A Survey for *Rhinocyllus conicus* and its Impacts on the Endangered Sacramento Mountains Thistle (*Cirsium vinaceum*).

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INTRODUCTION

The Sacramento Mountains thistle (Fig.1)(*Cirsium vinaceum* Wooton & Standley) is a native thistle endemic only to the Sacramento Mountains of south-central New Mexico. Because of its limited range, very specific habitat requirements and several other factors that may impact it, this plant was listed as a priority 2 threatened species, as amended, on June 16, 1987 (U.S. Fish and Wildlife Service 1987). Although the major threat to extinction is the very limited availability of suitable habitat, there are several other important factors that may impact the survivorship of this species (U.S. Fish and Wildlife Service. 1993).

Figure 1. Sacramento Mountains Thistle.
Photo courtesy of Robert Sivinski.

Carduus nutans L., or musk thistle, is an exotic thistle introduced to North America in the early 1900's. It is an aggressive invader and has established throughout much of New Mexico, including many of the riparian areas occupied by Sacramento Mountains thistle (SMT). Perhaps more important than the threat musk thistle poses through its competitive ability to displace native vegetation, presumably native thistles, is the threat posed to SMT by a biological control agent of musk thistle, *Rhinocyllus conicus* Froel. (Coleoptera, Curculionidae) (Fig 2).

Rhinocyllus conicus was first released in the United States in 1969 and has spread and been subsequently released in various states since that time (Weeden et al. 1976). Prior to its release, host range testing of *R. conicus* revealed potential for damage to several closely related genera, including *Cirsium* (Louda et al. 2003). Observations in several areas where *Rhinocyllus* has established suggest reduced seed production of the native thistles, possibly translating to future decreases in population size of an already limited species (Turner and Herr 1996). Specifically, *R. conicus* was determined to both feed and oviposit on *Cirsium vinaceum* in greenhouse studies (Richard Lee, unpublished data). As a result, the New Mexico Department of Agriculture abstained from implementing *R. conicus* as a biological control agent against musk thistle. However, *R. conicus* has become common in musk thistle infestations in northern New Mexico and have slowly spread southward. In 2001 it was found on the Lincoln National Forest and the Mescalero Apache Reservation (USDA-Forest Service, 2003). In 2006 it was found in musk thistle in the Silver Springs valley interspersed in one of the largest *Cirsium vinaceum* populations (personal observation).

Populations of SMT that had been closely monitored appeared to be stable in terms of recruitment and mortality in the late 1980's (Thomson and Huenneke 1990). However, since that time, musk thistle has expanded its range into areas where SMT occupy. A survey was conducted during the summer of 2007 on populations of SMT for musk thistle, *R. conicus*, and native insect presence. Furthermore, we determined the impact *R. conicus* and native insects had on seed production of SMT.

Figure 2. ***Rhinocyllus conicus*** oviposition sites (A), larvae (B), pupae (C) and adult (D).

METHODS

Thirty-two historic sites representative of the entire range of SMT on the Lincoln National Forest were located and delineated using GPS in early August 2007. Individual sites were numerically identified by markers posted at each site. For ease of discussion and the lack of insect variability among sites within a drainage, the sites were grouped and named according to the major drainage or landmark of their location (Fig. 3).

Density of bolting thistle plants and rosettes were estimated using ocular estimations and area of each SMT population was measured using GPS. A visual survey of the area and adjacent habitats were conducted to determine presence of musk thistle. Distance to nearest musk thistle population was recorded and its density and area estimated.

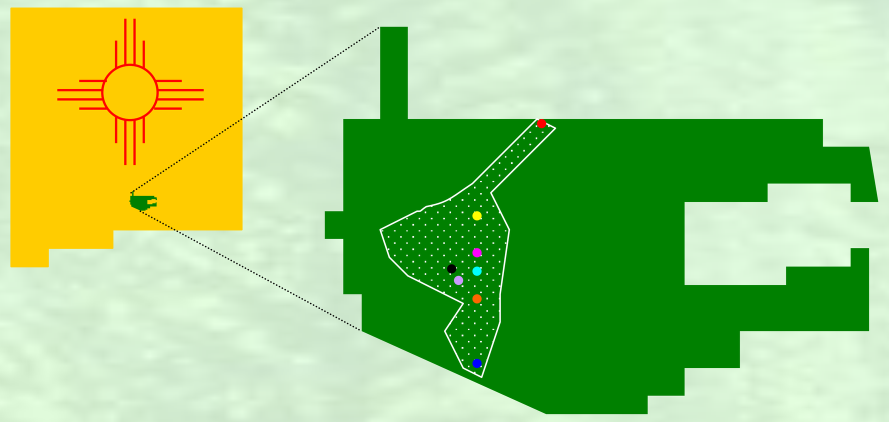

Figure 3. Relative locations of Sacramento Mountains Thistle sites in the Cloudcroft District of the Lincoln National Forest in New Mexico.

