

# Biological Control of Spotted Knapweed and Canada Thistle at the Fort Carson Military Reservation, Ft. Carson, Colorado

## 1998 Progress Report

Submitted to the Directorate of Environmental  
Compliance and Management, Ft. Carson, Colorado



*Original photo by USDA-ARS*



*Original photo by USDA-BLM*



*Original photo by Montana State University*

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**BIOLOGICAL CONTROL OF SPOTTED KNAPWEED AND CANADA  
THISTLE AT THE FORT CARSON MILITARY RESERVATION,  
FT. CARSON, COLORADO**

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by

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**Introduction**

The goal of the proposed biological weed control program is to reduce the existing populations and control the spread of selected state- and federal-listed noxious weeds at two military installations located on the Front Range of the Rocky Mountains in Eastern Colorado. The two sites are: the Fort Carson Military Reservation (FCMR) at Colorado Springs, CO and the Piñon Canyon Maneuver Site (PCMS) at Trinidad, CO. In the initial program, spotted and diffuse knapweed and Canada thistle are the target species.

The objectives of the research are to 1. Develop and implement procedures and sampling methods to assess the present state of any existing biological controls on the selected species at FCMR and/or PCMS; 2. Monitor abiotic and biotic factors that may be peculiar to FCMR and/or the PCMS through field data collection and release-site weather stations. Assess the impact of these factors on establishment of natural enemies; 3. Conduct greenhouse studies to determine the interaction of several available natural enemies of the selected weed species with each other and their combined effect on the plant, and conduct herbicide/natural enemy compatibility tests to help make decisions for IPM strategies. Use the greenhouse populations of the natural enemies for additional releases; 4. Release several species of natural enemies in field trials using release cages and open field releases to compare survival and establishment over a period of at least three years. Monitor and redistribute established populations.

This report describes the progress during 1998 and early 1999. Several organizations have cooperated with this project, including the Colorado Department of Agriculture, Forestry Sciences Laboratory at Montana State University, USDA-APHIS at Montana State University, Pennsylvania Department of Agriculture, and USDA-APHIS at Spokane, Washington.

**On the Cover**

*Urophora affinis*, the banded gall fly, was released at Cantonment I and Turkey Creek (spotted knapweed sites) in 1997 and was recovered from both locations in 1998.

Five hundred *Chaetorellia acrolophi*, the knapweed peacock fly, were released at the Turkey Creek site in July 1998. Larvae from seed heads were recovered in October 1998 and adults emerged in January 1999.

*Larinus minutus*, the lesser knapweed flower weevil, was released in 1997 at the Turkey Creek and Cantonment I sites. It was recovered from both sites in 1998.

## **Chronology**

### January

Three cages containing *Urophora cardui* galls, obtained from Dr. George Markin, Forestry Sciences Laboratory, Montana State University, were placed at two new Canada thistle sites on January 28, 1998 (Fig.1). The galls are rated on a scale of 1 – 5 according to the size of the gall, with a 1 rating approximately walnut-size and a 5 rating approximately pea-size. It takes 80 size 1 galls to release about 1000 live larvae and 200 size 4 galls for 1000 live larvae (Table 1). The two sites are designated as Outdoor Recreation and Duck Pond (Table 2). At each of the new release sites, plant height and density were recorded at 10, 20 and 30-m intervals where possible to obtain baseline information for future comparison data (Tables 3 and 4).

Knapweed plants at the Cantonment I and Turkey Creek sites were examined for *L. minutus* emergence holes. Emergence holes were found at the Cantonment I site inside the cage and within 10-m of the open release site.

Seed heads were collected from the Cantonment I and Turkey Creek sites to determine the number of *U. quadrifasciata* and *U. affinis* galls. At each site, both *L. minutus* and *U. affinis* had been released in June 1997. Approximately 100 seed heads were collected from each release location for a total of 400 seed heads at both sites. Fifty seed heads were dissected from both *L. minutus* and *U. affinis* release areas for a total of 200 seed heads at both sites (Table 5). No galls were determined to be caused by *U. affinis*. However, the *Urophora* larvae were retained in individual containers for species confirmation upon emergence. Larvae were found from the 1<sup>st</sup> and 2<sup>nd</sup> generations, but the 1<sup>st</sup> generation larvae were dead.

