mirid populations increased and mirids migrated to these new plants, such as at Ferron Reservoir in 1993 and 1997, and 12-Mile in 1996 and 1997.

Table 1. Mirid damage to infested larkspur plants, compared to non-infested plants (± SE)

		% Leaf damage		% Flower heads aborted	
Location	Year	Infested	Non-infested	Infested	Non-infested
Ferron	1992	—	—	100	11 ± 5
	1993	59 ± 7	25 ± 10	85 ± 6	66 ± 21
	1995	80 ± 5	—	92 ± 3	—
	1996	24 ± 4	0	24 ± 7	11 ± 9
	1997	48 ± 4	13 ± 8	76 ± 14	48 ± 47
	1998	18 ± 7	5 ± 5	3 ± 3	7 ± 7
	Mean	46 a	10 b	66 a	28 b
12-Mile	1996	68 ± 3	18 ± 3	99 ± 1	40 ± 8
	1997	55 ± 7	34 ± 7	91 ± 9	41 ± 19
	1998	11 ± 7	4 ± 2	33 ± 19	0
	Mean	45 a	20 b	74 a	28 b
Skyline	1996	31 ± 3	9 ± 3	91 ± 2	0
	1997	26 ± 4	5 ± 2	78 ± 14	5 ± 3
	1998	6 ± 4	3 ± 2	0	1 ± 1
	Mean	22 a	5 b	60 a	2 b
Salina	1996	57 ± 12	27 ± 4	96 ± 2	5 ± 4
	1997	45 ± 11	18 ± 4	95 ± 2	3 ± 1
	1998	27 ± 6	4 ± 2	37 ± 10	1 ± 1
	Mean	43 a	16 b	75 a	3 b
Yampa	1996	81 ± 4		59 ± 3	
	1998	100		79 ± 6	
	Mean	91		69	

Means of leaf damage and aborted heads followed by different letters are significantly different ($P < 0.05$).

At the Yampa site, mirids were abundant in 1989 and 1990, and the marked plants had poor to fair vigor. Mirid-damaged plants were shorter than undamaged plants (30 ± 5 cm vs 46 ± 1.5 cm, respectively). Few mirids were present in 1992, and little damage was apparent. However, in 1996, mirids were thriving and damage to both leaves and heads was high (Table 1). In 1998, all leaves on marked plants, as well as all other larkspur plants in the patch growing in full sunlight, were heavily damaged and had senesced, and most of the flowering heads had aborted. Larkspur plants growing under aspen were not infested with mirids and were still green and growing vigorously.

Mirid damage was considerable on larkspur plants at Ferron Reservoir from the time the plants were marked in 1992 until 1995 (Fig. 1). Almost all heads aborted, and damage to leaves increased to 80% in 1995. However, the population declined in 1996. There were very few eggs in larkspur stems collected just as the snow melted in the spring of 1996 (Ralphs, unpubl. data), suggesting that environmental conditions or other factors prevented egg deposition the previous fall. At the end of the 1996 season, 50% of the larkspur heads aborted but leaf damage was only 20%. The mirid population apparently recovered in 1997, but declined again in 1998 as evidenced by the lack of damage (Table 1).

Mirids were still abundant in 1996 at other sites on the Wasatch plateau (12-Mile and Skyline) and at Salina on the Fishlake National Forest (Table 1). The close proximity of these thriving populations suggests that weather alone may not be a

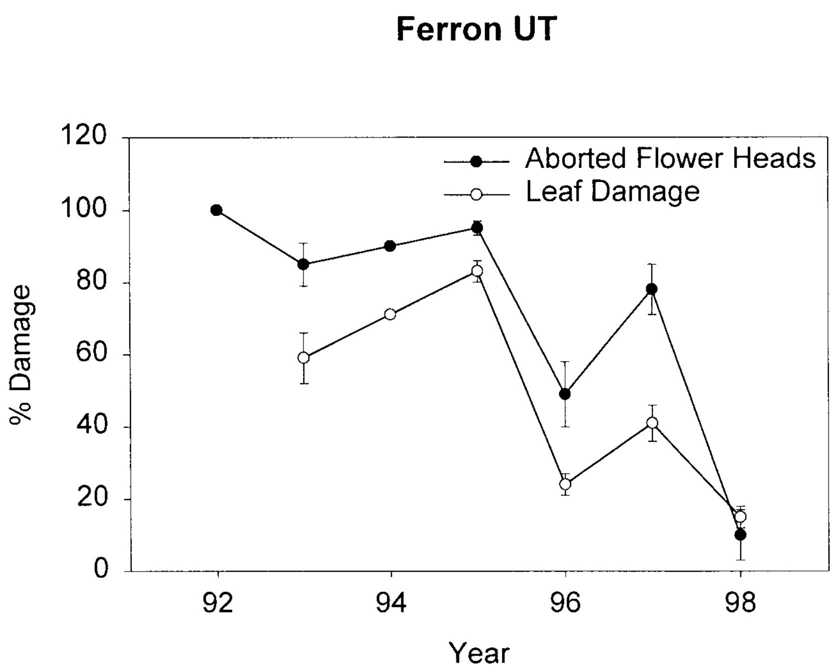

Fig. 1. Mirid damage to larkspur leaves and flowering heads over time on marked plants at Ferron UT.

cause of the population decline. However, there may have been microclimate differences that were not readily apparent. Predators were not observed in these mirid populations (Jones, pers. obser.). Mirid populations at all the Utah sites declined greatly in 1998, as evidenced by leaf damage from 11 to 27% and aborted heads from 0 to 37%.

