Biological Control of Carduus thistles in northeastern U.S.A.

by
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ABSTRACT

Two introduced weeds, *Carduus nutans* L. (musk thistle) and *Carduus acanthoides* L. (plumeless thistle), have become widespread in North America and are serious problems in pastures. Heavy infestations are impenetrable to grazing livestock, and areas with lower densities are unsuitable for grazing. Biological control was initiated in 1969 with the importation of *Rhinocyllus conicus* Froelich, a thistle-head weevil, from France. This weevil has become well established in many thistle-infested counties in Virginia where the first success in musk thistle control was documented in 1975. Adults collected from several Virginia sites were distributed to neighboring states.

A second weevil, *Ceuthorhynchidius horridus* (Panzer), an Italian rosette-feeder officially approved for field release in Virginia after 3 yr intensive host specificity testing was initially released in the fall of 1974. Several releases were made in 1975 for field establishment and evaluation of its efficiency in thistle control. Biological studies of *Cassida rubiginosa* Müll., a chrysomelid foliage feeder found infesting thistles in northern Virginia and Maryland were initiated in 1973 to evaluate its potential for *Carduus* thistle control.

INTRODUCTION

Carduus thistles have become one of the most serious weed problems of pastures in the U.S.A. First introduced from Europe in the early 1900's, they have spread rapidly and have become noxious weeds throughout much of North America. Two major species of thistles are common in Virginia and the neighboring states, *Carduus nutans* L. (musk or nodding thistle) and *C. acanthoides* L. (plumeless or curl thistle). Both species have a prolific reproductive capacity; each plant can produce up to 20,000 seeds which may germinate over a number of years. They frequently infest poorly managed and overstocked pastures and are commonly found along highways, railroad tracts and wasteland. In the absence of their natural enemies, the spread of thistles is unchecked. Their ability to grow in a wide range of soil conditions plus their large reproductive capacity and longevity of seed viability make them very persistent and hard to control. Despite attempts by individual farmers, States Departments of Agriculture and Highway Departments to control the weeds through use of herbicides and by mechanical means, the total acreage with thistle infestation continues to increase. Where infestations occur in rough terrain, applications of herbicides are very difficult and expensive. Untreated sites provide a continous source for reseeding. Heavy infestations are impenetrable to livestock grazing and result in loss of valuable pasture. As they are often found on marginal land, biological control as a long term solution to the problem is a feasible alternative to the existing costly or ineffective control procedures. The following is a brief review of progress on the biological control of thistles in northeastern U.S.A. involving the use of introduced weevils and the search for indigenous insects as potential biological agents.

I: *Use of Introduced* Insects

The first attempt of biological control of thistles was initiated in 1969 with the importation of two European weevils, *Rhinocyllus conicus* Froel. and *Ceuthorhynchidius horridus* (Panzer). *R. conicus* was imported based on the results of specificity tests by Zwölfer (1967) which showed that it would not adversely affect beneficial plants. Eggs of this weevil are laid on bracts of thistle heads and the weevil larvae feed on developing seeds within the receptable. This species was introduced into Virginia in 1969/70 with three shipments of adults collected by Zwölfer near Munchhouse, France. It was released in 23 selected sites, and subsequently became established in several of them. In the summer of 1972, adults were collected from

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one of the established sites in southwest Virginia for additional releases in Virginia and its neighbouring states. Four thousand weevils were handed to J. D. Hacker for releases on 3 plumeless thistle sites in West Virginia and another 3,000 weevils to Dr. E. A. Heinrichs for releases on 3 musk-thistle sites in Tennessee. Dr. S. W. T. Batra made several releases in Maryland and New Jersey in 1975 and in Pennsylvania in 1976 with adults collected from an established site in northeastern Virginia. The releases in West Virginia have become well established. I have no report on the status of releases in Tennessee; the Maryland, New Jersey and Pennsylvania releases are too recent to draw any firm conclusions about their establishment. Thus, attempts on the biological control of thistles in northeastern U.S.A. are quite recent and most of the results presented here are from studies in Virginia.

The biological control of *Carduus* thistles in Virginia can be divided into two phases:

(i) Introduction and releases of imported adults 1969/70 and
(ii) Releases and establishment of preadapted weevils (progenies from the above) since 1972.