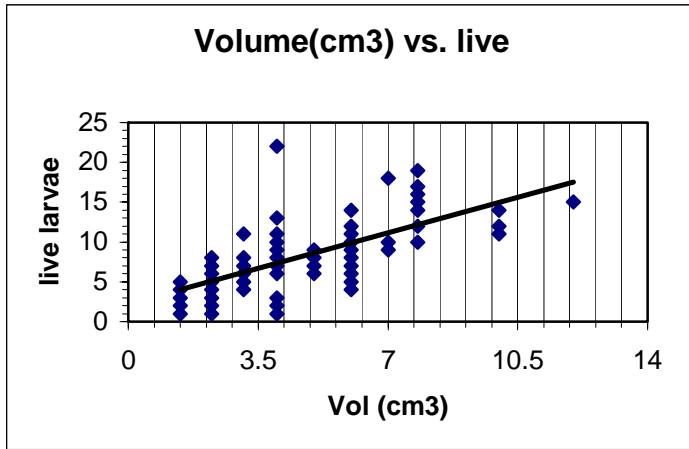
### April

On April 21<sup>st</sup>, 1998, *Cassida rubiginosa* adults were found in field cages in which they had been released on musk thistle, *Carduus nutans* L., at Bushland, Texas in the late summer of 1997, indicating the *C. rubiginosa* overwintered in Bushland during 1997-98. A new release of the spotted knapweed seed head moth, *Metzneria paucipunctella* (Zeller) was made on April 28, 1998. The releases were made at three sites, Turkey Creek, Duck Pond, and a new site designated as the Bunker site. Each release consisted of approximately 3000 *Metzneria*-infested knapweed seed heads. Of this 3000, approximately 2160 *Metzneria* will emerge (72% emergence) (Table 2).



Fig. 1. *Urophora cardui* galls are placed in small screened cages to prevent rodent predation. Each gall is rated on a scale of 1 – 5. Galls with a 1 rating are approximately the size of a walnut and a 5 rating is approximately pea size. It takes 80 size 1 galls to release about 1000 live larvae and 200 size 4 galls for 1000 live larvae. Releases were made at two Canada thistle sites designated as Duck Pond and ARA release sites in Fort Carson, Colorado in 1998.

Table 1. Scale to determine the approximate number of live *Urophora cardui* larvae per gall. Scale derived by Dr. George Markin, Forestry Sciences Laboratory, MSU, Bozeman, MT.



<u>Class</u>	<u>Approx.# live larvae/gall</u>	<u>Class</u>	<u>Gall volume (cm<sup>3</sup>)</u>
1	12	1	7.55 "walnut size"
2	10	2	6.1
3	8	3	4.3
4	5	4	2.4
5	4	5	1.3

<u>Class</u>	<u># galls / 1000 live larvae</u>
1	80
2	100
3	125
4	200

Table 2. Summary of Insects Released for Biological Control of Canada Thistle and Spotted Knapweed, 1997-1998.

