

## Evaluating *Rhinocyllus conicus* (Coleoptera: Curculionidae) on *Silybum marianum* (Compositae) in Texas

P.E. Boldt and C.J. DeLoach

USDA, Agricultural Research Service, Grassland, Soil and Water Research Laboratory, Temple, TX 76503,  
U.S.A.

### Abstract

The weevil, *Rhinocyllus conicus*, infested 48, 84 and 78% of the flowerheads of milk thistle, *Silybum marianum*, 3, 4 and 5 yrs respectively, after the original release was made in Central Texas. Egg to adult mortality was 71.7% with the greatest amount, 43.8%, occurring in the early instars. Weevils dispersed up to 5 km from the release site and reached densities of up to 27 larvae/head. The ovipositional period lasted 6 wks and was synchronized with development of terminal flowerheads but not with subterminals. The highest density of weevils was found in milk thistle plants growing in moist low areas, near trees and fencelines.

### Évaluation de l'Efficacité de l'Agent Biologique *Rhinocyllus conicus* dans la Lutte Contre *Silybum marianum* au Texas

Le charançon *Rhinocyllus conicus* a infesté respectivement 48, 84 et 78% des capitules de chardon-Marie, *Silybum marianum*, 3, 4 et 5 ans après leur introduction à Marlin, au Texas. Au cours de la quatrième année, l'aire de dispersion des charançons s'était étendue sur 6,5 km au sud du site original d'introduction, mais n'a pas augmenté au cours de la cinquième année. Parmi les facteurs influant sur le développement des populations, mentionnons l'incapacité de la larve néonate à pénétrer l'épiderme des capitules, la courte période de floraison et le faible taux de ponte. La phénologie de la plante a également été étudiée.

### Introduction

*Rhinocyllus conicus* Froelich (Coleoptera: Curculionidae) was first introduced from Europe into North America in 1968 for the biological control of several species of *Carduus* (Compositae) thistles and was widely credited with the successful reduction of thistle populations in several areas (Batra *et al.* 1981). A biotype of this weevil which appeared to prefer a closely related plant, milk thistle, *Silybum marianum* (L.) Gaertner (Compositae), was found in southern Italy by Goeden (1976). It was collected and released in California from 1971-74 (Goeden and Ricker 1977; Hawkes *et al.* 1972).

Milk thistle, a biennial or winter annual weed of Mediterranean origin, has become an increasingly obnoxious weed of winter pastures, disturbed and overgrazed rangeland, and wasteland of the southwestern United States (Correll and Johnston 1979; Parker 1972; Munz 1965). In Texas it was first reported growing in Sutton County in 1938 (Cory 1940) and is now a problem in many areas throughout the central region of the State. The weed competes with the more valuable grasses for water, space, and nutrients and grows in dense, compact stands which restrict cattle from parts of the pasture. The initial release of the weevil in Texas and some factors affecting its establishment on milk thistle are reported in this paper.

## Materials and Methods

Approximately 800 overwintered adults of the univoltine *R. conicus* were collected from milk thistle in northern California by R.B. Hawkes and sent by air freight to Temple, Texas. Releases of 400 adults/site were made on 4 May 1978, in each of two pastures: Big Creek, located 8.1 km, and Reagan, located 19.3 km, southeast of Marlin, Texas (Falls County), along Texas Highway 6. Dense patches of milk thistles in the early flowering stage of development, occurred at both release sites, and were widely distributed in the area. Surveys to determine the percent infestation and distribution of the weevil were made on 21 May 1981, 2 June 1982, and 26 May 1983, at the original release sites and along transects of up to 15 km radiating out in the four cardinal directions from the release sites. The exact sampling locations were determined by the presence of the thistles and sometimes varied between years.

In 1981 and 1982, 25 central or lateral terminal heads were removed without bias from each site and dissected to determine the percent infestation and total mortality of the late larval and pupal stages. In 1983, 10 plants were removed without bias and the percent infestation and late larval and pupal mortality were determined for central terminal, lateral terminal, and sublateral heads. Density of milk thistle plants in the 2 ha pasture at the Big Creek release site was determined on 1 June 1983, by counting the number of plants of all sizes present, in 25 randomly selected 1 m<sup>2</sup> quadrats in each of two 200 m long transects laid parallel across the field.

