

7/19/95

Steve B-J

**Biological Control of  
Musk Thistle (*Carduus nutans*)  
in Mesa Verde National Park**

**Annual Report to the  
United States Department of the Interior  
Rocky Mountain Region  
Denver, Colorado  
Project Number: MEVE-R92-0197  
Cooperative Agreement Number: CA 1268-1-9016  
Account Number: 1268-2301-183**

**Deborah M. Kendall  
Department of Biology  
Fort Lewis College  
Durango, CO 81301**

**1 April, 1993**

## Table of Contents

|                                                             |    |
|-------------------------------------------------------------|----|
| Abstract . . . . .                                          | 1  |
| Introduction . . . . .                                      | 2  |
| Study area . . . . .                                        | 3  |
| Materials and methods . . . . .                             | 8  |
| Results and discussion . . . . .                            | 8  |
| Monitoring of insects on musk and native thistles . . . . . | 11 |
| Seedhead analysis . . . . .                                 | 14 |
| Management implications . . . . .                           | 14 |
| Acknowledgments . . . . .                                   | 14 |
| Literature cited . . . . .                                  | 16 |

## ABSTRACT

Heavy infestations of musk thistle, *Carduus nutans* Desf. occur primarily in fire-burned areas and continuously disturbed sites in Mesa Verde National Park. Musk thistle can also invade moist areas with sparse vegetation. The current study investigated the establishment of two biocontrol agents, *Rhinocyllus conicus* Froel. and *Trichosiromachus horridus* (Panzer) (both species belong to the order Coleoptera (beetles) and the family Curculionidae (weevils)) and a resident herbivore (plant feeder) of thistles, *Vanessa cardui* L. (order Lepidoptera, family Nymphalidae-the brush-footed butterflies) in a study area 1 km south of the Morefield sewage facility in Morefield Canyon. In light of concern that *R. conicus* can become established on native thistle (*Cirsium* sp.), the effects of all three insect herbivores on native thistle and musk thistle were investigated. *R. conicus* populations have become established from releases made outside Mesa Verde National Park for control of musk thistle in agricultural areas. *T. horridus* was released in the study sites on 29 May 1992 and 4 June 1992. *V. cardui* is a migratory species that overwinters in Mexico and returns to the southwestern United States in the spring.

The study indicates the establishment of *R. conicus*, *T. horridus*, and *V. cardui* in the study sites. Total seasonal means for the three species were as follows: (a) *R. conicus* was present at 1.078 per plant in the musk thistle release site, 0.822 per plant in the musk thistle control (non-release site), and 0.776 per plant in the native thistle site; (b) *T. horridus* was present at 0.126 per plant in the musk thistle release site, but never present in the musk thistle control site or the native thistle site; (c) *V. cardui* was present at 0.114 per plant in the musk thistle release site, 0.124 per plant in the musk thistle control site and 0.086 per

plant in the native thistle site. Seasonal means are based on bi-monthly records taken from 500 individual plants.

Seedhead analysis of musk and native thistle indicated the presence of *R. conicus* at an average of 16.49 per seedhead (based on 106 seedheads) and 0.05 per seedhead (based on 55 seedheads) in native thistle.

## INTRODUCTION

Mesa Verde National Park has experienced heavy infestations of musk thistle, *Carduus nutans* Desf. in continuously disturbed sites and in fire-burned areas. Control of exotic pests such as musk thistle presents a difficult situation that requires complex, well-formulated strategies. An Integrated Pest Management (IPM) program that suggests biological, mechanical and chemical control methods is the currently accepted mode of achieving exotic weed control in national parks (Currie 1984). The 1992 study focused on the primary objective of an IPM program which is the identification of thistle species and release of biological control methods in Morefield Canyon.

Reduction measures for thistle include herbicide application, mechanical control and biocontrol agents. Herbicide use for control of thistles is not always desirable in a national park for several reasons, including great expense in chemical purchase and manual labor, development of herbicide resistant musk thistles, detrimental effects on native vegetation, and contamination of ground water (Wapshere 1989). Because of the detrimental effects of herbicide use, research in Mesa Verde National Park is currently focused on control of the thistle in Morefield Canyon through the biological control agent, *Trichosirocalus horridus* (Panzer) (Coleoptera: Curculionidae) which directly attacks the crown stem. Secondary agents, such as bacteria and other pathogens enter the feeding scars caused by the weevil which further debilitates the plant.