Table 1 summarizes the results to date of the initial releases in 1969/70 and Table 2 shows an equivalent number of 1972/74 releases which have been monitored annually. Of the 23 releases made in 1969/70, all except 2 were in summer with adults ranging from 100-1,000. The other 2 were spring releases of 100 adults. Since the latter were successful, subsequent releases between 1972-74 were made mainly in spring with weevil progenies numbering 25-100 per site, except for 4 summer releases: 2 of 50 and 2 of 1,000 weevils. These 1972/74 releases were spread over 11 counties, 9 of which had no previous weevil establishment.

Only 6 of the 23 1969/70 releases have become established—4 on musk thistle and 2 on plumeless thistle. Three of the musk thistle sites have shown significant decreases in thistle density with the first substantial control occurring after 6 years (Kok and Surles 1975). Establishment has been obtained in 22 of the 24 1972/74 releases, although 1 is barely maintaining itself. More significantly, 3 of the 1972 releases have resulted in substantial control of musk thistle after 4 years. *R. conicus* established sites are now found in 15 counties in Virginia.

Comparison of establishment between spring releases using preadapted progenies versus summer releases of imported adults (Table 3) shows more successes of the former in spite of lower numbers of weevils per release. While the imported adults had only 26% establishment from summer re-

Table 1. Establishment of *R. conicus* for *Carduus* Thistle Control in Virginia from 1969/70 Releases.

1969/70 Release Date	No. of Weevils Released	Thistle Species	No. of Releases	No. of Sites Established	Control Status
Spring	100	Musk	1	1	Substantial
Spring	100	Plumeless	1	1	Partial
Summer	100-1,000	Musk	7	3	2 Substantial, 1 Partial
Summer	100-1,000	Plumeless	14	1	Partial

Table 2. Establishment of *R.conicus* for *Carduus* Thistle Control in Virginia from 1972/74 releases.

1972/74 Release Date	No. of Weevils Released	Thistle Species	No. of Releases	No. of Sites Established	Control Status
Spring	25-100	Musk	10	10	2 Substantial, 8 Partial
Spring	25-100	Plumeless	10	10	1 Substantial, 8 Partial, 1 None
Summer	1,000	Musk	2	2	1 Substantial, 1 Partial
Summer	50	Plumeless	2	0	None

Table 3. Comparison of Spring Versus Summer Releases of *R. Conicus.*

	Spring Release	Summer Release
Time of Release	May/June	July/August
No. of Weevils/ Release	25 - 100	500 - 1,000
Type of Weevils	Preadapted Progenies	Imported Adults
% Successful Establishment	100	26.1

leases all spring releases of their progenies became established. These data clearly demonstrate that:

(a) Releases of progenies are more successful than their imported parents for establishment.
(b) Spring releases are superior to summer releases.
(c) Weevil population increase has been more rapid on musk than on plumeless thistle, and
(d) Impact on thistle density has been more apparent on musk than plumeless thistle.

These results confirm our earlier reports (Surles *et al.* 1974; Kok 1974) that spring releases are superior and that musk thistles are preferred because of better synchronization of the weevil and its thistle host. Although *R. conicus* can become well established on plumeless thistle, the impact is reduced by the long flowering period of this species of thistle.

C. horridus was imported from Italy in 1970/72 under quarantine for further host specificity testing on the basis of Frick's (1969) recommendation. It was officially approved for field release in Virginia in June 1974, after undergoing 3 years of intensive host specificity testing (Ward *et al.* 1974; Kok 1975). The larvae of this weevil damage thistle rosettes by feeding on the meristematic tissues. We have made several initial larval and adult releases at several test plots in Virginia. The first was in the fall of 1974 in a field nursery with 30 adults and 2,000 larvae. Adults were recovered at this site in late spring 1975 and 1976. Nine other adult releases of 100-300 weevils have been made in 1975 and 1976. Although it is too early to predict establishment, several of the sites showed indications of adult feeding. Establishment and evaluation of this rosette feeder are currently being undertaken. Biological studies of this weevil under laboratory conditions have indicated its potential for damaging both musk and plumeless thistle (Kok *et al.* 1975). This is particularly significant because *R. conicus* has not been shown to effectively control plumeless thistle. Due to our limited supply of *C. horridus,* we have restricted the number of releases of this weevil. There is however, considerable interest in this weevil as shown by the numerous requests by farmers and landowners. We are currently studying ways to efficiently propagate them.

