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Transfer of Cinnabar Moth, *Tyria jacobaeae*, in Eastern Canada for Control of Tansy Ragwort, *Senecio jacobaea*

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Abstract

Attempts to establish the cinnabar moth, *Tyria jacobaeae* (Lepidoptera: Arctiidae), on tansy ragwort, *Senecio jacobaea* (Compositae), in Ontario by transfer of fourth- and fifth-instar larvae from established populations in Nova Scotia in 1979 and 1981 were not successful. Larval populations declined very rapidly with no apparent overwintering. In mid-June 1983, 470 cinnabar moth adults were netted in Nova Scotia and tansy ragwort leaves with 224 egg masses containing about 11,000 eggs were collected and flown to Ontario. Ten moths in flying condition and 147 weak ones were released immediately. About one day prior to egg hatch, leaves with egg masses were paper-clipped to healthy leaves on tansy ragwort plants at two release sites. Larvae from about 10% of 10,000 released eggs passed the fifth instar under field conditions in 1983. In June 1984, several flying adults were observed at one site, followed by a population of about 450 larvae indicating survival of the insect through one complete generation under field conditions in Ontario. From 3000 late-instar larvae collected in Nova Scotia on 14 July 1983 and reared in laboratory cages at Guelph, 900 pupae were recovered. In June 1984, adults emerged from 15% of pupae held in peat moss at 2°C, 10% of pupae in peat moss in 75% r.h. over saturated salt solution at 2°C, and 12% of pupae in peat moss in plastic containers outside.

Introduction du Lépidoptère Tyria dans l'est du Canada pour la Lutte Contre le Séneçon jacobée

Les tentatives d'établissement de la tyria *Tyria jacobaeae* (Lepidoptera: Arctiidae) sur *Senecio jacobaea* (Composées) en Ontario par le transfert en 1979 et 1981 de larves des quatrième et cinquième stades de populations permanantes en Nouvelle-Écosse n'ont pas réussi. Les populations de larves ont diminué très rapidement, ne survivant pas à l'hiver. À la mi-juin 1983, 470 lépidoptères tyria adultes ont été capturés au filet et des feuilles de seneçon jacobée sur lesquelles avaient été déposées 224 masses d'oeufs englobant environ 11 000 oeufs ont été recueillies en Nouvelle-Écosse et transportées par avion en Ontario. À leur arrivée, seuls dix lépidoptères étaient en état de voler. Ces dix spécimens ainsi que 147 lépidoptères affaiblis ont été relâchés sur un site le 20 juin. Environ un jour avant l'éclosion des oeufs, les feuilles sur lesquelles reposaient les masses d'oeufs ont été attachées au moyen de trombones à des feuilles saines de plants de séneçon jacobée en deux emplacements. Les larves d'environ 10% des 10 000 oeufs introduits ont survécu au-delà du cinquième stade larvaire et ont atteint l'état de pupe dans les conditions du terrain. Des larves obtenues en laboratoire aux stades 1 à 3 et 2 à 4 ont été libérées sur deux autres sites. Le 14 juillet, 3 000 larves parvenues aux dernières étapes larvaires ont été recueillies en Nouvelle-Écosse pour terminer leur développement dans un laboratoire de Guelph. Environ 900 spécimens ont atteint le stade de pupe et sont actuellement soumis à l'état d'hibernation dans quatre séries de conditions différentes en vue d'être libérées au printemps de 1984.

Introduction

Tansy ragwort, *Senecio jacobaea* L. (Compositae) is a short-lived herbaceous perennial or biennial which has been introduced from Europe into North and South America, New Zealand, Australia, and South Africa. In Canada, this weed dates from about

1850 in the eastern Maritime provinces, being especially widespread in Prince Edward Island, eastern Nova Scotia and parts of New Brunswick where it is continuing to spread (Harris *et al.* 1971). Extensive infestations dating from about 1913 occur along the east coast of Vancouver Island and near Abbotsford in the lower Frazer Valley of British Columbia. In contrast to the extensive Maritime infestations on Canada's east and west coasts, a small, mid-continent infestation has persisted near Guelph, Ontario, since prior to 1927.