Wills Canyon: sites 15, 16, 17, 18, 59, 62, 65, 66, 67 and 88.
Water Canyon: sites 47, 51, 53, 57, 79, 87 and 94.
Upper Rio Penasco: sites 41, 43 and 44.
Rio Penasco (including Bluff Springs): sites 4, 7, 24 and 27.
Silver Springs: site 29.
Scott Able Canyon: site 100.
Chippeway Park: site 73.
Lucas Canyon: sites 28, 30, 31, and 32.
Sacramento Mountain thistle range.

Flower heads of each thistle population were visually sampled as populations were marked and measured for insect activity. *R. conicus* egg scars were counted on the outer phyllaries on a minimum of 100 flower heads (where appropriate) of both musk thistle and SMT at each population. In late September, an additional 50 mature seed heads of each species in sites near where *R. conicus* was detected earlier were destructively sampled post-seed set to determine if *R. conicus* developed within the seed head, estimate the percent seed reduction to each species and to derive baseline data for future *R. conicus* population trend monitoring. Representative samples of all insects collected from seed heads of both plant species were photographed, preserved in 95% ethanol and identified to species when possible. Representative specimens were stored in the New Mexico State University Watts Entomology lab.

RESULT AND DISCUSSION

SMT sites that were quantified were variable in both area and density (Table 1), which appears to be associated with the availability of surface water. In all cases where area of the population was less than 10 m², surface water was not apparent (Fig 4). Conversely, most of the largest (≥ 100 m²) sites were in or near actively flowing springs and were denser where travertine soils were present (Fig 4). Many of the historic sites in Lucas Canyon appear to be extinct as are several in Wills Canyon. In each case of nonexistent plants at a site the springs or water source they were associated with were dry at the time of the survey. The remainder of the populations appear to be reproducing since rosettes were common in all other locations.

Table 1. Average density and area of Sacramento Mountains thistle sites and their associated musk thistle populations included in 2007 survey.

	Sacramento Mountain Thistle			Musk Thistle	
Site(n)	Area (m²)	Density (#/m²)	Distance (km)	Area (m²)	Density (#/m²)
Silver Springs (1)	16,896	11	0	86	0.1
Chippeway Park (1)	0	0	0.2	3	0.5
Lucas Canyon (4)	5	0.2	0.4	9	1
Upper Rio Penasco (3)	160.3	6.7	0.8	49.3	2
Lower Rio Penasco (4)	16.5	4.4	0.1	9	1
Water Canyon (6)	71.6	7.2	0.6	26.2	1.5
Wills Canyon (10)	11.4	0.7	0.5	20.1	2.6
Scott Able Canyon (1)	1,029	7	2.7	13	3

Figure 4. Typical area and density at a site with no flowing water (left) vs. sites with actively flowing spring with travertine soil deposits (right).

Musk thistle is well established in nearly all of the drainages that SMT occupies. Only the Scott Able Canyon sites are further than 2 km from at least scattered populations of musk thistle. Large, dense stands of musk thistle are common in many of the lower stretches of the drainages, while small scattered populations are found in their upper portions.

Rhinocyllus conicus was found only in the Silver Springs SMT site; in both, SMT and musk thistle (Table 2) and in musk thistle at Marcia (N 32°49'42", W 105°45'58") in the upper Rio Penasco drainage (Fig. 5). *R. conicus* was not found at or near any other sites surveyed. Although *R. conicus* was detected at Marcia, a very small number of egg scars (2 scars/100 heads) were found. The weevil's peak breeding season occurs prior to when this survey was conducted so its actual presence may be higher than reported here. However, no sign of *R. conicus* was found in the destructive samples in September at this site so the population seems to be very small at this time.