*Rhinocyllus conicus* Froel. (Coleoptera: Curculionidae), the musk thistle seed head weevil was not released in Mesa Verde National Park because of possible infestation of native *Cirsium* thistles. According to Turner et al. (1987), *R. conicus* has been found in

native *Cirsium* thistles in California, but in extremely low densities (range of 0.01 - 11.07 mean number of weevils per head from 3,231 heads taken from 850 plants). Actual damage to native thistles has not been evaluated and appears to be an essential objective in evaluating the effects of *R. conicus* on *Cirsium* sp. However, *R. conicus* has naturally dispersed into Mesa Verde National Park from the surrounding agricultural land where it is extensively used for biocontrol of musk thistle. In light of the concern surrounding the weevil's potential to colonize native thistle, research has also been directed toward investigation of the effects of *R. conicus* on native thistles. Only one larva and two pupal cells were found in fifty-five flower heads of native thistles examined to date. Further research is necessary to facilitate establishment of agents for control of musk thistle and also examine the effects of these biocontrols on native thistles.

Thistles belong to the Asteraceae (composites) family and to a complex of several genera of plants that share many characteristics including numerous sharp, stiff spines on the leaves, stalks, and flowers. This characteristic alone causes considerable nuisance to people and animals, especially in an area of high use such as a National Park. The two most common exotic thistle pests in Mesa Verde National Park are the musk thistle, *C. nutans* and the canada thistle, *C. arvense*. Although musk thistle populations are more extensive than those of canada thistle (Table 1), both species represent significant detriment to the native vegetation and reduce visitor usage of the park. The current study focused only on control of *C. nutans*.

**Current status of thistle populations in Mesa Verde National Park.** In many areas of Mesa Verde National Park, musk thistle has spread at an alarming rate and covered over

809.4 ha (2000 acres) in 1986 (Table 1).

Table 1. Coverage of musk thistle and Canada thistle in Mesa Verde National Park. Numbers are in hectares (acres). Data compiled from 1986 Thistle Survey by Marilyn Colyer, Natural Resource Manager.

| Location         | Musk thistle     | Canada thistle |
|------------------|------------------|----------------|
| Morefield Canyon | 4.17 (10.03)     | 0.417 (1.03)   |
| Prater Canyon    | 2.06 (5.08)      | 0.10 (0.24)    |
| Parkwide         | 633.18 (1564.57) | 1.30 (3.20)    |

Musk thistle is especially problematic in continually disturbed areas such as the Morefield and Wetherill sewage facilities.

**Biology of musk thistle, *C. nutans*.** The musk thistle invades disturbed areas, such as the fire-burned sites and continuously disturbed locations, such as the Morefield sewage facility in Mesa Verde National Park. *C. nutans* is also capable of invading moist sites with sparse vegetation. The musk thistle is a biennial that reproduces solely by seed. A rosette of leaves develops the first year, followed the second year by growth of an erect stem that will bolt (flower). Final plant height ranges from 0.6 to 1.5 m. Primary (terminal) inflorescences bloom first and lateral blossoms develop later. This pattern extends the flowering period and increases seed production (McCarty et al. 1967).

Seeds are released 7 to 10 days following blooming. Fifty to seventy heads may be produced by large plants. Seed production is related to plant size and inflorescence pattern. Lateral blossoms may produce only 25 seeds or less and terminal blooms may produce 1,200 to 1,500 seeds (McCarty et al. 1967).

Contributing to an already high seed production rate is the fact that musk thistle can also reproduce as an annual in areas of sparse vegetation. Spring seedlings can flower and produce seed by the end of the growing season (McCarty et al. 1967).

**Biocontrol Strategies.** Biocontrol agents, such as the weevils, *R. conicus* and *T. horridus* have been used extensively in IPM programs throughout the United States for control of musk thistle. They are especially effective when used together (Puttler, et al. 1978; McCarty and Lamp 1982; Rees 1982; Wapshere 1989).

***R. conicus* in Mesa Verde National Park.** *R. conicus* belongs to the order Coleoptera (beetles) and the family Curculionidae (weevils). It was first released in the United States in 1969. In pasture areas that possess considerable plant competition, the weevil has reduced musk thistle by 90 - 99 %. Other plant species can successfully invade areas where musk thistle has been eliminated by *R. conicus* (Wapshere et al. 1989). *R. conicus* has virtually eradicated the musk thistle in Montana and Wyoming ( Personal communication, Dr. Robert Lavigne, University of Wyoming).

