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Effectiveness of the Gall Mite, *Eriophyes chondrillae*, as a Biological Control Agent of Rush Skeletonweed (*Chondrilla juncea*) Seedlings

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A laboratory experiment was conducted to quantify the effects of the gall mite, *Eriophyes chondrillae*, on seedlings of rush skeletonweed, *Chondrilla juncea*. Two mite infestation levels were evaluated on the Washington late-flowering biotype of the weed. Mites introduced at low and high rates, respectively, reduced plant height (25-68%), internode length (41-47%), root dry weight (60-85%), stem dry weight (31-71%), plant dry weight (40-75%), seed production (98-99%), and root bud regenerative capacity (4-57%), and increased the plant mortality rate.

Introduction

Rush skeletonweed, *Chondrilla juncea* L. (Asteraceae), is a troublesome weed in California and the Pacific Northwest states of Idaho, Oregon and Washington. It infests rangeland, semiarid pastureland, cropland, abandoned fields, transportation rights-of-way, and residential properties. The plant's noxious characteristics are well documented (Cuthbertson 1967, Wells 1971, Cheney *et al.* 1981). This Eurasian, herbaceous perennial was first reported in the United States in the 1870s (Schirman and Robocker 1967). It is distributed along the east coast from New York to West Virginia but is not considered a problem in that area. Rush skeletonweed was first reported in Washington in 1938, in Idaho in 1960, in California in 1965, and in Oregon in 1971 (Schirman and Robocker 1967, Coleman-Harrell 1978). The weed has spread at an estimated rate of 41,000 ha/yr in the Pacific Northwest and in Washington it presently infests over 809,000 ha in 12 eastern counties (Cheney *et al.* 1981, Lee 1986).

Three biological control agents have been released against rush skeletonweed in the western United States. The gall midge, *Cystiphora schmidti* Rubsaamen (Diptera: Cecidomyiidae), was first released in Washington in 1976, the rust fungus, *Puccinia chondrillina* Bubak & Syd. (Pucciniaceae), in 1978, and the gall mite, *Eriophyes chondrillae* (G. Canestrini) (Acari: Eriophyidae), in 1979. The organisms have established and spread well throughout Washington and also in other states where released. In eastern Washington, the most damaging natural enemy of rush skeletonweed is *E. chondrillae*. This eriophyid infests developing vegetative and flower buds, transforming them into leafy, hyperplasic galls (Caresche and Wapshere 1974). The other biological control agents have succeeded to a lesser degree, the gall midge suffering from high parasitization by the pteromalid *Mesopolobus* sp. (Wehling and Piper 1988), and the rust fungus from the low relative humidity of eastern Washington (Adams 1982).

There are 2 distinguishable biotypes of rush skeletonweed in Washington. The Washington early-flowering (WEF) biotype is short (0.6-0.9 m) and bushy with profuse lateral branching (Rosenthal 1968). It flowers from July to August and is found only in northeastern Washington.

The Washington late-flowering (WLF) biotype is taller (0.9-1.2 m) and lacks extensive lateral branching. Flowering occurs from late July through October. It is the predominant biotype found throughout eastern Washington (Old 1981).

Quantitative studies of the impact of *E. chondrillae* on Australian rush skeletonweed biotypes have been conducted by Cullen *et al.* (1982) and Cullen and Moore (1983). They demonstrated that mite infestation reduced flower and seed production, plant height, number of secondary stems, plant biomass, and number of root buds regenerating after shoot senescence. The Australian and Washington *C. juncea* biotypes are morphologically distinct and no such studies have been conducted on rush skeletonweed found in Washington.

The mite's potential to reduce *C. juncea* populations in Washington is largely dependent upon its ability to produce plant mortality or to prevent seed production (flower formation) and regeneration of new shoot buds on the roots (Rosenthal *et al.* 1968, Schirman and Zamora 1978). Suppression of mature stands of the weed is difficult because plants that are 2 or more years old exhibit increased tolerance to mite-induced stress, and their root systems are capable of producing multiple satellite plants (Cheney *et al.* 1981). However, field observations of mite-infested rush skeletonweed seedlings suggested that many cannot survive a full growing season and that young satellite plants may be just as susceptible to mite injury as are seedlings. The purpose of this study was to quantify the damage and effects of *E. chondrillae* on seedlings of the Washington late-flowering biotype, and to predict the mite's potential to control *C. juncea* in Washington.

Methods and Materials

Laboratory research was conducted at Washington State University, Pullman. Vernalized WLF biotype seedlings were collected near Pasco, Franklin County, Washington on 20 March 1986. Plants at this site were free of all introduced natural enemies. Seedling rosettes were collected prior to bolt formation and transplanted into 13 cm diam x 13 cm deep plastic pots in sandy loam soil. Seedlings were identified as those plants with no attached stem remnant from the previous year's growing season. Seedlings also could be readily distinguished from young satellite plants by their lack of a fibrous root system and/or connection to a parental root. Individual plants received 2.5 g of a 14N-14P-14K slow-release fertilizer and were watered at 36-48 h intervals.