In 1983, plants were sampled periodically throughout the immature life cycle of the weevil to determine the percent infestation, duration of oviposition, and density and mortality of each developmental stage in the central terminal, lateral terminal, and sublateral flowerheads. The number of eggs on the head was counted and 100 eggs were held to determine percent eclosion. Percent early larval mortality was determined by dividing the number of larvae found in the head by the number of entrance holes in the bracts and subtracting from 100. Percent late larval, pupal, and teneral adult mortalities were determined by dividing the number of dead individuals of each stage by the total number of individuals in each stage times 100.

Temperature and precipitation data from the Waco, Texas, meteorological station 35 km northwest of the site were used (Anon. 1983).

## Results and Discussion

### *Recovery and Establishment*

On 7 May 1981, three years after the initial release, numerous eggs and larvae and five adults were found on c. 200 milk thistle plants at the Big Creek release site. Two weeks later, 48% of 25 dissected heads from Big Creek were found to be infested with an average of 0.8 larvae/head (Table 1). Dissections of thistle heads from nearby areas indicated that the weevils had dispersed 0.5–3.0 km from the release site, although areas up to 10 km away were searched.

Number and density of weevils sharply increased at Big Creek in 1982. At the release site, 84% of 25 heads were infested with 4.7 larvae/head. Dispersal also increased and weevils were found as far as 6.3 km east and 3.0 km west of Big Creek.

No weevils were found at the second release site at Reagan nor in the immediate vicinity of this site despite several visits to the area in 1981–83.

In 1983 all heads on 10 plants sampled at each location were dissected. The number of weevils and percent of infestation at the release site continued to increase in the central terminal and lateral terminal heads at Big Creek (Table 2). The density and

mortality of weevils found in the sublateral heads cannot be compared because they were not sampled in 1981 and 1982, but percent infestation and number of larvae/head were less than in the terminal heads, while mortality was higher. Sublateral head diameter of  $1.37 \pm 0.49$  cm was significantly less than the  $3.36 \pm 0.23$  and  $2.34 \pm 0.55$  cm diameter of the central and lateral terminal heads (Table 2), respectively, and may not have been suitable for oviposition (Zwölfer and Harris 1984) or larval development. Terminal heads were more susceptible to infestation than sublateral heads because they were present at the time the weevils were ovipositing, and the sublaterals appear later after oviposition has substantially decreased. Over 80% of the terminal heads were infested at the release site, 0.2 km north and 0.2 km west of the site. Weevils were present 5 km west of the release site but only one of 10 central terminal heads were infested. Weevils were not found 6.5 km east of the release site as they were in 1982.

**Table 1. Number and percent infestation of *Rhinocyllus conicus* Froelich in terminal milk thistle (*Silybum marianum* L.) flowerheads at Big Creek site, Marlin, Texas, 1981-82.**

Location <sup>1</sup>	1981		1982	
	No. of <i>R. conicus</i> /infested head <sup>2</sup>	% heads infested	No. of <i>R. conicus</i> /infested head <sup>2</sup>	% heads infested
Release site	$0.82 \pm 1.15$	48	$4.67 \pm 3.62$	84
North 0.2	$1.00 \pm 0.00$	16	$3.61 \pm 2.57$	72
0.5	$1.00 \pm 0.00$	20	$2.83 \pm 2.46$	72
1.0	— <sup>3</sup>	—	$0.00 \pm 0.00$	0
West 0.2	$1.14 \pm 0.38$	32	$3.11 \pm 2.40$	76
2.0	$0.00 \pm 0.00$	0	$0.00 \pm 0.00$	0
3.0	— <sup>3</sup>	—	$1.00 \pm 0.00$	8
South 0.2	$2.18 \pm 1.72$	42	$2.75 \pm 1.71$	20
2.0	$1.00 \pm 0.00$	8	$2.50 \pm 1.29$	16
East 0.2	$0.00 \pm 0.00$	0	$2.00 \pm 0.00$	4
0.5	$1.33 \pm 0.58$	12	$0.00 \pm 0.00$	0
6.5	— <sup>3</sup>	—	$2.00 \pm 1.41$	8

<sup>1</sup>Direction and distance (km) from release site.