In the spring, *R. conicus* females oviposit principally on the primary developing flower bud bracts. If the primary buds become oversaturated with eggs, females will oviposit on lateral buds and stems. Within 6 to 8 days, the eggs hatch and the larvae burrow into the future seed producing area called the receptacle. The larvae feed on the developing seed tissue for 25 to 40 days. Larval feeding stimulates the plant to transport nutrients to the affected area which reduces available resources for other parts of the plant, such as the roots. After an 8- to 14-day pupal stage, the adults emerge and chew out of the receptacle (Rees 1982).

Because the musk thistle depends entirely on seed for propagation, strategies that reduce seed set and number are most effective. *R. conicus* injures the thistle by significantly reducing viable seed production (McCarty and Lamp 1982; Puttler et al. 1978).

*R. conicus* has spread into Mesa Verde National Park from surrounding agricultural land where it is used for control of musk thistle. The weevil is locally established in very low sparse populations in some areas of Mesa Verde National Park.

***T. horridus* in Mesa Verde National Park.** *T. horridus* is another member of the family Curculionidae. It is used extensively in IPM programs throughout the United States for control of musk thistle. The weevil attacks the stems and crown and produces feeding scars that allow entry of pathogens, further weakening the plant. *T. horridus*, in conjunction with *R. conicus* is very effective in controlling this thistle (Cartwright and Kok 1985).

*T. horridus* larvae feed on musk thistle stems that disrupt the apical dominance of the plant. A single weevil female may oviposit 2,000 eggs in the foliage of the musk thistle (Cartwright and Kok 1985).

**Established insect herbivores of thistle in Mesa Verde National Park.** The painted lady butterfly, *Vanessa cardui* L. (Lepidoptera: Nymphalidae) is currently established on thistles in Mesa Verde National Park. *V. cardui*, the painted lady butterfly is a migratory herbivore of thistles. Because it cannot tolerate cold winter temperatures, it migrates to the southwestern United States and Mexico in the fall. In the spring, the adults return to the southwest and the adult females oviposit on the thistles. The larvae later hatch and begin feeding on foliage (Scott 1986). The larvae are effective herbivores of Canada and musk thistle (Marilyn Colyer, Natural Resource Specialist, Mesa Verde National Park, Colorado; Larry Hays, Natural Resource Specialist, Wind Cave National Park, South Dakota, personal communication).

## STUDY AREA

The study area is located in Morefield Canyon in Mesa Verde National Park. The study plots are located 1 km south of the Morefield sewage facility. The study site consists of moist areas of sparse vegetation that have been invaded by large populations of musk thistles.

## MATERIALS AND METHODS

The experimental design can be divided into four sections: (1) study quadrat selection; (2) biocontrol releases; (3) initial and subsequent monitoring of populations of herbivorous (plant-feeding) insects; (4) seed head analysis of musk thistle and native thistle.

### (1) Study quadrat selection.

**Musk thistle.** Two 10 X 10 m plots in Morefield Canyon were chosen for **treatment** (release of weevils) and **control** (no treatment) sites. The study plots were chosen for accessibility and presence and absence of *R. conicus*. The treatment plot already contained populations of *R. conicus* and the control plot possessed fewer numbers of the weevils. Each 10 X 10 m plot was subdivided into 5 equally-sized quadrats. Twenty plants were sampled within each quadrat, giving a total of 100 plants per plot that were monitored for herbivore populations during the growing season.

**Native thistles, *Cirsium* sp.** Because the native thistles exhibit sparse distribution, the sampling plot for *Cirsium* plants was extended to a 30 X 30 m plot adjacent to the musk thistle monitoring plots. 100 plants from this plot were monitored for populations of insect herbivores throughout the growing season.

## **(2) Biocontrol releases.**

**Musk Thistle.** *T. horridus* weevils were obtained from BCW (Biological Control of Weeds) and the United States Department of Agriculture - Biological Pest Control Section - Palisade Colorado. Adult weevils were released into the treatment (release) plot according to the following program: (a) 100 individual weevils were released on 29 May 1992. Five weevils were placed on 4 randomly selected musk thistle plants within each of the 5 sampling quadrats within the 10 X 10 m treatment plot which produced a total of 20 plants that received 5 weevils. (b) 1,000 individual weevils were released on 4 June 1992. Twenty weevils were placed on 10 randomly selected plants within each of the 5 sampling quadrats within the 10 X 10 m plot which produced a total of 50 plants that received 20 weevils.

