CODLING MOTH[1] CONTROL BY STERILE INSECT RELEASE: IMPORTATION OF FRUIT AND FRUIT CONTAINERS AS A SOURCE OF REINFESTATION[2]

M. D. PROVERBS AND J. R. NEWTON
Research Station, Agriculture Canada
Summerland, British Columbia

ABSTRACT

A program of codling moth, **Laspeyresia pomonella** (L.), control by the sterility principle is planned for the entire Similkameen Valley of British Columbia. If the program is successful, reinfestation by moth fly-in is unlikely because the Valley is fairly well isolated. Importation of host fruits and fruit containers (bushel boxes) for roadside fruit stands could lead to reinfestation unless the boxes are fumigated. Localized annual releases of sterile moths around fruit stands may also be necessary. Orchard bins, used by commercial packinghouses, are unlikely to be a serious source of codling moth reinfestation.

INTRODUCTION

It has been shown that the codling moth, *Laspeyresia pomonella* (L.), can be controlled effectively by release of sterile moths, but the method is about twice as expensive as chemical control if releases have to be made over the entire area every year (Proverbs 1974). Results of small scale sterility programs, in which treated orchards were exposed to fly-in of inseminated female moths from nearby orchards, have indicated that even under these conditions of reinfestation it is usually unnecessary to apply control measures in the first year following termination of sterile moth release, and that in the second year only one spray is required instead of the normal 3-spray program.

An area-wide sterile moth release program is planned for the Similkameen Valley of British Columbia. Because this Valley is semi-isolated, moth fly-in would be virtually eliminated and the effects of the program should persist for some years. Pockets of reinfestation would likely occur from time to time, but it should be possible to eliminate these incipient infestations by localized release of sterile moths. Consequently, in the long run, area-wide control by the sterility procedure probably would be cheaper than chemical sprays.

The validity of this premise was questioned by fruit growers who pointed out that there is some movement of fruit and fruit containers into the Similkameen Valley from distant fruit-growing areas. Plywood bins used for transporting fruit from orchards to packinghouses are moved annually into the Similkameen to service a few growers who have their fruit packed in the neighboring Okanagan Valley. The imported empty bins may contain spun-up larvae and pupae of the codling moth. A more likely source of reinfestation, however, is from boxes of apples and pears that are brought into the Similkameen for sale at roadside fruit stands. Before the fruit is sold and transferred to the purchaser's container, some mature larvae leave the fruit and spin-up in the boxes where they complete development and emerge as adult moths the following spring. This report examines the importance of fruit and fruit containers imported into the Similkameen Valley as sources of codling moth reinfestation after a theoretically successful program of moth control by the sterility method.

MATERIALS AND METHODS

The numbers of moths likely to emerge from empty fruit containers in spring were determined as follows. In early April, before the start of adult moth emergence, 50 one-bushel (ca. 36 dm^3) wooden boxes, the standard fruit container used by fruit stand operators, were taken at random from each of 5 fruit stands in the Similkameen Valley. The boxes were placed in a mothproof room in which the daily temperature fluctuation was between 21° and 27° C and the light/dark regime was 18/6 hr. A screen-mouthed glass jar containing ca. 100 laboratory-reared diapausing larvae was placed in the room to determine whether environmental conditions were satisfactory for pupation and subsequent adult emergence. A similar jar of larvae was held in the laboratory at ca 27° C and a light/dark regime of 18/6 hr. Because there was some doubt about the health of the diapausing insects, 20 mature nondiapausing larvae and 20 pupae were also placed in the room in separate jars. Control nondiapausing insects were kept in the laboratory. A 40-watt black light trap was installed to capture the wild moths as they completed development and emerged from the boxes.

[1]Lepidoptera: Olethreutidae.
[2]Contribution No. 417, Research Station, Summerland

The efficiency of the trap was determined, prior to the start of the adult emergence, by introducing into the room a known number of laboratory-reared moths that were marked externally with Day Glo® fluorescent powder. Later, when emergence of wild moths from the boxes had commenced, the efficiency of the trap was rechecked with moths marked internally with calco oil red. This marking method was adopted to prevent pigment transfer to wild moths which could lead to misidentification of the wild insects. The experiment was discontinued 2 weeks after the last capture of a wild moth.

The procedure for estimating the numbers of moths likely to emerge from bins was essentially the same as that used for boxes. The experiment was conducted in a large storage room in a packinghouse with 500 so-called standard bins (0.8 m^3) from the Summerland district. The daily temperature fluctuation in the room was between ca. 23° and 29° C and the light/dark regime was 17/7 hr. Three screen-mouthed glass jars, each with ca. 100 diapausing larvae, 3 with 10 nondiapausing larvae and 10 pupae, and 2 with ca. 30 adult moths each, were placed at different locations among the bins. Four black light traps were installed, and trapping efficiency estimated, prior to emergence of wild adults, by release of a known number of marked moths. The numbers of traps were later increased to 8, and trapping efficiency reassessed before emergence of wild adults. The experiment was discontinued 3 weeks after the last capture of a wild moth.