Ceuthorhynchus trimaculatus (F), a third curculionid, is another thistle rosette feeder that is being screened in our laboratory. This species was imported under quarantine from Italy. The initial shipment was sent by P. E. Boldt of the USDA laboratory, Europe in 1975 and another was received in the spring of 1976. A cooperative project with Dr. Lloyd Andres of the USDA laboratory at Albany, California was recently initiated. The objective of this project is to conduct host specificity testing to determine whether it would be a threat to economic or esthetic plants in the U.S.A. Preliminary adult starvation and oviposition tests conducted by P. H. Dunn in Rome indicated that *C. trimaculatus* apepars to be a promising biological control agent and that further testing is justified. We are presently conducting oviposition and larval feeding tests. Plants included in the host specificity tests include a cross-section of wild, ornamental and crop plants of the U.S.A.

The use of introduced weevils for thistle control is an attempt to reestablish the biological equilibrium position of the thistles to an acceptable level by their natural enemies. I feel that *R. conicus* and *C. horridus,* with perhaps *C. trimaculatus,* could serve as the nucleus of an effective pest management program in the control of musk and plumeless thistle. Biological studies of the first two weevils have been very encouraging because of their reproductive potential and good searching ability for the target hosts. The combined infestation of *R. conicus* and *C. horridus* would greatly enhance their impact on the control of *Carduus* thistles, since each weevil attacks a different growth stage of the same host.

II. *Indigenous Insects*

Indigenous phytophagous insects attacking *Carduus* thistles have also been under investigation. Surveys have been conducted to screen species associated with the thistles for potential use as biological control agents. Several prominent feeders have been found regularly feeding on *Carduus* thistles. These are summarized in Table 4. Although some species inflict serious damage on thistles in localized patches, most are not very

Table 4. Indigenous Insects Commonly Attacking *Carduus* Thistles.

Family	Species	Nature of Damage
Noctuidae	*Papaipema arctivoren*	Stem-borer
	Euoxa Sp.	Foliage Feeder
Nymphalidae	*Vanessa cardui*	Foliage Feeder
Geometridae	*Eupithecia* sp.	Feeds on Flowering Head
Curculionidae	*Rhodobaenus tredecimpunctata*	Basal Stem and Root Feeder
Chrysomelidae	*Cassida rubiginosa*	Foliage Feeder
Miridae	*Poecilocapsus lineatus*	Necrotic Leaf-Spots
	Plagiognathus obscura	Sap-Sucking Terminal Growth
Aphididae	*Aphis Cardui*	Sap-Sucking Stems and Tips
Pentatomidae	*Nezara viridula*	Sap-Sucking Leaves

host specific, or are pests of agricultural crops. This makes them unsuitable for use as biological control agents. One species which we studied in further detail is *Cassida rubinosa* Mull., a chrysomelid foliage feeder. This is a naturalized species that was accidentally introduced into North Americ (Fyles 1902). It is present in many counties in northeastern Virginia and also in several of the northeastern States. It has been found causing extensive foliage damage to the *Carduus* thistles, and biological studies were conducted by Ward*. Its potential usefulness, however, is limited because of heavy parasitization.

The attributes of the introduced weevils and the support of the biological approach to thistle control at the farm level fully justify every effort in our continuing search for biological agents. Success would be extremely significant because it would be achieved without contamination of the environment, and without a major recurring expense to the producer. The potential value of complete biological control of thistles would have a major impact on the cattle and dairy industry as it would mean millions of acres of extra pastures for meat production. We have made significant progress towards this ultimate goal, but are restricted in our efforts because of limited resources. Without increased financial support above its current minimal level, further progress will be difficult against these very persistent weeds.

*R. H. Ward. 1976. Biological studies of *Cassida rubiginosa*. Ph.D. dissertation, VPI & SU, Blacksburg, VA. In preparatio.n

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