

Impact of 2,4-D on *Ceuthorhynchidius horridus* (Coleoptera: Curculionidae) and their compatibility for integrated control of *Carduus* thistles

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Summary: Résumé: Zusammenfassung

Acute and chronic effects of spring application of 2,4-D on adult *C. horridus* (Panzer) were examined by determining dose-mortality response and adult vitality. LC₅₀ values for males (70.2 kg/ha) and females (61.4 kg/ha) corresponded to 41.7 and 36.6 times, respectively, the recommended application rate of 1.68 kg/ha. Survival of weevils treated with 1.68 kg/ha was not different from untreated controls, but higher doses (16.8-147.8 kg/ha) caused significantly greater mortality. Adult vitality, measured by number of feeding marks per weevil and rate of weight change, was unaffected by the herbicide. When thistle infested fields were sprayed with 1.68 or 2.24 kg/ha of 2,4-D the host plants died, but the survival, reproduction, and population increase of *C. horridus* were not affected.

Effets du 2,4-D sur Ceuthorhynchidius horridus (Coléoptère, Curculionidae) et leur compatibilité pour la lutte intégrée contre les chardons (Carduus)

Les effets aigus et chroniques d'applications printanières de 2,4-D sur des *C. horridus* (Panzer) adultes ont été examinés par évaluation de la réponse mortalité/dose, et de la vitalité des adultes. Les valeurs de la CL₅₀ pour les mâles (70,2 kg/ha) et pour les femelles (61,4 kg/ha) ont correspondu respectivement à 41,7 et 36,6 fois la dose recommandée: 1,68 kg/ha. La survivance des charançons traités à 1,68 kg/ha n'a pas été différente de celle des témoins non traités, mais des doses plus élevées (16,8 à 147,8 kg/ha) ont provoqué une mortalité significativement plus élevée. La vitalité des adultes mesurée par le nombre de morsures de nutrition par charançon et le taux d'évaluation du poids, n'ont pas été affectés par l'herbicide. Lorsque les champs infestés de charançons ont été traités avec 1,68 ou 2,24 kg/ha de 2,4-D, les plantes hôtes sont mortes, mais la survie, la reproduction et l'accroissement de la population de *C. horridus* n'ont pas été affectées.

Wirkung von 2,4-D auf Ceuthorhynchidius horridus (Coleoptera: Curculionidae) und deren Brauchbarkeit für eine integrierte Bekämpfung von Cardus-Disteln

Akute und chronische Wirkungen von 2,4-D-Frühjahrsapplikationen auf adulte *C. horridus* (Panzer) wurden untersucht, indem die Sterberate in Abhängigkeit der Dosis, sowie die Vitalität der adulten Tiere bestimmt wurde. Die LC₅₀-Werte für Männchen (70,2 kg/ha- und Weibchen (61,4 kg/ha) lagen um das 41,7- bzw. 36,6-fache über der praxisüblichen Dosis von 1,68 kg/ha. Die Überlebensrate der Rüsselkäfer, die mit 1,68 kg/ha behandelt wurden, unterschied sich nicht von unbehandelten Kontrolltieren, dagegen verursachten höhere Dosierungen (16,8-147,8 kg/ha) eine signifikant höhere Sterblichkeit. Die Vitalität von adulten Tieren, gemessen an der Anzahl von Frasstellen pro Rüsselkäfer und der Gewichtsänderung, war durch das Herbizid unbeeinflusst. Wenn Felder, die mit Disteln verunkrautet waren, mit 1,68 bzw. 2,24 kg/ha 2,4-D gespritzt wurden, starben die Wirtspflanzen, aber die Überlebens- und Fortpflanzungsrate, sowie der Populationszuwachs von *C. horridus*, blieben unbeeinflusst.

Introduction

Ceuthorhynchidius horridus (Panzer), a thistle-rose tawny weevil imported into Canada (Dunn 1978) and the U.S.A. for control of *Carduus* thistles, has become established in Virginia (Kok & Trumble 1979). Basic studies on its host specificity (Kok 1975), laboratory propagation (Trumble & Kok 1978), and life cycles in Italy (Frick 1969) and the U.S.A. (Trumble & Kok 1979b) have provided essential background information for management of this weevil to increase its efficacy in thistle control.

Since 2,4-dichlorophenoxyacetic acid (2,4-D) is commonly used in Virginia for thistle control (Kates *et al.* 1979), information on the compatibility of this herbicide with biological control agents is necessary for successful management strategies. Trumble & Kok (1979a) have described the impact of 2,4-D on development and survival of an imported thistle-head weevil, *Rhinocyllus conicus* Froelich. The effects of 2,4-D on *C. horridus* in laboratory and field experiments are presented here.

Materials and methods

Laboratory tests

Newly emerged *C. horridus* adults, collected from unsprayed musk (*Carduus nutans* L.) and plumeless thistles (*C. acanthoides* L.) in June 1978, were separated by sex and caged with bouquets of musk thistle leaves in 0.4 l plastic containers. After 48 h, two replicates of fifteen males and two replicates of fifteen females were treated with sticker (Nufilm 17®) plus commercial 2,4-D low volatile amine (LVA) at doses of 0.17, 1.68, 16.8, 84.0, or 147.8 kg/ha. These doses corresponded to 0.1, 1, 10, 50, and 88 times, respectively, the manufacturer's recommended application rate. Controls were sprayed with water plus sticker. Volume rate was 326 l/ha at a pressure of 1.8 kg/cm².