Common Name	Species	Agency	Release		
			Date	Site <sup>1</sup>	Number Cage/Open
<b>1998 releases in BOLD</b>					
Canada thistle ( <i>Cirsium arvense</i> )					
Thistle-feeding shield beetle	<i>Cassida rubiginosa</i>	Penn.Dpt.of Agric.	07/03/1997	4	25 / 0
<b>Thistle-feeding shield beetle</b>	<b><i>Cassida rubiginosa</i></b>	<b>Penn.Dpt.of Agric.</b>	<b>07/08/1998</b>	<b>3</b>	<b>15 / 0</b>
Canada thistle bud weevil	<i>Larinus planus</i>	Penn.Dpt.of Agric.	07/03/1997	3	47 / 0
<b>Canada thistle bud weevil</b>	<b><i>Larinus planus</i></b>	<b>Penn.Dpt.of Agric.</b>	<b>07/08/1998</b>	<b>3</b>	<b>0/150</b>
<b>Thistle stem gall fly</b>	<b><i>Urophora cardui</i></b>	<b>Forestry Sci Lab,MT</b>	<b>01/28/1998</b>	<b>6</b>	<b>0 / 77</b>
<b>Thistle stem gall fly</b>	<b><i>Urophora cardui</i></b>	<b>Forestry Sci Lab,MT</b>	<b>01/28/1998</b>	<b>7</b>	<b>0 / 92</b>
Thistle stem gall fly	<i>Urophora cardui</i>	Forestry Sci Lab,MT	01/15/1999	3	0 / 1
Thistle stem gall fly	<i>Urophora cardui</i>	Forestry Sci Lab,MT	01/15/1999	4	0 / 1
Thistle stem gall fly	<i>Urophora cardui</i>	Forestry Sci Lab,MT	01/15/1999	6	0 / 1
Thistle stem gall fly	<i>Urophora cardui</i>	Forestry Sci Lab,MT	01/14/1999	7	0 / 1
Spotted knapweed ( <i>Centaurea maculosa</i> )					
<b>Sulphur knapweed moth</b>	<b><i>Agapeta zoegana</i></b>	<b>Colo.Dpt.of Agric</b>	<b>08/05/1998</b>	<b>1</b>	<b>50 / 0</b>
<b>Knapweed peacock fly</b>	<b><i>Chaetorellia acrolophi</i></b>	<b>Colo.Dpt.of Agric</b>	<b>07/02/1998</b>	<b>2</b>	<b>250/250</b>
Knapweed root weevil	<i>Cyphocleonus achates</i>	Colo.Dpt.of Agric	08/06/1997	5	50/200
<b>Knapweed root weevil</b>	<b><i>Cyphocleonus achates</i></b>	<b>Colo.Dpt.of Agric</b>	<b>08/04/1998</b>	<b>5</b>	<b>50/150</b>
Lesser knapweed flower weevil	<i>Larinus minutus</i>	USDA/APHIS, MT	06/05/1997	1	50 / 50
Lesser knapweed flower weevil	<i>Larinus minutus</i>	USDA/APHIS, MT	06/05/1997	2	50 / 50
<b>Spotted knapweed seed head moth</b>	<b><i>Metzneria paucipunctella</i></b>	<b>USDA/APHIS, WA</b>	<b>04/28/1998</b>	<b>2</b>	<b>0 / 2</b>
<b>Spotted knapweed seed head moth</b>	<b><i>Metzneria paucipunctella</i></b>	<b>USDA/APHIS, WA</b>	<b>04/28/1998</b>	<b>7</b>	<b>0 / 2</b>
<b>Spotted knapweed seed head moth</b>	<b><i>Metzneria paucipunctella</i></b>	<b>USDA/APHIS, WA</b>	<b>04/28/1998</b>	<b>-</b>	<b>0 / 1</b>
Banded gall fly	<i>Urophora affinis</i>	USDA/APHIS, MT	06/05/1997	1	0 / 1
Banded gall fly	<i>Urophora affinis</i>	USDA/APHIS, MT	06/05/1997	2	0 / 1
Knapweed seed head fly	<i>Urophora quadrifasciata</i>	determined to be previously established			

<sup>1</sup>Sites: 1-Cantonment I; 2-Turkey Creek; 3-ARA; 4-Reservoir; 5-Cantonment II; 6-Outdoor Recreation; 7-Duck Pond

<sup>2</sup>Released in bouquets of dead spotted knapweed with approximately 1200 larvae/bouquet.

<sup>3</sup>Released in galls, approximately 7 larvae/gall. Releases were made in small screened boxes to prevent rodent predation.

<sup>4</sup>Recovered on 7/2/98.

<sup>5</sup>Released in screened boxes containing infested seedheads; 2400 seedheads/box, approx. 1728 larvae/box (72% infestation)

<sup>6</sup>Released at HazMaterials Site which was accidentally mowed at a later date, then abandoned.

<sup>7</sup>Galls rated on a scale of 1 - 4; class 1=80 galls/1000 live larvae; class 4=200 galls/1000 live larvae

Table 3. Canada thistle plant height at *Urophora cardui* release sites, Ft. Carson, CO, January 1998.

