

THE IMPACT OF THE CINNABAR MOTH
ON RAGWORT IN EAST AND WEST CANADA AND ITS
IMPLICATION FOR BIOLOGICAL CONTROL

P. Harris*

INTRODUCTION

Ragwort, *Senecio jacobaea* L., is a herbaceous plant usually considered a biennial that has followed European settlement to many parts of the world. In Canada it occurs on both the east and west coasts. It is toxic to cattle and tends to be monopolistic on degenerated pastures. The preferred means of control is to cultivate and re-sow the pasture but this is not always possible. The hope was that biological control would reduce the problem in these areas. The control agent used was the cinnabar moth, *Tyria jacobaeae* L.

RESULTS

The first releases of the cinnabar moth were made in 1961 but it was not until 1963 that field survival was obtained. Even this release was initially unpromising as from approximately a thousand larvae released only two females produced progeny the following year. The result was that the first generation contained only 12% as many larvae as released. The field population was reinforced with a few larvae from a nearby field cage. The second generation just about maintained itself as did the third. Finally, in the fourth generation, there was a marked increase which was maintained until restricted by the food plant.

The same pattern of events occurred on the west coast except that initial mortality was greater than in Nova Scotia, so greater numbers were released. Once again, it was not until the fourth generation that there was a marked 56-fold increase and again the increase continued until limited by the abundance of the host plant.

Using larvae from these two colonies there has been less difficulty in establishing subsequent colonies. For example, stock from Nova Scotia released in New Brunswick in 1970 produced a three-fold increase in the first generation. Likewise, in British Columbia, establishment was obtained at Abbotsford, a place where the release of 6,000 larvae of European stock had failed. The moth is now esta-

*Canada Department of Agriculture, Research Station, Regina, Saskatchewan, Canada.

blished in most of the regions of Nova Scotia infested with the weed, two places in New Brunswick, at least three places in Prince Edward Island and most of the infested region in British Columbia.

These results suggest that the stock introduced from Europe was poorly adapted to Canadian conditions both on the east and west coasts. The released stock was subject to an intense natural selection that in four generations resulted in an adapted strain that was relatively easy to relocate within the same climatic region. In all places the moth has remained synchronised with the host plant so that defoliation coincides with flowering. This is roughly mid-June in British Columbia, mid-July in Nova Scotia and late July in Prince Edward Island.

The effect of defoliation by the cinnabar moth at the release site in Nova Scotia has been to depress the weed to a low density. There are now only scattered flowering ragwort plants and all those growing in the open are being found and defoliated by the moth. The moth has also eliminated most of the immature plants from the pasture as there were only 0.03/m² in 1972 and 0.06 in 1973. Normally rosette numbers are far higher than the number of flowering stems. For example, in 1972 in the nearest grazed permanent pasture to the release site not affected by the moth there were 62.2 immature plants/m² to only 1.6 flowering stems. In round figures both flowering stems and rosettes have been reduced by about a thousand fold. This reduction in rosette numbers was unexpected as in most biennials there is enough seed in the soil to sustain the population for several years.

A similar sequence of events occurred in Prince Edward Island. The weed has completely disappeared from the ungrazed release field where previously there had been a fairly steady population of around 2.6 flowering stems/m² and 6.1 rosettes/m². The weed survives in the disturbed soil along the edge of the road where it continues to be heavily attacked by the moth.

The results in British Columbia are dissimilar. There has been complete defoliation for at least four consecutive years with little effect on the density of the weed. The density of flowering stems declined this year but this was after an incomplete defoliation the previous year. The rosettes on the other hand did not decline as there were 74.4/m² in 1973.

DISCUSSION

Results in other parts of the world indicate that the cinnabar moth usually does not control its host, ragwort. For example, in Holland van der Meijden (1970) found that the cinnabar moth had little effect on the abundance of its host. Indeed his results show that the weed controlled the moth rather than vice versa. In Britain, Dempster (1971) found that the moth contributed to cycles in the abundance of the weed and that in wet summers defoliation of the rosettes by the moth increased the

numbers of plants by inducing vegetative budding from the roots. In New Zealand, Pool and Cairns (1940) reported that five artificial defoliations at monthly intervals killed out only six out of ten plants. Thus, it is unlikely that a single annual defoliation by cinnabar larvae would have much effect on the plant. From this it appears that the question is not why the moth failed to control the weed in British Columbia, but why it has worked so well in the Maritimes.

The explanation seems to be related to length of recovery time after defoliation. In Nova Scotia there is about two months between defoliation and the first winter frost whereas in British Columbia the period is about four months. It will not be known until later what effect this difference has on the winter root reserves in the two places but in the laboratory defoliation restricted the accumulation of carbohydrate reserves and plants with low reserves were less cold hardy than those with high reserves. Thus, plants that had been defoliated with root reserves of between 25-30% suffered an extremely high mortality, although a few plants had parts of their root system alive. Undeveloped plants with root reserves of about 30% survived better than the defoliated ones with a similar level but nevertheless about 1/3 of them were completely killed. On the other hand, defoliated plants with a root reserve of around 60% only suffered a 3% mortality and many of them were completely undamaged, including their leaves. These treatments were not meant to simulate field conditions but they do show that, for both the eastern and western Canadian strains of ragwort, there is a correlation between the level of the root reserves and winter mortality. Thus, with twice the recovery time the defoliated rosettes in British Columbia are likely to have higher reserves at the beginning of winter and be more cold tolerant than those in the Maritimes. These differences are accentuated by the colder winters in the Maritimes: The mean January minimum temperature for Nova Scotia is about -10.5°C compared to about -2°C for the British Columbia coast.