To simulate maximum initial spray contact in the field, weevils were placed on bare ground in 0.4 l containers, sprayed using a pressure-calibrated backpack sprayer, and sealed in the containers for 30 min. Adults were then returned to cages with musk thistle-leaf bouquets and their feeding monitored every 5 days for 30 days. Weight change (monitored monthly) and mortality (observed at 24 h intervals for 1 week and weekly thereafter) were recorded for 25 weeks. All weevils were maintained in a photoperiod chamber with a 16 h light–8 h dark (LD) cycle. Temperature throughout this test fluctuated between 21°C ± 1°C (day) and 13°C ± 2°C (night).

Log probit analysis was computer generated using the 'Probit Procedure' of SAS (Barr *et al.* 1976). Acute and chronic toxicity data were normalized with the arcsin transformation and analysed using the Student–Newman–Keuls test. Differences in adult feeding were analysed using the Student's *t*-test.

Field tests

Two thistle sites were selected for field studies. Site 1, located in Montgomery Co., Va. near Christiansburg, was treated with 2,4-D at 2.24 kg/ha on 25 May 1977, 1 week after adults had been released. Only plumeless thistles were present at this location. Site 2, located in Pulaski Co., Va. at Belspring, was sprayed with 2,4-D at 1.68 kg/ha on 27 June 1977, approximately 2 years after the initial releases. This field contained both

musk and plumeless thistles. The two locations were surveyed for *C. horridus* larvae and adults each spring in 1978 and 1979 to record survival under field-sprayed conditions.

Results and discussion

Laboratory tests

Log probit analysis of the dose-response data after 5 days indicated that application of 2,4-D at 1.68 kg/ha plus sticker did not cause acute mortality in *C. horridus* populations (Table 1). The LC₅₀ values for males (70.2 kg/ha) and females (61.4 kg/ha) corresponded to 41.8 and 36.6 times, respectively, the normally recommended dose. Survival of weevils treated with 1.68 kg/ha was not significantly different from controls for up to 175 days. Although application of 2,4-D at 16.8 and 84.0 kg/ha did not significantly increase adult mortality during the first 3 days of this test, significant differences in survival were apparent during the remaining 172 days. Treatment of adults with 147.8 kg/ha reduced the number of adults surviving 3 days after herbicide application.

The impact of 2,4-D on *C. horridus* was primarily acute, as populations treated with 16.8 kg/ha or more declined more rapidly ($P < 0.05$) during the first 5 days of the test than did weevils sprayed with 1.68 kg/ha or less. Differences in rates of decline were not significant between treatments for the remaining 24 weeks.

Adult vitality, measured by monitoring feeding punctures and weight changes, was not adversely affected by 2,4-D. No significant differences in mean number of feeding punctures per adult (range = 23.86 ± 12.69 to 17.60 ± 9.65) or weight change were found between treatments. However, some common weight fluctuations were observed.

Field tests

Application of 2,4-D to thistle-infested fields did not prevent survival and reproduction of *C. horridus* populations. In spite of the death of host plants and possible exposure to herbicide residue, larvae and adults were recovered during the spring of 1978 from both test locations. Few thistles and no weevils were found at the Montgomery Co. site during the spring of 1979 because thistles at this site were destroyed in the

Table 1 Toxicity of various concentrations of 2,4-D (LVA) to *C. horridus* adults

Treatment (kg/ha)	Mean survival at various durations (days) post-treatment				
	1	3	5	20	175
0 (control)	100.0 a*	100.0 a	100.0 a	98.3 a	93.3 a
0.17	98.3 a	96.7 a	96.7 a	96.7 a	96.7 a
1.68	100.0 a	98.3 a	98.3 a	98.3 a	83.0 ab
16.80	100.0 a	81.7 a	75.0 b	73.3 b	73.3 b
84.00	100.0 a	85.0 a	70.0 b	66.7 b	66.7 b
147.84	86.7 a	23.3 b	20.0 c	15.0 c	9.0 c

* Means in columns followed by the same letter are not significantly different at the 5% level of probability

summer and fall of 1978 by repeated applications of 2,4-D at 2.24 kg/ha and kerosene. However, in Pulaski Co., adults had increased to over 250% of initial releases (Kok & Trumble 1979) by spring of 1978, and were present in large numbers in the spring of 1979 despite an additional 2,4-D application at 1.68 kg/ha in June 1978.

The results indicate that 2,4-D at the doses normally used does not adversely affect the survival of *C. horridus* and may be compatible with the weevil in an integrated control programme for *Carduus* thistles. Trumble & Kok (1979a) reported that spring application of 2,4-D on musk thistles in the late-bud to early-bloom stages of the primary blooms prevented production of viable seed. At this stage of plant development, *C. horridus* occurs primarily in the pupal or adult stages (Trumble & Kok 1979b). Since the pupae develop underground (Kok, Ward & Grills, 1975), and some 2,4-D is adsorbed on soil colloids, they are not likely to be seriously affected by normal herbicide rates and application techniques.

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