**Native thistles.** 100 individual weevils were released on native *Cirsium* sp. on 4 June 1992. Twenty weevils were placed on 5 randomly selected plants within the 30 X 30 m plot of native thistles. Fewer *Cirsium* sp. plants were selected due to protected nature of native vegetation within Mesa Verde National Park.

## **(3) Monitoring program for plant phenology and populations of herbivores on thistle.**

**Musk thistle.** Records were completed for the following parameters: (a) number of *T. horridus* per plant; (b) number of *R. conicus* per plant; (c) number of *V. cardui* per plant; and (d) plant height. These parameters were recorded on the following dates in 1992: 7 June, 18 June, 3 July, 17 July, and 3 August. Monitoring was conducted for 100 plants within the 10 X 10 m treatment (release) plot and 100 plants in the 10 X 10 m control (no release) plot.

**Native thistle.** Records were completed for the following parameters on native thistles: (a) number of *T. horridus* per plant; (b) number of *R. conicus* per plant; (c) number of *V. cardui* per plant; and (d) plant height. These parameters were recorded on the following dates in 1992: 7 June, 18 June, 3 July, 17 July and 3 August. Monitoring was conducted for 100 plants within the 30 X 30 sampling plot.

**(4) Seedhead analysis of thistles.**

Thistle seed heads were destructively sampled at the end of the growing season from various sites throughout and adjacent to Mesa Verde National Park to monitor the spread of *R. conicus* and *T. horridus*. Seed heads were not destructively sampled from the study sites in order to insure maximum survival of the weevils, because significant numbers of weevil larvae could be destroyed.

## RESULTS AND DISCUSSION

**Monitoring of common insects on musk and native thistles.** Over the course of the field season, *R. conicus* remained in fairly high numbers on both musk and native thistle in both release and control sites (Table 2). However, the distribution of weevils on the thistles

Table 2. Mean number of *Rhinocyllus conicus*, *Trichosirocalus horridus*, and *Vanessa cardui* on musk and native thistles in Mesa Verde National Park.

| Insect species                  | Date                          | Mean number of insects per plant (100 plants examined per date)/frequency |                           |                |
|---------------------------------|-------------------------------|---------------------------------------------------------------------------|---------------------------|----------------|
|                                 |                               | Musk thistle release site                                                 | Musk thistle control site | Native thistle |
| <i>Rhinocyllus conicus</i>      | 7 June                        | 0.73/47                                                                   | 0.77/40                   | 0              |
|                                 | 18 June                       | 1.36/53                                                                   | 0.20/33                   | 0.06/6         |
|                                 | 3 July                        | 1.45/70                                                                   | 0.52/31                   | 0.66/20        |
|                                 | 17 July                       | 0.73/22                                                                   | 1.74/36                   | 1.23/29        |
|                                 | 3 August                      | 1.12/20                                                                   | 0.88/16                   | 1.94/29        |
|                                 | Seasonal total for 500 plants | 539                                                                       | 411                       | 388            |
| <i>Trichosirocalus horridus</i> | 7 June                        | 0.31/17                                                                   | 0                         | 0              |
|                                 | 18 June                       | 0.06/6                                                                    | 0                         | 0              |
|                                 | 3 July                        | 0.26/18                                                                   | 0                         | 0              |
|                                 | 17 July                       | 0                                                                         | 0                         | 0              |
|                                 | 3 August                      | 0                                                                         | 0                         | 0              |
|                                 | Seasonal total for 500 plants | 63                                                                        | 0                         | 0              |
| <i>Vanessa cardui</i>           | 7 June                        | 0.14/5                                                                    | 0.05/5                    | 0.43/29        |
|                                 | 18 June                       | 0.43/38                                                                   | 0.57/33                   | 0              |
|                                 | 3 July                        | 0                                                                         | 0                         | 0              |
|                                 | 17 July                       | 0                                                                         | 0                         | 0              |
|                                 | 3 August                      | 0                                                                         | 0                         | 0              |
|                                 | Seasonal total for 500 plants | 57                                                                        | 62                        | 43             |

was different throughout the season. The frequency refers to the number of individual thistle plants that possessed insects. Although the number of *R. conicus* remained constant on the musk thistles in the release site, the distribution was widespread on a greater number of plants through 3 July and then localized to fewer plants. These results suggest that large numbers of *R. conicus* were present in a few thistles during the latter part of the season. The distribution of *R. conicus* on thistles in the control remained fairly constant throughout the season. *R. conicus* distribution on native thistles was quite localized through 18 June and then became more widespread during the latter part of the season (Table 2).