Boxes

The environment in the room used for processing the boxes was satisfactory for codling moth development; adult emergence from the caged nondiapausing insects was 95.0% in the room vs. 92.5% in the laboratory. Emergence from caged diapausing insects was much less than that—an estimated 40% in the room and laboratory. Microscopic examination of dead and moribund larvae indicated that poor emergence with caged diapausing insects was due to a severe infection of granulosis virus.

Use of a single black light trap proved to be an effective way of capturing adult moths in the room. In the first trapping efficiency test 25 marked moths were released and they were all captured within 3 days; in the second test 92 moths were released and 84 were captured. Thus the average trapping efficiency was 93.16%.

Twelve wild (unmarked) moths were captured in the black light trap in the 7-week period in which the 250 boxes were exposed to long photophase at 21-27° C.

With respect to importation of fruit during the growing season, only a very small number of codling moths are likely to be introduced with cherries, plums, apricots, and peaches. The fruit itself would not be a carrier for only very rarely are stone fruits infested with the codling moth in British Columbia. If the boxes were used the previous year for handling apples and pears, virtually all the overwintered larvae that were spun-up in the boxes would have completed development and emerged as adult moths before the commencement of stone fruit imports, usually in early and mid July.

Moths could be introduced with imports of late maturing cultivars of peach if the boxes were used earlier in the year for very early maturing cultivars of apples and pears. However, the numbers of moths introduced in this way probably would be extremely small.

Very early maturing cultivars of apples, which might be imported during the third week of July, could be infested with small numbers of late maturing first generation larvae. However, such imports would not contribute measurably to reinfestation since the volume of these imports is relatively small and by the third week in July many or most of the first generation larvae have already completed development and left the fruit.

Large-volume imports of apples and particularly pears normally start in mid August and it is these imports which could play an important role in reinfestation. Some of the fruit would be infested with second generation larvae and virtually all of those that develop to the fifth instar would enter diapause and be potentially capable of starting a new infestation next spring.

We do not know what percentage of the diapausing larvae spin up in the boxes, but because the number of infested apples and pears per box is very small, it seems reasonable to assume that the vast majority of the larvae would hibernate in or on the boxes for there are many attractive spin-up sites in cracks and corners of the boxes. Future investigations will show whether larvae do leave the boxes and whether artificial oviposition sites are needed to trap these larvae.

Fruit stand operators normally use each box several times yearly, sometimes for imported fruit, other times for locally-grown fruit. Despite this it is still possible to estimate the approximate number of overwintered moths that originate from imported fruit if we know the total number of boxes used in the fruit stand business, and the respective volumes of imported and locally-grown fruit sold through this outlet. We must also assume (and there is no reason to believe otherwise) that the per cent codling moth infestation is about the same for imported and locally-grown fruit.

Fruit stand operators use a total of ca. 17,800 boxes in their business, and we estimate that ca. 20% of apples and pears sold after mid August (i.e, that period in which fruit is

infested with second generation larvae) are imported. On the basis of the experiment conducted with the Similkameen boxes, we would expect 917 moths to emerge in spring from 17,800 boxes. About 20% of these, i.e. 183 moths, would be from imported fruit. Since most of the moths would emerge in a 2-3-week period, they could easily start new infestations once sterile insect release is discontinued. The most practical method of eliminating this source of reinfestation is by fumigation of all boxes with methyl bromide during winter.

Even though only small numbers of nondiapausing insects are likely to come into the Valley in boxes of stone fruits and early maturing cultivars of apples and pears, they could conceivably start new infestations. Traps, baited with the synthetic sex pheromone of the codling moth, should be deployed around all fruit stands to monitor adult moth populations. Results of monitoring would indicate whether yearly localized releases of sterile moths should be made around all fruit stands, at least until fruit stand owners can be convinced that they should discontinue importing apples and pears, and that only codling moth free boxes should be used for importing stone fruits.

Bins

The environment in the room used for processing the bins was satisfactory for completion of codling moth development; adult emergence from caged nondiapausing insects was 93.3%. Emergence from caged diapausing larvae was abnormally low, as in the previous experiment with boxes.

Four black light traps were too few to give maximum moth capture in the large room of the packinghouse. When 49 marked adult moths were released only 42 were captured. Caged adult moths lived for several days indicating that the relatively low trapping efficiency (85.7%) was not due to poor adult survival. There was an appreciable increase in trapping efficiency when the number of traps was increased to 8; 94 of 100 released moths were captured within 4 days.

Five wild (unmarked) moths were captured in the light traps during the 7-week period in which the 500 bins were exposed to long photophase at 23-29° C. On the basis of 94% trapping efficiency, emergence in spring would be 1.06 moths/100 bins.