Plant No	Plant Height (cm) at indicated meters from release point										
	10m			20m		30m		10m			20m
Site: Duck Pond						Site: Outdoor Recreation					
<u>Point of Release</u>											
1	125	168	99						120	92	87
2	92	105	94						69	80	108
3	96	158	110						52	72	102
4	98	110	111						79	81	103
5	110	108	128						80	77	98
<b>Avg.</b>	<b>104</b>	<b>130</b>	<b>108</b>						<b>80</b>	<b>80</b>	<b>100</b>
<u>North</u>											
1	72	106	73	71		62			86	81	
2	83	91	58	68		84			90	82	
3	92	72	75	52		70			83	79	
4	83	83	76	63		80			78	85	
5	80	79	60	31		74			76	86	
<b>Avg.</b>	<b>82</b>	<b>86</b>	<b>68</b>	<b>57</b>		<b>74</b>			<b>83</b>	<b>83</b>	
<u>South</u>											
1	74	72		114					41	22	
2	63	84		109					38	18	
3	88	81		101					22	56	
4	100	85		110					30	49	
5	70	91		112					15	41	
<b>Avg.</b>	<b>79</b>	<b>83</b>		<b>109</b>					<b>29</b>	<b>37</b>	
<u>East</u>											
1	82	131	71	118					78	72	88
2	111	135	32	110					69	71	64
3	83	58	33	107					69	61	75
4	89	93	62	119					74	68	79
5	86	96	41	128					73	74	93
<b>Avg.</b>	<b>90</b>	<b>103</b>	<b>48</b>	<b>116</b>					<b>73</b>	<b>69</b>	<b>80</b>
<u>West</u>											
1	105	125		115	98	68	94		76	87	52
2	80	110		101	110	84	102		71	78	62
3	89	120		96	92	109	98		83	69	57
4	56	118		82	106	118	102		92	99	50
5	101	123		118	105	85	97		81	91	64
<b>Avg.</b>	<b>86</b>	<b>119</b>		<b>102</b>	<b>102</b>	<b>93</b>	<b>99</b>		<b>81</b>	<b>85</b>	<b>57</b>

Table 4. Canada thistle plant density at *Urophora carduii* release sites, Ft. Carson, CO, January 1998.

Release Site	Plants/m <sup>2</sup> at indicated distance from release point								
	<u>Site: Duck Pond</u>				<u>Site: Outdoor Recreation</u>				
	<u>0m</u>	<u>10m</u>	<u>20m</u>	<u>30m</u>		<u>0m</u>	<u>10m</u>	<u>20m</u>	<u>30m</u>
					<b><u>Point of Release</u></b>				
1	82					36			
2	24					38			
3	11					34			
					<b><u>North</u></b>				
1		78	44	22			44		
2		28					40		
3		20							
					<b><u>South</u></b>				
1		38							
2							8		
3		32	36				14		
					<b><u>East</u></b>				
1		30					28		
2		38	52				26		
3		8					32		
					<b><u>West</u></b>				
1		26	30	36			22		
2		34	38	48			26		6
3									
<b>Avg.</b>	<u>39</u>	<u>33</u>	<u>40</u>	<u>35</u>		<u>36</u>	<u>27</u>	<u>6</u>	



Table 5. Summary of insects recovered on spotted knapweed at Ft. Carson, CO, in 1998.

Common name	Species	Source	Release					Recovered				
			Date	Site <sup>1</sup>	Number		Total	Date	Site	#/50 heads <sup>2</sup>		Total
					Caged	Open				Caged	Open	
Lesser knapweed flower weevil	<i>Larinus minutus</i>	Helena, MT	06/05/1997	1	30-50	50-70	100	07/02/1998	1	5	5	10
Lesser knapweed flower weevil	<i>Larinus minutus</i>	Helena, MT	06/05/1997	2	30-50	50-70	100	07/02/1998	2	0	6	6
Banded gall fly	<i>Urophora affinis</i>	Three Forks, MT	06/05/1997	1	1	3	4800 <sup>3</sup>	07/02/1998	1	0	2	2
Banded gall fly	<i>Urophora affinis</i>	Three Forks, MT	06/05/1997	2	1	3	4800 <sup>3</sup>	07/02/1998	2	5	21	26
Knapweed peacock fly	<i>Chaetorellia acrolophi</i>	Palisade, CO	07/02/1998	2	250	250	500	10/28/1998	2	25	0	25

<sup>1</sup> Sites: 1- Cantonment I; 2- Turkey Creek

<sup>2</sup> Data obtained from the seedhead samples collected in September and October 1998 only.

<sup>3</sup> Released in bouquets of dead spotted knapweed with approximately 1200 larvae/bouquet.

## June

All release sites (Canada thistle and Spotted knapweed) were georeferenced on June 2<sup>nd</sup> and June 3<sup>rd</sup>, 1998. Maps were generated by Linda Moeder, DECAM (Fig.2). The Bunker site, which was a new release site, had inadvertently been mowed; therefore georeferencing was not necessary. This area will be monitored, but no future releases are planned for this site. Seedheads from all sites were collected and brought back to Bushland, Texas for further examination. On June 12<sup>th</sup>, 1998, *U. affinis* emerged from seed heads collected from both open field collections and cage collections at the Turkey Creek site. *U. affinis* also emerged from open field collections from the Cantonment I site (Table 5).