Total seasonal numbers of *R. conicus* were fairly high in all study plots which indicates that this weevil is probably established in many areas of Morefield Canyon (Fig. 1).

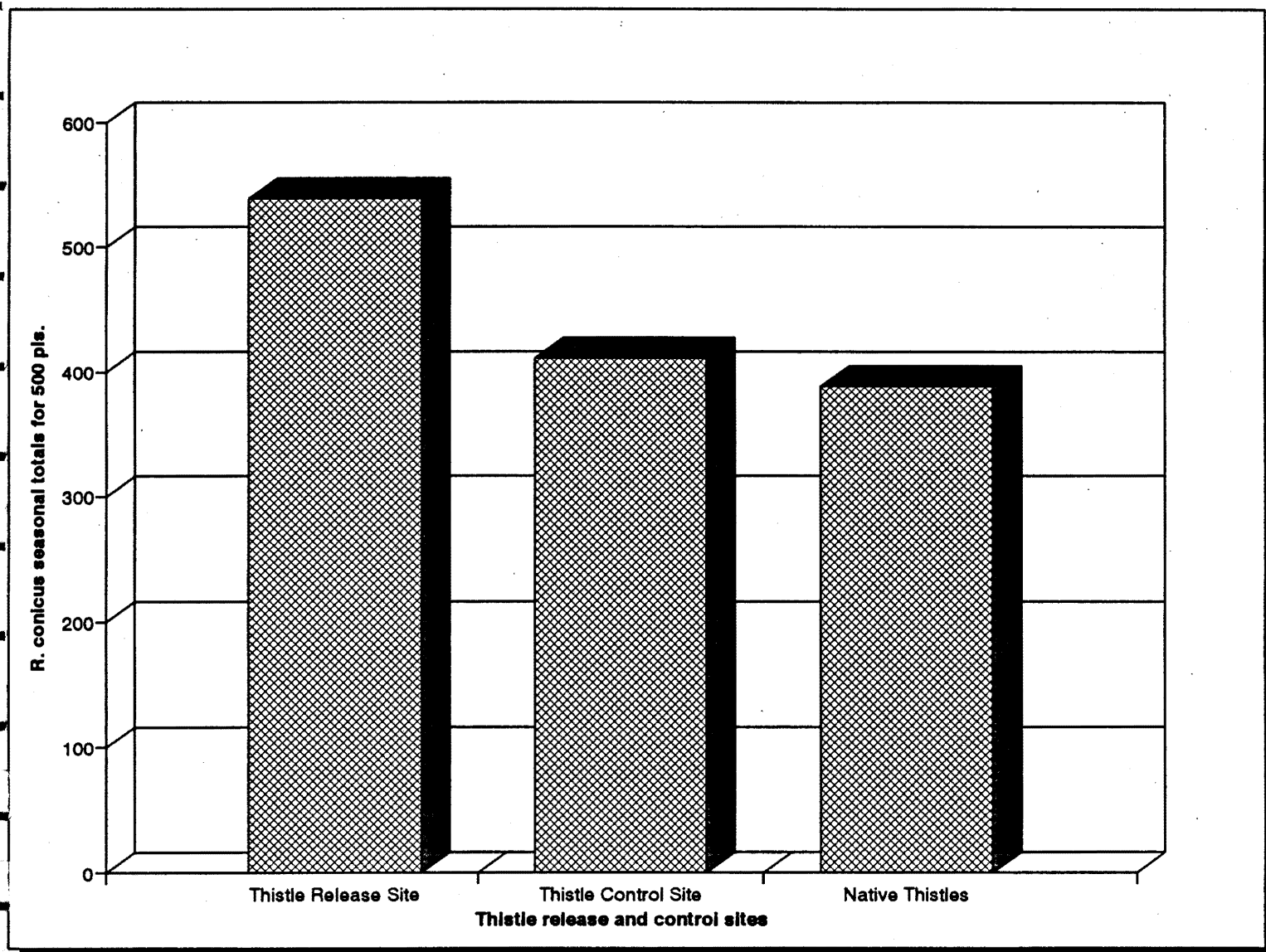


Fig. 1. Seasonal abundance of *R. conicus* on musk thistle in both the release site and the control (non-release) site and on native thistle. Numbers refer to total seasonal abundance of *R. conicus* on 500 plants.