Although tansy ragwort does best in open, well-drained sites on medium soils, it will tolerate and persist under shade and in poorly-drained areas. It does not survive regular cultivation but establishes readily in newly-seeded pastures, in moderate to poor grass swards, and in undisturbed open areas where it may eventually form solid stands. In addition to reducing forage yield by competition with hay and pasture species, tansy ragwort contains toxic alkaloids which make it a hazard to livestock whether eaten fresh, in hay or in silage. Harris *et al.* (1971), in presenting a concise discussion of the pest status and biological control work against this weed in Canada, cited references which estimated that losses due to poisonings during 1968 were 30–50 head of cattle in King's County and 10–15 head in Queen's County, Prince Edward Island.

Attempts at biological control of tansy ragwort in Canada have centred on the cinnabar moth, *Tyria jacobaeae* L. (Lepidoptera: Acrtiidae), utilizing open releases of larvae and some adults imported from Sweden, Switzerland and California in the 1960s in British Columbia, Nova Scotia and Prince Edward Island (Harris *et al.* 1971). Establishment of the moth followed a pattern of high mortality of laboratory-reared stock during the first year after release, approximate maintenance of the larval population in the following two years and a four- to five-fold annual increase in the fourth and later years. Complete defoliation of the weed over 0.2 to 0.4 ha patches was observed by the third and fourth years. The cinnabar moth has continued to increase and spread and has been providing effective control in a variety of habitats on both eastern and western coasts of Canada (Harris, pers. comm.; Thomson, pers. comm.; Alex, unpubl. data).

The ragwort seed-fly, *Hylemya seneciella* Meade (Diptera: Muscidae), and the ragwort flea beetle, *Longitarsus jacobaeae* Wat. (Coleoptera: Chrysomelidae), have also been released and may provide supplemental pressure against the weed in areas where the cinnabar moth is established, as well as the only pressure in habitats where ecological restrictions on the moth prevent it from attacking the weed (Harris *et al.* 1971; Harris, pers. comm.).

Status of Tansy Ragwort in Ontario

The small infestation of tansy ragwort near Guelph, Ontario, was virtually ignored by weed control personnel for more than 50 yrs. The earliest record is a herbarium specimen deposited in the University of Guelph herbarium, collected in 'Oct. 1927' by I.E. Thomas and giving as locality: 'Oil Well Swamp near Puslinch Lake' [about 8 km southwest of Guelph]; habitat: 'Pastures, roadsides, waste places'; and remarks: 'Not common in this section'. Subsequent collections in 1934, 1951, 1952, and 1955 also specify the same locality. Their habitat data imply that the weed was persisting but not spreading. However, in 1974 and 1976 reports were received of the weed a few km distant. In 1977 it was observed established in about 10 sites scattered through a 10 km radius from the original 'Oil well swamp' site. A detailed survey in 1978 determined that it occurred in at least 52 parcels of land, with individual infestations ranging from a single plant in a well-maintained residential lawn to numerous small

and large dense patches throughout a 20 ha permanent pasture on rolling gravelly soil (Alex, unpubl. data). The majority were located within 10 km of the original infestation but the range extended in an ellipse about 40 × 20 km. The weed occupied such a wide variety of habitats that effective control or containment by herbicides or cultivation was judged impractical.

Evidence indicates that tansy ragwort failed to survive at two other sites in Ontario. Herbarium specimens deposited with Agriculture Canada, Ottawa (W.J. Cody, pers. comm.) and the University of Guelph give one locality as Niagara Falls in 1903 and the other as Ottawa in 1932 but the weed has not been reported from either locality since those original collections were made.

Because tansy ragwort was apparently spreading rapidly in the Guelph area, because it was circumstantially implicated in cases of livestock illness, and because Harris *et al.* (1971) recommended the cinnabar moth as a promising biological control agent against this weed, a program was initiated in 1979 to introduce and establish the insect at Guelph.