## July

On July 2<sup>nd</sup>, 1998, an 8' X 6' cage provided by Mr. Fred Stahl, Colorado Department of Agriculture, was erected at the Turkey Creek release site. *Chaetorellia acrolophi*, the knapweed peacock fly, was released in the cage and in the open (Table 2). Both *Larinus minutus* and *Urophora affinis* were recovered (Table 5). We collected several unknown insects at the Duck Pond site and sent them to the Systematic Entomology Laboratory in Beltsville, MD for positive identification. Results are pending. Spotted knapweed plants were collected and brought back to Bushland for greenhouse colony rearing and future studies. Mr. Jim Stimmel, Pennsylvania Department of Agriculture, Harrisburg, PA provided *Larinus planus* and *Cassida rubiginosa*, for release on Canada thistle. Both releases were made at the ARA site on July 8, 1998 (Table 2).

## August

On August 4<sup>th</sup>, 1998, *Cyphocleonus achates* adults were released in the cage and in the open at the Cantonment II site (Table 2). No recoveries of previously released *C. achates* were made. At Cantonment I the first cage release of *Agapeta zoegana*, the sulphur knapweed moth (also called the yellow-winged knapweed root moth), was made on August 5<sup>th</sup>, 1998 (Table 2).

## October

An older cage was replaced at the Cantonment II site on Oct. 1<sup>st</sup>, 1998 (Fig. 3). Seed heads were collected from all sites except Turkey Creek, which was inaccessible due to training maneuvers in the area. No recoveries were made. On October 29<sup>th</sup>, 1998, we met with Ms. Linda Moeder, DECAM, for training on *Arcview* and GIS/GPS computer technology.

## December

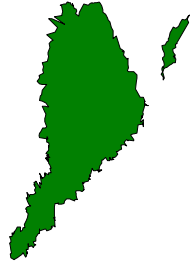
Fifty seedheads were dissected from each release site and larvae recovered from the spotted knapweed seed heads were recorded (Tables 6 & 7). The *Chaetorellia acrolophi* larvae were recovered from the caged site at Turkey Creek (Table 5). They emerged in January 1999. *Urophora affinis* larvae were also recovered from open collections made at Turkey Creek and Cantonment II. A tephritid fly species (*Terellia ruficauda*) was recovered from all three Canada thistle sites and is pending positive

## Canada Thistle Sites

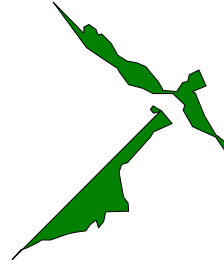
ARA



Duck Pond



Outdoor Recreation

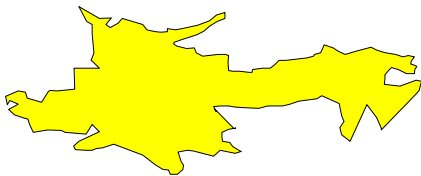


Reservoir

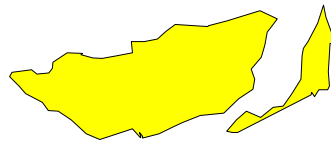


## Spotted Knapweed Sites

Turkey Creek



Cantonment I



Cantonment II

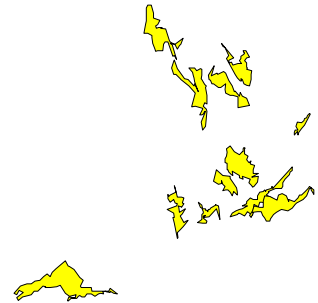


Fig. 1. Georeferenced release sites located at Fort Carson, Colorado, in April, 1998. ARA, Outdoor Recreation, Reservoir, and Duck Pond are the sites infested with Canada thistle. Turkey Creek, Cantonment I, and Cantonment II are Spotted knapweed sites.



Fig. 3. A new cage was erected at the Cantonment II release site at Fort Carson, Colorado in 1998. It is made of a lighter, less dense material that allows better sunlight penetration as well as less water retention, but retains the strength and protection of the other cages used.

Table 6. Summary of *U. quadrifasciata* larvae recovered from spotted knapweed in 1998.