Table 2. Number of *Cirsium vinaceum* and *Carduus nutans* flower heads used by *Rhinocyllus conicus* by life stage in the Silver Springs Valley. Number of individual *R. conicus* detected are in parenthesis.

	August 6, 2007 (n=115)		September 25, 2007 (n=50)	
	C. vinaceum	*C. nutans*	*C. vinaceum*	*C. nutans***
No Damage*	96	78	26	18
Egg Scar	19 (30)	37 (58)	0	0
Larvae	N/A	N/A	22 (73)	18 (33)
Pupae	N/A	N/A	0	12 (38)
Adults	N/A	N/A	2 (2)	8 (11)

* No damage from *R. conicus*, other insect damage may have been apparent.
** More than one life stage was present in some flower heads resulting in the total number of occurrences being greater than n.

Figure 5. Musk thistle population near Marcia where *Rhinocyllus conicus* was detected.

The establishment of *R. conicus* at this site will likely occur in the near future. This population of musk thistle is the largest and most dense in the surrounding area, but scattered plants are found throughout the nearby drainages. In most cases SMT sites are within a few meters of scattered, low density musk thistle which will provide a conduit for *R. conicus* establishment on SMT throughout the upper Rio Penasco watershed. Although there are reports of *R. conicus* being present in the Chippeway Park area in Cox Canyon, our surveys in that area did not detect them.

Egg scars were found on 16.5% of SMT flower heads and 32% of musk thistle heads in the Silver Springs site during the August survey and none in September indicating that oviposition had ceased by late September. In August, the number of egg scars per head when oviposition was detected averaged 1.6 scars per head on both plant species; however, the number of heads used was 51% less on SMT than it was on interspersed musk thistle even though the plants phenology was extraordinarily similar. A similar survey conducted in July (Sivinski 2007) found oviposition rates of 63.8% on SMT indicating a much higher rate of use during the peak *R. conicus* breeding season. That same study revealed similar rates (17.8%) to ours during its mid-August survey. Heavy rains in the area during late July undoubtedly washed away many of the oviposition caps reducing the number of detected oviposition sites in both August surveys but the reduction also coincides with the normal breeding cycle of *R. conicus*.

During the September destructive sampling, 74% of the musk thistle heads sampled at Silver Springs had early through late instar larvae, pupae, adults or a combination of all three life stages of *R. conicus* present in them. Fifty-two percent of the SMT heads sampled had *R. conicus* larvae. The number of larvae/head averaged 3.3 in SMT heads where larvae were found and 1.8 per head in musk thistle. Numerous early (1st or 2nd) instar *R. conicus* larvae were present in the SMT heads, but no pupae and only 2 adults were found in the SMT heads. The lack of large larvae, pupae and adults in SMT heads could be indicative of *R. conicus* developmental rates or survival being less in SMT compared to musk thistle. Although there were 2.2 times as many larvae in SMT as musk thistle, the total number of *R. conicus* was very similar (75 in SMT vs. 82 in musk thistle). The fact that all larvae found in SMT were very small could be attributed to *R. conicus* selecting SMT late in their breeding cycle, but more likely is that their development was hindered by intraspecific competition and/or competition from native insects. In all cases where *R. conicus* larvae were found in SMT there was evidence of the native insect *Paracantha gentilis* Hering (Diptera: Tephritidae) (Fig. 6) having developed in coexistence with it. Although it appears unlikely that the small *R. conicus* larvae would complete development before freezing temperatures kill them, they undoubtedly had impacted seed viability. Studies to determine developmental rates and survival percentages of *R. conicus* within SMT are warranted.

Figure 6. An adult Tephritid fly, *Paracantha gentilis* (above) and puparia (right) on Sacramento Mountains thistle.

P. gentilis were present in 94% (47 of 50) of the flower heads sampled at Silver Springs. As many as 10 puparia were found in a single flower but the average was 3.5. In flower heads where fewer than 4 puparia were found and *R. conicus* was absent, seed production was more than 60%; however, viability was less than 10% when more than 4 *P. gentilis* were present or when 1 or more *R. conicus* larvae was present with any number of *P. gentilis.* Three of the 50 heads sampled had no viable seeds. No flower heads were sampled that included only *R. conicus*. Selection of plants for our survey excluded any plants that were obviously stressed or dying from other causes or was senescing.