Methods and Materials

Three attempts were made to transfer the cinnabar moth from Nova Scotia to Guelph. On 13 July 1979, 5500 larvae, mostly in fourth- and fifth-instar, were collected near Durham and Toney River, Nova Scotia, packaged in lots of 500–1000 with fresh tansy ragwort foliage in plastic bags, placed with block ice in styrofoam picnic coolers, and shipped by air as checked baggage to Ontario. The next day the surviving larvae were counted, provided with fresh foliage and released as follows: open release of 1013 on dense patches of the weed in the fenceline of a grazed pasture on well-drained, level loam soil on 14 July; open release of 1018 in an old alfalfa, *Medicago sativa* L. (Leguminosae), field on undulating, well-drained loam soil on 14 July; open release of 846 and cage release of 200 in a fenced-off portion of a grazed pasture on rolling, gravelly loam on 16 July; and open release of 1002 and cage release of 400 in a lightly-grazed pasture on moderately-drained, stony clay loam soil on 16 July. The release sites were monitored at two-day intervals.

The second attempt was 24 July 1981. About 2000 fourth- and fifth-instar larvae were collected in the morning in Nova Scotia, packaged as before but in smaller lots, flown to Ontario in the afternoon and open-released that evening at two locations near Guelph. One was an ungrazed pasture (Site 52) on a gentle south slope on sandy loam soil. The other (Morriston) was in a heavily-grazed pasture on rolling gravelly loam soil. These releases were monitored at one- to two-day intervals.

Between 16 and 19 June 1983, 470 adult cinnabar moths were netted near Antigonish, Nova Scotia, and leaves with 224 egg masses containing about 11,000 eggs were collected in the same area. These were packaged with ice in insulated boxes and flown to Ontario. On 20 June, 10 vigorous flying adults and 147 weak adults were released at Site 52. About one day prior to egg hatch (when egg colour changes from yellow to grey), leaves bearing egg masses were paper-clipped to healthy leaves on vigorous plants at each release site. In this way, about 5000 eggs were released 21 and 22 June at Site 52, and about 5000 from 23 to 25 June at the Morriston site. Of the 1000 eggs which emerged in the laboratory, 500 first- to third-instar larvae were released 24 June on a moderately-dense stand of the weed on poorly-drained organic soil (Cedar Swamp site) and another 500 second- to fourth-instar larvae on 27 June on a stand of the weed around the edge of a small pond in strongly rolling stony loam soil (Crawley's Pond site).

Attempts to make detailed counts of the young larvae at Site 52 in early July had to be abandoned because many dropped off the plants with such slight disturbance as touching or walking past. However, general monitoring was continued until there was no further sign of any larvae.

On 15 July 1983, 3000 late-instar larvae were collected in Nova Scotia, packaged as before, flown to Ontario and placed in rearing cages in the laboratory the same evening. These larvae were regularly supplied with fresh tansy ragwort foliage and allowed to pupate in mineral soil or peat moss. Of the 900 pupae so obtained, 200 were overwintered in peat moss at 2°C, 200 in peat moss over a saturated salt solution to maintain 75% r.h. at 2°C, 300 unprotected over a saturated salt solution at 2°C, and 200 in peat moss in plastic containers with metal screen vents in an outside storage area. All but 300 of the pupae were removed from storage in June 1984 and placed in cages to emerge. Emerged adults were then released at the Morriston and Crawley's Pond sites. The remaining 300 were removed in late July, allowed to emerge in cages and lay eggs on fresh foliage and then the adults, with 150 of their own larvae, were released at the Morriston site on 29 July.

All release sites were examined at intervals during each succeeding year, searching for evidence of successful overwintering and subsequent egg-laying.

Results and Discussion

The 1979 shipment of larvae resulted in about 20% mortality on arrival in Guelph. Most of this appeared due to drowning in a pool of water which had accumulated at the bottom of each plastic bag; the moisture coming from the fresh foliage added to the bags just before packaging and from respiration of the insects, which condensed on the inner surface of the plastic bags adjacent to the ice blocks. Mortality was virtually nil in the 1981 and 1983 shipments of larvae because the number of larvae in each individual plastic bag or firm plastic container was reduced to only 100–500, and the time lapse between collecting and releasing was reduced to < 12 h.