Potted plants were placed in 58 x 31 x 6 cm trays and positioned on laboratory benches. Illumination was provided by 7, 40-watt cool white, and 7 ultraviolet fluorescent lamps suspended above the plants. Lamp position was adjustable to accommodate increases in plant height, with fully elevated lights being 0.9 m above the bench surface. A 14:10 (L:D) photoperiod was maintained. Temperature and RH were recorded continuously with a hygrothermograph. Mean daily temperature was 22 ± 1.5°C, and RH averaged 50 ± 11% throughout the 17-wk experiment.

Plants were subjected to 1 of 3 levels of mite infestation: high, low, or none (control). The number of plants tested/treatment was 23. Mites were obtained from galls produced on greenhouse-grown WLF *C. juncea* and released on a seedling when the developing shoot was between 3 and 7 cm high. High mite plants were inoculated with 300-500 mites by placing 3 galls, each approximately 3 x 1 mm in size, at the base of each stem. Prior laboratory dissection of 10 galls of this size indicated an average of 125 mites/gall. As the detached galls desiccated, the mites within exited and colonized seedling shoot buds. This treatment was representative of mite density within galls formed on rush skeletonweed during mid- to late summer (Cullen *et al.* 1982). Low mite plants were inoculated with 15 mites each. Mites were carefully placed on the developing shoot with a fine camel's hair brush. Vernalized *C. juncea* collected from the field had between 5 and 30 mites/plant so the low mite treatment approximated a typical overwintering population.

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Parameters analyzed at the termination of the experiment included primary stem length, internode length, dry stem, root and total (galls, stems, roots and seeds) plant biomass, and number of shoot buds regenerated from the root 14 d after aerial biomass was harvested. A comparison of parameters was facilitated by using a 2-way analysis of variance (ANOVA). Means were compared using Fisher's protected LSD. Seed production was compared between treatments but was not subjected to statistical analysis due to the low numbers of plants yielding seed.

Results and Discussion

Control plants had significantly greater primary stem lengths, internode lengths, dry stem, root and total plant weights, and formed more regenerative buds than either low or high mite treatment plants (Table 1). Seed production was virtually eliminated in mite-affected plants. These results compare favorably with those reported by Cullen *et al.* (1982) and Cullen and Moore (1983) on *E. chondrillae* impact on Australian rush skeletonweed biotypes in greenhouse experiments.

Compared to the control mean, stem height was reduced 25.6 and 67.9% for low and high mite treatments, respectively. Gall mite feeding had a pronounced effect on shortening internode length and stem thickening. Mean internode length was reduced by 41.4 and 47.3% for low and high mite treatments, respectively, compared to the controls.

Mean dry stem weight was significantly different between the control, low and high mite treatments (Table 1), being significantly greater in the uninfested plants. Stem biomass was reduced by 30.5 and 70.5% for low and high mite treatments, respectively, compared to the controls.

Mean dry root weight also was significantly different among all three treatments (Table 1), and significantly greater in control plants than in either low or high mite plants ($P < 0.0001$). Root biomass was reduced 60.5 and 84.5% for low and high mite treatments, respectively. Mean total dry plant weight was reduced by 39.8 and 74.9% for low and high mite treatments, respectively, compared to the controls.

Table 1. Effects of *Eriophyes chondrillae* on the primary parameters of *Chondrilla juncea*.

Parameter ($\bar{x}$)	Treatment			
	Control (N= 23)	Low Mite (N= 21)[1]	High Mite (N= 18)[1]	
Primary stem length(cm)	73.60*a*[2]	54.74*b*	23.60*c*	(P< 0.001)
Internode length (cm)	2.56*a*	1.50*b*	1.35*b*	(P< 0.05)
Stem dry wt. (g)	5.09*a*	3.54*b*	1.50*c*	(P< 0.001)
Root dry wt. (g)	2.20*a*	0.87*b*	0.34*c*	(P< 0.05)
Total dry wt. (g)	7.33*a*	4.41*b*	1.84*c*	(P< 0.0001)
No. root buds regenerated	6.65*a*	3.04*b*	1.43*c*	(P< 0.05)
Total seed production	736	10	14	

skeletonweed (Table 1). New buds were produced on 100% (23/23) of the control plants, 96% (22/23) of the low mite treatment plants, and 43% (10/23) of the high mite treatment plants.

C. juncea reproductive potential was decreased by *E. chondrillae* infestation. Mean seed production by plants subjected to mite treatments was reduced by 98-99% compared to uninfested plants (Table 1). As only a single plant from both the high and low mite treatments produced any seed, a statistical comparison was not performed.