<sup>2</sup>Mean  $\pm$  standard deviation of 25 heads/site/yr.

<sup>3</sup>Location was not sampled.

Overall, the population density increased to the north and west of the release site but decreased to the south and east. The highest density of weevils were observed in moist low areas, near trees and along fence lines while few or no weevils were observed in plants on an open rangeland near the release site. Cattle in the same field as milk thistles may also reduce weevil populations. Although the population density increased at the release site and up to 5.0 km distant, the migration rate was less than the 6.0-9.0 km/yr as reported by Rees (1977) in Montana.

### Mortality

Oviposition occurred in the field from mid-April to mid-May. Weevils laid eggs under caps of masticated food particles on all parts of the bracts and on the base of the receptacles but not on the stem. In Texas, 21.4% of 98 eggs observed in 1983 did not enclose. Some predation but no parasitism was observed. Some physical dislodgement

Table 2. Number and percent infestation of *Rhinocyclus conicus* Froelich in milk thistle (*Silybum marianum* L.) flowerheads at Big Creek site, Marlin, Texas, 1983.

Location <sup>1</sup>	Flowerhead types											
	Central Terminal			Lateral Terminal			Sublateral			No. of heads		
	No. of <i>R. conicus</i> /infested heads <sup>2</sup>	% infested	No. of heads	No. of <i>R. conicus</i> /infested head <sup>2</sup>	% infested	No. of heads	No. of <i>R. conicus</i> /infested head <sup>2</sup>	% infested	No. of heads	No. of <i>R. conicus</i> /infested head <sup>2</sup>	% infested	No. of heads
Release site	13.90±17.17	82 (19)	10	8.73±7.63	87 (16)	52	2.50±3.00	66 (11)	30			
North 0.2	11.80±10.60	100 (8)	10	13.22±12.0	95 (10)	58	9.53±8.86	92 (16)	38			
1.0	4.11±3.62	66 (8)	9	6.77±4.49	9 (16)	30	3.75±4.22	6 (22)	12			
West 0.2	6.50±5.28	90 (5)	10	7.48±6.57	85 (3)	46	2.89±4.99	33 (31)	27			
3.0	0	—	10	0.15±0.62	9 (0)	45	0.06±0.24	6 (0)	17			
5.0	0.10±0.32	10 (0)	10	0.08±0.40	4 (100)	25	0	—	10			
South 1.0	0	—	10	0.15±0.37	11 (1)	39	0.80±1.08	40 (8)	15			
2.0	0.10±0.32	10 (0)	10	1.04±1.75	32 (24)	28	0	—	10			
East 2.0	0.44±0.88	22 (25)	9	0.21±0.66	8 (60)	24	0.33±0.71	11 (60)	9			
6.5	0	—	10	0	—	29	0	—	10			

<sup>1</sup> Direction and distance (km) from release site.

<sup>2</sup> Mean and standard deviation.

<sup>3</sup> Values in parentheses are percent late larval and pupal mortality.

Table 3. Mortality of *Rhinocyclus conicus* Froelich in flowerheads of milk thistle (*Silybum marianum* L.).

Type of flowerhead	Early larva			Late larva			Pupa			Adult		
	No. entrance holes/head <sup>1</sup>	% mortality	No. of heads	No. sampled /head <sup>1</sup>	% mortality	No. of heads	No. sampled /head <sup>1</sup>	% mortality	No. of heads	No. sampled /head <sup>1</sup>	% mortality	No. of heads
Central terminal	1.87±2.00	28.2	25	6.80±6.53	19.7	10	5.84±3.96	18.0	10	8.11±9.58	9.6	10
Lateral terminal	2.52±3.31	60.7	25	4.25±3.71	14.3	52	3.34±2.74	15.5	52	4.75±3.63	5.0	47
Sublateral	1.40±2.81	33.7	25	1.58±3.00	11.3	30	0.07±0.27	0	30	1.18±1.39	25.6	33

<sup>1</sup> Mean ± S.D.

of egg caps was observed. Goeden and Ricker (1980) reported no mortality from dislodging.