In both 1979 and 1981, numbers of larvae observable at release sites declined very rapidly after release. Within two days, the numbers had dropped to $< 30\%$. After four days only about 5% of the larvae were seen, and all had disappeared by seven days after being released. We assumed the decrease was due to predation, although there had been little observed predation of the larvae on the plants by birds, mammals or other insects during daylight hours. Because we observed little predation at any site, it was therefore assumed that most larvae had passed their fifth instar and were pupating. However, limited digging through the surface soils of these release sites after the larvae had disappeared failed to turn up any pupae. Wilkinson (1965) reported that high mortality in British Columbia resulted when, as the larvae descended to the ground to pupate, they were attacked by carabid beetles. The same may have happened here because carabids were also present at all release sites.

Both the 1979 and 1981 releases of larvae were judged to have failed when, in subsequent years, there were no observed flights of adults, no egg laying, and no new populations of larvae. This was not surprising in that Harris *et al.* (1971) reported that 12 of 15 open releases of larvae from 1962–67 in both eastern and western Canada had failed to establish.

The 1983 releases of eggs, however, resulted in substantial populations of larvae in 1983 followed by survival into 1984. Detailed counts were not made in 1983 because young larvae fell off plants very readily, but it was estimated that larvae from 10% of the released eggs at each site passed the fifth instar and descended from the plants to

pupate. This would have represented about 500 from released eggs at each of Site 52 and the Morriston site, and 50 from young laboratory-hatched larvae released at the Cedar Swamp and Crawley's Pond sites. The only predation observed in 1983 was an unidentified species of stink bug (Pentatomidae) sucking on one early fourth-instar larva.

The first indication of overwinter survival of the cinnabar moth in Ontario was the appearance of three adults flying on 15 June 1983, at Site 52. This was followed by 12 adults flying on 18 June and three on 20 June. Six egg masses, totalling over 300 eggs were found. All were presumed fertile, after one mass with 69 eggs hatched completely after being removed to the laboratory. By 25 June clusters of second-instar larvae were seen feeding near two of the egg masses. During the next 4 wks the numbers of larvae increased to an estimated 450 and they became well dispersed throughout the 0.2 ha release site. A detailed count on 24 July recorded 165 fourth- and fifth-instar larvae. This count was taken after the population had decreased by about two-thirds from those observed the previous week as the fifth-instar larvae had begun to leave the plants. At Site 52 the sequence of an estimated 500 larvae passing fifth instar in 1983, followed by about 450 larvae in 1984 approximates the first 2 yrs of the establishment pattern described by Harris *et al.* (1971), in which there was high mortality during the first year followed by approximate maintenance of larval populations in the following 2 yrs.

At the Morriston site one flying adult was observed on 20 June 1984. However, as that was the only adult seen and as neither egg masses nor colonies of larvae could be found later, the population did not successfully overwinter at this site.

There was no apparent overwintering survival at either the Cedar Swamp site or at the Crawley's Pond site which had been seeded with laboratory-emerged larvae in 1983.

Overwintering pupae in peat moss held at 2°C in a plastic container resulted in 15% emergence of adults in 1984, whereas 12% survived storage in peat moss in the outdoor compound, 10% in peat moss in 75% r.h. over a saturated salt solution at 2°C, and nil when unprotected over the same saturated salt solution.

All adults from the first group of artificially overwintered pupae were released at the Crawley's Pond site as they emerged. They produced several groups of larvae which fed extensively on the weed. On 20 July, there were about 70 fifth-instar larvae, but by 25 July this number had dropped to 32.

The collection of cinnabar moth larvae in Nova Scotia and their release on field stands of tansy ragwort in Ontario has failed to establish the insect here. On the other hand, collecting tansy ragwort leaves bearing egg masses, holding them until just prior to hatching, and clipping them to healthy leaves of established plants at the release site has resulted in survival of the insect through one complete generation. This parallels the experience of Harris *et al.* (1971) in those releases which resulted in successful establishment of the cinnabar moth.

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