The winter mortality of the defoliated rosettes explains the decline in the number of flowering stems the following year. It does appear to account for the rapid decline in the number of rosettes that was observed from about 50/m² to about 0.05/m² as in most biennials the rosettes are recruited from seed annually. However, according to most authorities (Cameron, 1935; Pool and Cairns, 1940) seeds either do not germinate or the seedlings do not survive in competition with other plants. Thus, ragwort is rare or absent when the sward is closed, even if adjacent pastures are infested. It would appear that in both the British Columbia and the Nova Scotia stands the weed has been perpetuating itself vegetatively ever since an initial disturbance removed the competing vegetation and allowed the ragwort seedlings to enter. In British Columbia this event was the clearing and burning of the forest cover by the present owner. In Nova Scotia it was probably serious over-grazing although the present pasture usage is light.

Support that ragwort tends to be perennial in a pasture is provided by a sur-

vey of the rosettes in the British Columbia release field. Seedlings comprised 1.7% of the population; plants that had been propagated from root or crown buds within the past year comprised 5.8% and 92.6% of the rosettes appeared to be more than one year old. Indeed to judge from the number of leaf scars even rosettes with only one or two leaves were several years old.

Seedlings were more prevalent in Nova Scotia in a permanent pasture un-attacked by cinnabar moth; they comprised 39% of the immature plants but were clumped in dense masses where a flowering ragwort plant had excluded the grass the previous year; 3% had been propagated vegetatively within the past year and 58% were rosettes apparently more than a year old. Even in this example the seedlings are dependent on the presence and death of the flowering plants in the fall. Thus again, defoliation by the cinnabar moth in mid-summer would break the cycle.

The effect of defoliating 55 rosettes growing on a square metre in British Columbia (by adding 500 cinnabar larvae to the plot) was to reduce the population to 50 rosettes and one flowering plant (18 died, 28 remained single plants and nine divided to produce 22 rosettes). The number of leaves on the rosettes remained almost constant, 178 compared to 176. In another square metre plot 140 rosettes with 1440 leaves increased to 179 rosettes with 2468 leaves one year after complete defoliation. In a similar test in which 35 flowering plants were defoliated, 30 of them had died the previous year but the remaining five plants produced a total of 18 rosettes and two flowering stems.

In Nova Scotia, 59 flowering plants defoliated by cinnabar larvae produced only three rosettes and there was a solitary seedling in the area of about 4m². The results were still more striking in Prince Edward Island and New Brunswick as 50 flowering plants defoliated in each of these provinces did not produce any new rosettes.

CONCLUSION

In conclusion biological control of ragwort is succeeding in the Canadian Maritimes because the timing of defoliation by the cinnabar moth forces the plant to over-winter in a physiologically cold tender state. Defoliation either much earlier or later would probably be much less effective in the Maritimes. However, defoliation towards the end of August instead of mid-June would be needed to control the weed in British Columbia.

Most perennial plants like ragwort, can tolerate a single defoliation with few ill effects unless it is timed to force the plant into a period of stress such as winter or drought while it is in a physiologically unsuitable state. For example, alfalfa owes its value as a crop because it can be harvested several times a year. However, there is a critical period about six to seven weeks before frost when harvesting

reduces the root reserves in the wintering plant and increases cold mortality (Smith, 1964). Therefore, it is worth-while making an effort to determine this period before introducing an agent to control a perennial weed. However, if the climate is equitable throughout the year as it is in Hawaii and tends to be in New Zealand, the only strategy that will succeed is to attack the weed throughout the growing season. This can either be achieved by a multivoltine agent or a series of univoltine agents. In agreement with this against ragwort in British Columbia attempts to establish the flea-beetle, *Longitarsus jacobaeae* which feeds in the root crown in early spring are now being made.

REFERENCES

- Cameron, E. 1935. A study of the natural control of ragwort (*Senecio jacobaea* L.). *J. Ecol.* **23** : 265-322.
- Dempster, J. P. 1971. The population ecology of the cinnabar moth *Tyria jacobaeae* L. (Lepidoptera, Arctiidae). *Oecologia (Berl.)* **7** : 26-67.
- Pool, A. L. and Cairns, D. 1940. Botanical aspects of ragwort (*Senecio jacobaeae* L.) *Bull. N. Z. Dep. Scient. Ind. Res.* **82** : 1-61.
- Meijden, E. van der. 1970. *Senecio* and *Tyria* (*Callimorpha*) in a Dutch dune area. A study on an interaction between a monophagous consumer and its host plant. *Proc. Adv. Study Inst. Dynamics Numbers Popul. (Oosterbeek)* : 390-404.
- Smith, D. 1964. Freezing injury of forage plants. pp. 32-56. *In* Forage plant physiology and soil-range relationships. Amer. Soc. Agronomy Spec. Pub. **5**. 250 pp.