The level of mirid damage was negatively correlated with precipitation and positively correlated with temperature. Previous year's total and winter precipitation were negatively correlated with both larkspur leaf damage and aborted heads (Table 2). There was heavy precipitation in 1995 preceding the 1996 population decline at Ferron, and in 1997 preceding the population decline at all Utah sites in 1998. There was also a strong negative correlation with the previous September precipitation. September precipitation at the three Utah sites was above 13 cm, compared to the 10-yr average of 5 cm. Females lay eggs in senescing larkspur stems from late August to early September, so heavy precipitation (rain or snow) at this time could adversely affect egg deposition. Precipitation later in September may also have an adverse effect by saturating the larkspur stalks before the eggs have a chance to harden for the winter.

There were positive correlations of previous year's maximum temperature in July and August with the subsequent year's leaf damage and aborted heads (Table 2). Apparently, high temperatures during mid-summer promoted the next year's mirid population.

Stepwise multiple regression models selected previous year's total precipitation as the first variable in predicting leaf damage and aborted heads. The model next se-

Table 2. Correlation coefficients (r) between larkspur leaf damage and aborted heads caused by the larkspur mirid, and current and previous years precipitation and temperature

		Leaf damage		Aborted heads	
Weather parameter	Month	Current year	Previous year	Current year	Previous year
Precipitation	Total	−0.12	−0.78**	−0.08	−0.81**
	Winter	−0.02	−0.71*	−0.01	−0.65**
	June	-0.43^{+}	0.01	−0.73**	0.11
	July	−0.62**	−0.54*	−0.60**	-0.47^{+}
	Aug	−0.21	−0.28	−0.30	-0.44^{+}
	Sept	−0.41	−0.68**	−0.07	−0.83**
Temperature	June	0.21	−0.12	0.41^{+}	−0.15
	July	−0.08	0.45^{+}	−0.16	0.75**
	Aug	0.27	0.34	0.20	0.61**
	Sept	0.14	0.25	−0.37	0.07

Significant correlations: $^{+}$ $P < 0.10$, * $P < 0.05$, ** $P < 0.01$.

lected current year's June precipitation, then previous year's July and August temperature ($R^2 = 0.98$):

Aborted heads = 82.7 − 16.4 Jun ppt − 3.9 prev. yr total ppt + 6.4 prev. July temp − 15.3 prev. Aug temp.

Varying levels of mirid damage on larkspur in this study suggest that mirid populations are cyclic. The mirid population cycles may be attributed, in part, to specific weather patterns. There were strong negative correlations between the level of mirid damage and previous year's total precipitation, and specifically September precipitation, suggesting that storms during and shortly after eggs deposition adversely affects mirid populations in subsequent years. The years of 1997 and 1998 were considered El Nino years with above average precipitation. However, the above average precipitation in Colorado in 1998 did not adversely affect mirid populations there. More research is needed on the ecology of the larkspur mirid to identify its limiting factors and determine if high populations can be maintained to prevent cattle grazing and subsequent poisoning.

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References Cited

Fitz, F. K. 1972. Plant-insect interactions, tall larkspur, and biological control, Pp. 436-463. *In* J. A. Behnke (ed.), Challenging biological problems, directions to their solutions. Oxford Univ. Press., Oxford, UK.

Jones, W. A., M. H. Ralphs and L. F. James. 1998. Use of a native insect to deter grazing and prevent poisoning in livestock, Pp. 23-28. *In* T. Garland and A. C. Barr (eds.), Toxic plants and other natural toxicants, CAB International, Wallingford, UK.

Peterson, N. and C. Clementson. 1989. Larkspur losses—can nature help? Cattle Guard, Feb. 1989, Colorado Cattlemens Assoc., Denver, CO.

Pfister, J. A., M. H. Ralphs, G. D. Manners, K. E. Panter, L. F. James, B. L. Stegelmeier and D. R. Gardner. 1993. Tall larkspur poisoning in cattle: current research and recommendations. Rangelands 15: 157-160.

Ralphs, M. H., W. A. Jones and J. A. Pfister. 1997. Damage from the larkspur mirid deters cattle grazing of larkspur. J. Range Manage. 50: 371-373.

Ralphs, M. H., D. R. Gardner, W. A. Jones and G. D. Manners. 1998. Diterpenoid alkaloid concentration in tall larkspur plants damaged by the larkspur mirid. J. Chem. Ecol. 24: 829-840.

Uhler, P. R. 1895. Descriptions of new species, Pp. 1-37. *In* C. P. Gillete and C. F. Baker (eds.), A preliminary list of the Hemiptera of Colorado. Colorado Agr. Exp. Sta. Bull. 31.