About 2% of the Similkameen fruit growers use imported bins to ship their fruit to Okanagan Valley packinghouses or to outside markets. Import of so-called half bins (0.4 m^3) for the stone fruit harvest is unlikely to contribute to codling reinfestation. Since Golden Delicious is the only host fruit cultivar shipped in half bins, their re-use for host fruits in any one year is very restricted. Consequently, there is only a very limited opportunity for diapausing larvae to spin-up in the bins. Furthermore, the few overwintered larvae that might have been present would have mostly completed development and emerged as adult moths by the time the bins were imported.

We estimate that ca. 530 standard and 290 half bins are shipped into the Similkameen Valley every year for the apple and pear harvest. Empty bins are sometimes imported in spring before adult emergence from overwintered insects is complete. On the other hand, imports are sometimes delayed so long that some of the bins may have already been used for early-maturing host fruits, and consequently may harbor small numbers of nondiapausing larvae and pupae of the first generation. However, the probability of reinfestation is likely to be very low since only ca 820 bins are involved, and only ca. 8 moths should emerge in spring from these bins on the basis of the experiment conducted with Summerland bins. The chances of reinfestation could be further reduced by importing as many bins as possible in early July, i.e., after adult emergence of overwintered insects, but about one week before harvesting host fruits.

There soon may be another potential source of codling moth reinfestation. The British Columbia tree fruit industry is being reorganized and it is possible that some packinghouses may eventually handle only certain species or cultivars of fruit. This would entail a fairly considerable movement of fruit and bins between fruit-growing areas, with consequent increase in the chances of reinfesting the Similkameen Valley. There is only a slight chance that mature larvae will leave infested fruit after it has been imported because the bins of fruit are put into cold storage immediately on arrival at the packinghouses. It is prior to transport, when harvested fruit is often left in orchards for 1 or more days, that mature larvae are likely to leave the fruit and spin-up in the bins. These will be almost entirely diapausing larvae. Consequently, the contribution of imported bins to reinfestation would be limited almost exclusively to the following spring.

The number of moths that emerge from bins in spring evidently is not large enough to create a serious problem of reinfestation. About 11,500 bins are used in the packinghouse operations in the Similkameen Valley. On the basis of our experiment at Summerland, this number would contribute 122 adult moths to the overwintered codling moth population. However, it seems unlikely that more than one-fourth of the bins, i.e. 30 moths, would originate from outside the Valley. If the standard bins were held at Similkameen Valley packinghouses until early July, it should be possible, by releasing small numbers of sterile moths around the packinghouses, to prevent emerging adults

from starting new infestations. The half bins can be fumigated if they have to be distributed to stone fruit growers before all the overwintered insects have emerged. Of course, no bins should be imported before early July in order to avoid introducing overwintered insects.

In conclusion, it seems that the greatest danger of codling moth reinfesting the Similkameen Valley after discontinuance of sterile moth release would be through importation of boxes of apples and pears for the fruit stand trade. Incipient infestations could be suppressed or avoided by fumigating the empty boxes and by localized release of sterile moths. At this time the numbers of imported bins are so small that they are unlikely to contribute to codling moth reinfestation.

Reference Cited

Proverbs, M.D. 1974. Codling moth control by the sterility principle: estimated cost and some biological observations related to cost. Pages 81-88. In Proc. Panel on The Sterile-Insect Technique and its Field Applications. I.A.E.A., Vienna, Austria.

MITES AND INSECTS COLLECTED FROM VINEYARDS IN THE OKANAGAN AND SIMILKAMEEN VALLEYS, BRITISH COLUMBIA[1]

B. J. MADSEN AND C. V. G. MORGAN
Research Station, Agriculture Canada,
Summerland, B.C.

ABSTRACT

Five species of mites and 122 species of insects were collected from leaves, stickyboards and beating trays in 14 vineyards in 5 different areas in southern British Columbia between May and October 1972. Two mite species and 5 insect species are potential economic pests in British Columbia but only one insect species, the Virginiacreeper leafhopper, **Erythroneura ziczac** Walsh requires control measures.

INTRODUCTION

A survey of vineyards in the Okanagan and Similkameen Valleys was made in 1972 to determine the species of insects and mites present, their distribution, parasites and predators.

METHODS

Mites and insects were collected from yellow stickyboards hung in vineyards, from grape leaves examined under a binocular microscope and from beating trays. In each vineyard and for each variety the samples consisted of 10 leaves collected randomly, one beating tray count from each of 10 vines and one yellow stickyboard hung on the top trellis wire. Samples were taken and stickyboards changed at weekly intervals from 30 May to 6 October. Insects were mounted or pinned and sent to taxonomists at the Biosystematics Research Institute, Ottawa, for identification. Mites were identified by us along with R. S. Downing and T. K. Moilliet of the Research Station, Summerland, British Columbia. Varieties of grapes sampled were Foch and Bath at Westbank; Campbell Early, Patricia, Himrod, and Sheridan at Kelowna; Riesling, Bath, Diamond and S-10878 at Oliver; Foch at Cawston; S-9549, Diamond and numerous experimental varieties at Summerland.

[1] Contribution No. 403, Research Station, Summerland, B.C.