The formation of galls on mite-infested plants further added to the gross morphological differences expressed between control and infested plants. During wk 12 of the experiment, mite-infested plants turned yellow and/or brown prematurely, and appeared to be physiologically stressed when compared to mite-free *C. juncea*.

E. chondrillae-infested seedlings in the field resembled in size and morphology the high mite plants in the laboratory. If the results of this experiment can be extrapolated to field conditions, then field seedlings may experience from 90-100% seed production losses. As healthy seedlings are capable of producing from 500-1500 seeds/plant (McVean 1966), this represents a significant propagule loss. Diminished regenerative capacity attributable to high mite infestation levels would further add to the loss of plant reproductive potential. Observations of galled rush skeletonweed in the field suggest that mite effects on seedlings are even greater than these projected levels due to the occurrence of additional environmental stress factors.

The reduction of biomass, especially that of the roots of galled laboratory plants, suggested that the mite adversely affected carbohydrate translocation and storage in rush skeletonweed. This finding is supported by the research of Dimock (1982) who reported that total nonstructural carbohydrate root reserves were lower in *E. chondrillae*-infested plants compared to uninfested plants. Field populations of *C. juncea* infested by the mite will likely exhibit diminished tolerance to both drought and competition from neighboring vegetation.

The gall mite appears to be the most successful biological control agent released to date against the weed, and should continue to play a key role in lessening rush skeletonweed persistence and spread throughout the Pacific Northwest. The mite's high fecundity, dispersal attributes, and ability to establish on both biotypes make it a desirous natural enemy. Currently, natural spread of *E. chondrillae* in Washington is being supplemented by seasonal collection and redistribution in an effort to expedite saturation of mite-deficient *C. juncea* populations.

References

Adams, E.B. 1982. Use of a plant pathogen (*Puccinia chondrillina*) to control rush skeletonweed (*Chondrilla juncea*). Ph.D. dissertation, Washington State University, Pullman.

Caresche, L.A. and A.J. Wapshere. 1974. Biology and host specificity of the *Chondrilla* gall mite *Aceria chondrillae* (G. Can.) (Acarina: Eriophyidae). *Bulletin of Entomological Research* **64**:183-92.

Cheney, T.M., G.L. Piper, G.A. Lee, W.F. Barr, D.C. Thill, R.B. Hawkes, R.F. Line, R.R. Old, L.L. Craft, Jr. and E.B. Adams. 1981. Rush skeletonweed: biology and control in the Pacific Northwest. *University of Idaho College of Agriculture Current Information Series Number* **585**.

Coleman-Harrell, M.E. 1978. Tri-state skeleton weed consortium newsletter. University of Idaho **1(3)**:1-5.

Cullen, J.M., R.H. Groves and J.F. Alex. 1982. The influence of *Aceria chondrillae* on the growth and reproductive capacity of *Chondrilla juncea*. *Journal of Applied Ecology* **19**:529-37.

Cullen, J.M. and A.D. Moore. 1983. The influence of three populations of *Aceria chondrillae* on the three forms of *Chondrilla juncea*. *Journal of Applied Ecology* **20**:235-43.

Cuthbertson, E.G. 1967. Skeleton weed: distribution and control. *New South Wales Department of Agriculture Bulletin Number* **68**.

Dimock, W.J. 1982. Nonstructural carbohydrate analysis of the roots of rush skeletonweed, *Chondrilla juncea* L., affected by the gall mite, *Aceria chondrillae* (G. Can.) (Acarina: Eriophyidae) and picloram. M.Sc. thesis, University of Idaho, Moscow.

Lee, G.A. 1986. Integrated control of rush skeletonweed (*Chondrilla juncea*) in western U.S. *Weed Science* **34 (Supplement 1)**:2-6.

McVean, D.N. 1966. Ecology of *Chondrilla juncea* L. in southeastern Australia. *Journal of Ecology* **54**:345-65.

Old, R.R. 1981. Rush skeletonweed (*Chondrilla juncea* L.): its biology, ecology and agronomic history. M.Sc. thesis, Washington State University, Pullman.

Rosenthal, R.N., R. Schirman and W.C. Robocker. 1968. Root development of rush skeletonweed. *Weed Science* **16**:213-7.

Schirman, R. and W.C. Robocker. 1967. Rush skeletonweed – threat to dryland agriculture. *Weed Science* **15**:310-2.

Schirman, R. and B.A. Zamora. 1978. Bud development in excised roots of rush skeletonweed (*Chondrilla juncea*). *Weed Science* **26**:582-4.

Wehling, W.F. and G.L. Piper. 1988. Efficacy diminution of the rush skeletonweed gall midge, *Cystiphora schmidti* (Diptera: Cecidomyiidae), by an indigenous parasitoid. *Pan-Pacific Entomologist* **64**:83-5.

Wells, G.J. 1971. The ecology and control of skeleton weed (*Chondrilla juncea*) in Australia. *The Journal of the Australian Institute of Agricultural Science* **37**:122-37.