*T. horridus* populations were observed only in the release site and then only through 3 July (Table 2). *V. cardui* was present at all sites in fairly low numbers through 18 June (Table 2).

Plant phenological characteristics were fairly similar for thistles in all three plots (Table 3). There may be a correlation of numbers of weevils with plant height. Larger plants may support greater numbers of insects.

Table 3. Mean plant height (cm) for thistles in three study sites.

| Date             | Musk thistle release site | Musk thistle control site | Native thistle |
|------------------|---------------------------|---------------------------|----------------|
| 7 June           | 26.67                     | 29.34                     | 25.07          |
| 18 June          | 58.82                     | 54.60                     | 57.19          |
| 3 July           | 81.92                     | 83.04                     | 71.17          |
| 17 July          | 86.24                     | 80.59                     | 76.53          |
| 3 August         | 96.79                     | 93.42                     | 76.94          |
| Seasonal average | 70.09                     | 68.20                     | 61.38          |

**Seedhead analysis.** Musk thistle and native thistle seedheads were analyzed for insect damage at the end of the season from areas surrounding Morefield Canyon. 1,748 seedhead weevils, *R. conicus* emerged from 106 musk thistle seedheads. Only 1 *R. conicus* larva and two pupal cells were present in 55 native thistle (*Cirsium undulatum*) seedheads.

**Management implications.** The Integrated Pest Management strategy has definite implications for development of an effective management program for exotic pest thistles in Mesa Verde National Park.

#### ACKNOWLEDGMENTS

We thank Marilyn Colyer and Steve Budd-Jack for providing information relating to this proposal. We also thank Dr. Robert Heyder for his insights and continued support of

the project. We are also grateful for the help and support of Fred Stahl and research associates at the United States Department of Agriculture - Biological Pest Control Section, Palisade Colorado for cultures of *T. horridus* used in the release program. Noah and Leona Poritz of BCW (Biological Control of Weeds) were most helpful in supplying weevils and information on their releases and biology. We also thank Kai Ford and Sean Sand for field research assistance.

### VIII. LITERATURE CITED

- Cartwright, B. and Kok, L.T. 1985. Growth responses of musk and plumeless thistles (*Carduus nutans* and *C. acanthoides*) to damage by *Trichosirocalus horridus* (Coleoptera: Curculionidae). *Weed Sci.* 33:57-62.
- Currie, W. E. 1984. Thistles- National Park Service IPM Information Package. United States Department of the Interior- National Park Service Final Report.
- McCarty, M.K. and Lamp, W.O. 1982. Effect of a weevil, *Rhinocyllus conicus*, on musk thistle (*Carduus thoermeri*) seed production. *Weed Sci.* 30:136-140.
- McCarty, M.K., Scifres, D.J., Robison, L.R. 1967. A descriptive guide for major Nebraska thistles. *Neb. Agric. Exp. Stn. Bull. No. 493.*
- Puttler, B., Long, S.H., and Peters, E.J. 1978. Establishment in Missouri of *Rhinocyllus conicus* for the biological control of musk thistle (*Carduus nutans*). *Weed Sci.* 26:188-190.
- Rees, N.E. 1982. Collecting, handling, and releasing *Rhinocyllus conicus*, a biological control agent of musk thistle. U.S. Dept. Agric. Agric. Handbook No. 579.
- Scott, J.A. 1986. The butterflies of North America. Stanford University Press. Stanford, California.
- Turner, C.E., Pemberton, R.W, and Rosenthal, S.S. 1987. Host utilization of native *Cirsium* thistles (Asteraceae) by the introduced weevil *Rhinocyllus conicus* (Coleoptera:Curculionidae) in California. *Environ. Entomol.* 16:111-115.
- Wapshere, A.J., Delfosse, E.S., and Cullen, J.M. 1989. Recent developments in biological control of weeds. *Crop Protect.* 8:227-250.