Compatibility of *Rhinocyllus conicus*[1] and 2,4-D (LVA)[2] for Musk Thistle Control

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ABSTRACT

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Herbicidal effect on *Rhinocyllus conicus* Froel., a thistle head weevil, was studied by examining the mortality, emergence rates and weights of weevils developing from plants treated with 2,4-D (LVA). Infested heads, obtained by caging ovipositing *R. conicus* on primary heads of musk thistle (*Carduus nutans* L.) (resembles *C. thoermeri* Weinmann), were treated with 2,4-D at 1.68 kg/ha 0–3 wk after oviposition. Mortalities of larvae developing from untreated plants and those plants sprayed 1–3 wk were significantly lower than mortality from plants sprayed within 48 h of oviposition. The latter failed to support larval development beyond the 2nd instar. Developmental times and weights of weevils that emerged from blooms sprayed at 1, 2, and 3 wk were not significantly different from controls. Plants sprayed up to 2 wk after oviposition (late-bud to early-bloom) did not produce viable seeds, but treatments at 3 wk after oviposition (full-bloom) allowed 10% germination of seeds not damaged by *R. conicus* in primary heads, and plants survived to produce additional heads. Treatment of musk thistles with 2,4-D at late-bud to early-bloom stage of the primary heads prevented formation of viable seeds without adversely affecting *R. conicus* development.

Carduus nutans L. (musk thistle), a noxious European import, has been the target of extensive control efforts in the United States and Canada. Biological (Harris and Zwölfer 1971, Surles et al. 1974, Puttler et al. 1978) as well as chemical and mechanical procedures (Kates 1968, McCarty and Hatting 1975) have been used to regulate this weed. Reduction of musk thistle seed production by the thistle-head weevil, *Rhinocyllus conicus* Froelich, was significant (Rees 1977, Surles and Kok 1978), as was well-timed applications of herbicides (McCarty and Hatting 1975). However, these studies did not relate the respective stages of weevil and plant development to the time of herbicide application. Consequently, our objective was to determine compatibility of the herbicide 2,4-D and the biocontrol agent *R. conicus* in a musk thistle management program.

Methods and Materials

Ovipositing *R. conicus* were caged on the primary (terminal) heads of musk thistle at a study site in Giles Co., Va. The weevils and all but 5 eggs/head were removed after 48 h. Light cotton sacks, used to confine weevils to heads, were retained to reduce parasite and predator influence, and to prevent additional oviposition and seed loss while the heads remained on the plants. Twelve replicated sprays of commercial 2,4-D (LVA) at 1.68 kg/ha (plus sticker) were conducted at 0 (within 48 h), 1, 2 and 3 wk post-oviposition on randomly selected thistles. The cotton sacks were removed before spraying and replaced after herbicide application; entire plants were sprayed. Control plants were not sprayed because counts after the 1st spray indicated that no eggs were dislodged. Herbicide application at 0 wk (June 1, 1978) coincided with extension recommendations[4] for musk thistle control in Giles Co., Va. (elevation 850 m). Terminal heads were in the early-bud stage, and plants were ca. 40 cm in height upon initiation.

Following senescence, heads were excised and brought to the laboratory to count and weigh newly emergent weevils. After 6 wk heads were dissected and larval, pupal or adult cadavers, and living adults were counted. In addition, seeds not physically damaged by *R. conicus* were placed on moistened filter paper, using the technique described by Surles and Kok (1978), and observed for 7 days to quantify germination.

Results and Discussion

Mortalities of larvae developing from plants sprayed 1–3 wk after oviposition, and from untreated plants, were significantly lower than mortalities from plants sprayed at 0 wk (within 48 h of oviposition) (Table 1). The latter failed to support larval development beyond 2nd instar. Developmental times of *R. conicus* were similar for all treatments producing adults.

No viable seeds were produced by thistles sprayed 0–2 wk after oviposition. The primary heads were in bud stage for the 0 and 1 wk sprays and in late-bud to early-bloom at the 2 wk treatment[5]. Primary heads were in full bloom when the plants were treated 3 wk after oviposition, with avg height exceeding 80 cm. The increased time available for development and the reduced effect of 2,4-D allowed some seeds from the 3 wk treatment to reach a viable state. Mean percent germination of seeds undamaged by *R. conicus* (ca. 10%) was significantly lower than the control (71.8%).

Although reduction in seed viability occurred from spraying infested plants with primary heads in full bloom, application of 2,4-D during bud stage was more effective in inhibiting seed production and killing the thistles. These results are similar to those of McCarty and Hatting (1975) who found that application of 2,4-D ester at 2.24 kg/ha during the early-bloom stage was more effective in reducing viable seed than treatment of plants in

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[2] LVA - low volatile amine.
[3] Research Assistant and Assoc. Professor respectively; received for publication October 25, 1978.
[4] 1977 Virginia Pest Management Guide. Ext. Div. Virginia Polytech. Inst. and State Univ. p. 206.
[5] "Bud" and "Bloom" stages; as used in McCarty and Hatting (1975).

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Table 1.—Mortality and mean developmental times of *R. conicus*, and percent germination of undamaged seeds from musk thistles treated at weekly intervals with 2,4-D[a].

Treatment	Plant stage	% mortality	No. wk to adult emergence[b]	% germination of undamaged seeds
Control		9.1a	11.9a	71.8c
0 wk spray	Bud	100.0b	0[c]	0a
1 wk spray	Late bud	12.5a	11.3a	0a
2 wk spray	Early bloom	19.3a	11.8a	0a
3 wk spray	Full bloom	11.1a	11.5a	9.9b

[a] Based on 12 replications of 5 eggs/head each; 2,4-D applied at 1.68 kg/ha. Means followed by the same letter in each column do not differ significantly at the $P < 0.05$ level (Student-Newman-Keuls test).
[b] Excluding egg stage and 1st instars not entering the head.
[c] No adult emergence, development to 2nd instar only.

full-bloom. In their tests, a small proportion of the seeds produced by heads sprayed in the early-bloom treatment were capable of germination. In our tests, absence of viable seeds from plants sprayed in the late-bud to early-bloom stage could be attributed to reduction in seed size, number, and viability from *R. conicus* infested heads (Rees 1977, Surles and Kok 1978), as well as to herbicidal effects. Germination in control seeds was similar to that found by Surles and Kok (1978).

Herbicide treatments did not cause any significant differences in weights of emergent ($\bar{x} = 154.2$) weevils. However, those insects which failed to emerge from thistle heads averaged 31.6 mg less, appeared weak, and may not have been capable of survival in the field. Nonemergent populations were small, ranging 6–18%/treatment.

Rees (1977) stated that the effects of herbicides on *R. conicus* survival varied with weevil density; as the larval population per head increased, survival decreased. Our field observations have shown that proper timing of herbicide application can reduce weevil larval density per head. Treatment during late-bud to early-bloom stage of the primary head interrupts oviposition by the weevils due to the death of the plant, causing fewer eggs to be laid on treated plants. Since treated plants become less attractive for feeding and oviposition, weevil movement to healthy unsprayed plants could occur. This could improve egg distribution and increase biological pressure against thistles in areas where spraying is uneconomical or unfeasible. Therefore, by spraying musk thistles with 2,4-D in the late-bud to early-bloom stages of the primary head, seed germination can be prevented without the destruction of *R. conicus* populations. Integration of herbicidal and biological control of thistles can be implemented by relating the application of herbicides to insect and plant developmental stages.

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