P. gentilis were found in 59% of flower heads surveyed in Water Canyon. However, the average number of puparia per flower head was 1.1. Seed viability was greater than 85% at each site within Water Canyon. The Rio Penasco sites averaged 73% presence with an average of 4 puparia per flower head in those heads that supported *P. gentilis.* Seed viability averaged 71%. All of the heads sampled in both the Rio Penasco and Water Canyon sites had at least some viable seeds.

Several other insects were found in SMT flower heads and are impacting seed production in variable amounts. The Scarab beetle, *Euphoria inda* (L.) (Fig. 7) was not common in any site, but was present in all sites visited. It was also found in musk thistle at Silver Springs and is a generalist seed and fruit feeder. Although not common, it reduces seed production by 95% in the flower heads it attacks.

Figure 7. Euphoria inda adult (left) and it's damage to seed production on Musk thistle. It also impacts Sacramento Mountains thistle.

Another native North American insect found to have a large impact on SMT at Silver Springs was *Lixus pervestitus* Chittenden, a large Curculionid that feeds in the stems of its host plant. The adult weevil feeds in the peduncles and oviposits in the stem. Larvae develop within the cortex and kill the plant prior to seed set in most cases. In our September survey 92% of the mature plants at Silver Springs were dead as a result of this insect (Fig. 8). It was not found in adjacent musk thistle, nor was it found in any other SMT population. Further studies of this insect should be incorporated in future surveys of SMT due to its propensity to cause extensive die offs of mature plants. Other insects of importance to SMT and complete descriptions of the above mentioned insects can be found in Sivinski's report (2007).

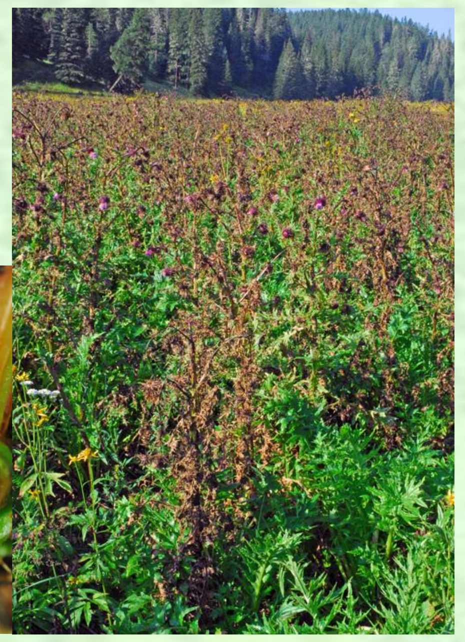

Figure 8. *Lixus pervestitus* adult (above), larvae (right) and damage to Sacramento Mountains thistle (far right).
Photos courtesy of Robert Sivinski.

CONCLUSION

Musk thistle has invaded most of the Sacramento Mountains thistle habitat in the Lincoln National Forest. At present time, its encroachment is not directly impacting the survival of SMT through competition. *Rhinocyllus conicus* is only present in damaging numbers at Silver Springs though it was detected in the Rio Penasco. It obviously utilizes SMT throughout its breeding cycle and reduces seed production in all cases. However, it is unknown how suitable SMT is as a host since it appears fewer adults are produced in SMT flowers. SMT flower heads are significantly smaller than musk thistle heads; thus they provide less food and space for larval development. Competition between *R. conicus* larvae may explain why all of the larvae found in SMT in late September were less developed than those found in musk thistle, though competition with *P. gentilis* is more prevalent and most likely retards the development of *R. conicus* larvae. A native Tephritid fly for which the Platte thistle (*Cirsium canescens* Nutt.) is a host has been documented by Louda et al. (1997). Whether or not *R. conicus* can or will displace *P. gentilis* remains to be seen. The native fly definitely reduces seed production in all of the existing SMT populations, though to a lesser extent in those populations excluding Silver Springs. Vegetative reproduction by SMT apparently will help offset reduced seed production caused by any of the seed feeding insects described here. *Lixus pervestitus* is potentially more detrimental to the SMT populations that it invades as mortality of the entire plant occurs and seed production is very limited. Dropping water tables and reduced spring flow due to long term drought and elevated tree density (Charles Dixon, personal communication) throughout the Forest appear to be a major contributor to Sacramento Mountains thistle population declines.

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