Newly eclosed larvae tunneled through the bracts into the receptacle where they fed on the receptacle and the immature achenes. Number of larval entrance holes/head was used as an estimate of the number of successfully eclosed larvae. At Big Creek, number of entrance holes and percent early-instar mortality were highest in lateral terminal heads (Table 3). Mortality for 75 heads was 43.7% with an average of 1.92 entrance holes/head. Few dead larvae were found either in tunnels or receptacles. Occasionally, a small syrphid predator was found in a tunnel.

Late instar larvae and pupae usually were found around the edge of the receptacle. As density increased, more weevils were crowded to the center, although density was never so great as to force them into the peduncle as sometimes occurs on *Carduus* (Rees 1977). Damage was restricted to receptacles and achenes. Both density and mortality were highest in central terminal heads. Pupal mortality was significantly less in sublateral heads (where all four pupae recovered were alive) than in the central terminal or lateral terminal heads (Table 3). For 92 heads, there was an average of 3.8 late instar larvae/head with 15.6% mortality and 2.6 pupae/head with 15.8% mortality. No parasitism was observed in either larvae or pupae as compared with Europe, where weevil larvae in *Carduus* were heavily parasitized (Zwölfer and Harris 1984).

Table 4. Mortality of *Rhinocyllus conicus* Froelich/100 eggs on milk thistle (*Silybum marianum* L.), Marlin, Texas.

Stage	No. entering stage	% mortality during stage
Egg	100	21.4
Larva, early	78.6	43.8
Larva, late	44.2	15.6
Pupa	37.3	15.9
Adult, teneral	31.2	9.2
Adult, diapause	28.3	

Of the 2.94 teneral adults/head dissected from 90 mature brown heads in June 1983, 9.16% were dead from unknown causes. Greatest mortality was among adults in sublateral heads. The maximum daily mean air temperature of 29.1°C (Anon. 1983) probably did not produce temperatures in the head of 52–57°C which are necessary to kill *R. conicus* (Goeden and Ricker 1980), but the weevil may have been stressed by the combination of temperature and lack of plant moisture (Zwölfer and Harris 1984; Dowd and Kok 1983).

Mortality from eggs to adult in the life cycle of *R. conicus* was estimated at 71.7% (Table 4). This mortality was greater than the mean 55.8±20.0% calculated from data on milk thistle in California presented by Goeden and Ricker (1980). Thus for every 100 eggs oviposited on milk thistle heads, 28.3 adults were calculated to survive to mid-summer. Assuming that 50% of the adults are females and lay c. 200 eggs each (Phillips 1982), the weevil population should continue to increase. Neither life table measures adult survival during diapause which could affect the number of ovipositing females the following year.

## Conclusions

Infestation rates of up to 27 larvae/individual head and a relatively low mortality rate of 71.7%, resulted in a substantial amount of damage to many heads. Nevertheless, damage was seldom complete and some undamaged, fully formed, and apparently viable achenes continued to be produced each year. In California, Goeden (1978) also found that even at the highest density achieved of 44 weevils/head total seed destruction did not result. Although *R. conicus* has been established for only five years in Texas, several factors were observed which may limit the weevil from achieving the degree of successful control reported in Virginia (Surlles *et al.* 1974) and Montana (Rees 1977): (1) A short ovipositional period of 6 wks as compared with a period of 11 wks on *Carduus* in Europe (Zwölfer and Harris 1984). Oviposition was well synchronized with the development of the terminal flowerheads but was nearly completed by the time the sublateral heads appeared. (2) Larval densities observed in the field were insufficient to consistently destroy all or most of the achenes produced, even in terminal heads. Milk thistle heads required proportionally more larvae than the smaller *Carduus* heads, to achieve the same amount of damage. (3) *R. conicus* preferred plants growing in moist areas, near trees or along fence lines. They avoided plants in open flat rangeland even near the release site. This may be due to climatic stress of high air temperatures with insufficient plant moisture.

*R. conicus* is not a completely successful biological control agent. The weevil is capable of causing a significant amount of damage to milk thistle flowerheads but does not appear to be reducing the population density.

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