Status	Larval density <sup>1</sup>			Emerging adults		Larval frequency distribution <sup>2</sup>										
	total/50 seedheads	average/ seedhead	std. error	total	percent	0	1	2	3	4	5	6	7	8	9	10
<b><u>Cantonment I Open</u></b>																
Live	18	0.36	0.13	14	0.78											
Dead	112	2.24	0.32													
Total	130	2.60				12	6	8	6	8	6	2	1	0	1	0
<b><u>Cantonment I Cage</u></b>																
Live	7	0.14	0.10	7	1.00											
Dead	79	1.58	0.27													
Total	86	1.72				19	10	7	5	4	1	2	2	0	0	0
<b><u>Turkey Creek Cage</u></b>																
Live	5	0.10	0.05	5	1.00											
Dead	30	0.60	0.17													
Total	35	0.70				33	8	4	3	0	2	0	0	0	0	0
<b><u>Turkey Creek Open</u></b>																
Live	20	0.40	0.11	20	1.00											
Dead	46	0.92	0.20													
Total	66	1.32				20	14	5	5	4	1	1	0	0	0	0
<b><u>Cantonment II Cage</u></b>																
Live	5	0.10	0.05	5	1.00											
Dead	117	2.34	0.34													
Total	122	2.44				17	7	5	5	2	7	3	3	1	0	0
<b><u>Cantonment II Open</u></b>																
Live	4	0.08	0.05	4	1.00											
Dead	111	2.22	0.31													
Total	115	2.30				11	15	13	5	1	4	3	1	0	0	1

<sup>1</sup> Fifty seedheads were dissected from each sample. Number of larvae in galls.

<sup>2</sup> Seedheads containing the specified number of larvae in a fifty seedhead sample.

Table 7. Summary of three different larvae species recovered from spotted knapweed in 1998.

Status	Larval density <sup>1</sup>			Emerging adults		Larval frequency distribution <sup>2</sup>										
	total/50 seedheads	average/ seedhead	std. error	total	percent	0	1	2	3	4	5	6	7	8	9	10
<b><u>U. affinis</u></b>																
<b><u>Cantonment I Open</u></b>																
Live	0	0.00	0.00	0	0.00											
Dead	2	0.04	0.03													
Total	2	0.04				48	2	0	0	0	0	0	0	0	0	0
<b><u>Turkey Creek Cage</u></b>																
Live	3	0.06	0.04	2	0.67											
Dead	2	0.04	0.03													
Total	5	0.10				46	3	1	0	0	0	0	0	0	0	0
<b><u>Turkey Creek Open</u></b>																
Live	13	0.26	0.12	6	0.46											
Dead	8	0.16	0.10													
Total	21	0.42				40	5	3	0	0	2	0	0	0	0	0
<b><u>C. acrolophi</u></b>																
<b><u>Turkey Creek Cage</u></b>																
Live	4	0.08	0.06	3	0.75											
Dead	21	0.42	0.13													
Total	25	0.50				38	2	8	1	1	0	0	0	0	0	0
<b><u>L. minutus</u></b>																
<b><u>Turkey Creek Open</u></b>																
Live	6	0.12	0.05	6	1.00											
Dead	0	0.00	0.00													
Total	6	0.12				44	6	0	0	0	0	0	0	0	0	0
<b><u>Cantonment I Open</u></b>																
Live	4	0.08	0.04	4	1.00											
Dead	1	0.02	0.02													
Total	5	0.10				45	5	0	0	0	0	0	0	0	0	0
<b><u>Cantonment I Cage</u></b>																
Live	5	0.10	0.10	5	1.00											
Dead	0	0.00	0.00													
Total	5	0.10				45	5	0	0	0	0	0	0	0	0	0

<sup>1</sup> Fifty seedheads were dissected from each sample. Number of larvae in galls.

<sup>2</sup> Seedheads containing the specified number of larvae in a fifty seedhead sample.

identification. Climatic data from two weather stations located at Duck Pond and ARA release sites was downloaded on a regular basis (Fig. 4).

## Results

*U. quadrifasciata* data taken in 1997 was compared with the data collected in 1998 (Table 8). A *t*-test was performed between years and also between release sites, Cantonment I and Turkey Creek (Table 9). The results indicated that there were significantly fewer live *U. quadrifasciata* larvae in 1998 than in 1997. There were significantly more dead larvae in 1998 than in 1997 and total larvae in 1998 were significantly higher than in 1997. In comparing Cantonment I and Turkey Creek release sites within a given year, there were significantly less live and total larvae at Cantonment I than Turkey Creek in 1997. In 1998, there were significantly more dead and total larvae at Cantonment I than Turkey Creek. One reason for the decline in *U. quadrifasciata* numbers could be the establishment of one or a combination of *U. affinis*, *L. minutus*, and *C. acrolophi*, which also attack the seed head, and therefore, may be competing with *U. quadrifasciata*.

## Plans for 1999

Field research in 1999 will continue at Fort Carson. Plant height and density data will be recorded at all sites established in 1997 and 1998. Additional releases of *C. achaetes*, *A. zoegana*, and *M. paucipunctella* on spotted knapweed, and *C. rubiginosa*, *L. planus*, and *U. cardui* on Canada thistle will be made in 1999. In addition to these additive releases, new insects scheduled to be released in 1999 include: the thistle crown weevil, *Trichosirocalus horridus* (Panzer) and the Canada thistle stem weevil, *Ceutorhynchus litura* (F.) on Canada thistle; and the blunt knapweed flower weevil, *L. obtusus* Gyll., on spotted knapweed. Redistribution of the established insects, *L. minutus*, *C. acrolophi*, and *U. affinis*, will be made in 1999 on spotted knapweed. Releases of broad-nosed seed head weevil, *Bangasternus fausti* (Reitter), brown-winged root moth *Pelochrista medullana* Staudinger, grey-winged root moth, *Pterolonche inspersa* Staudinger, bronze knapweed root-borer, *Sphenoptera jugoslavica* (Obenb.), and green clearwingfly, *Terellia virens* (Loew) will be made on spotted knapweed depending on availability of insects. Indications of insect damage to Canada thistle and spotted knapweed will be recorded. Plants will be examined for determination of insect establishment and spread. GPS mapping will continue to be used to monitor weed infestations at the release sites and to determine possible spread of established or newly colonized biocontrol agents.

## Conclusion

This year has been a very successful year for the biological control of weeds program. Of the releases made to date, three species; *Chaetorellia acrolophi*, *Larinus minutus*, and *Urophora affinis*, are established. We will begin redistributing these newly established agents to other knapweed-infested areas. We will also begin releasing a biological control agent, *Aceria malherbae*, and eriophyid mite on field bindweed,



Fig. 4. Weather station located at the ARA release site at Fort Carson, Colorado. Another weather station is located at the Duck Pond release site. These stations collect continual climatic data. The data is downloaded onto a portable computer at regular intervals and kept for future reference and analysis.



Table 8. Mean difference in *U. quadrifasciata* larvae between 2 different release sites in Ft. Carson, Co in 1997 and 1998.

Year	Larvae	Sample size (n)	Mean cantonment I	Mean turkeycreek	Mean difference	Std error	t- value	Prob> T
1997	live	100	0.72	1.32	-0.60	0.20	-3.03	0.0031
1997	dead	100	0.33	0.37	-0.04	0.11	-0.35	0.7235
1997	total	100	1.05	1.69	-0.64	0.22	-2.91	0.0045
1998	live	100	0.25	0.25	0.00	0.00	-	-
1998	dead	100	1.91	0.76	1.15	0.26	4.44	0.0001
1998	total	100	2.16	1.01	1.15	0.26	4.44	0.0001

Table 9. Mean difference in *U. quadrifasciata* larvae between 1997 and 1998 for 2 different release sites in Ft. Carson, CO.

Site	Larvae	Sample size (n)	Mean-1998	Mean-1997	Mean difference	Std error	t-value	Prob> T
Cantonment I	live	100	0.25	0.72	-0.47	0.17	-2.79	0.0063
	dead	100	1.91	0.33	1.58	0.23	6.73	0.0001
	total	100	2.16	1.05	1.11	0.28	3.94	0.0002
Turkey Creek	live	100	0.25	1.32	-1.07	0.14	-7.48	0.0001
	dead	100	0.76	0.37	0.39	0.16	2.45	0.0162
	total	100	1.01	1.69	-0.68	0.19	-3.52	0.0007

*Convolvulus arvensis*, which has been cleared for release through the Colorado Department of Agriculture.

We would like to begin a program for control of saltcedar, *Tamarisk* sp., with a leaf-feeding beetle, *Diorhabda elongata* in Piñon Canyon, pending the approval for release by the necessary authorities. If approval is received, we will begin a biological control program on saltcedar in 1999.