CONTROL OF DAMAGE BY MAMMALS IN ONTARIO ORCHARDS

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INTRODUCTION

Each year, mammalian wildlife causes extensive and costly damage to fruit tree growers throughout Ontario. In 1981, in response to the concern among fruit growers over high levels of this damage, the Ontario Apple Marketing Commission and the Ontario Ministry of Agriculture and Food requested that we initiate a long-term study of this problem. However, the desire to improve available control practices was impeded by a general lack of knowledge of the scope of mammalian pest problems in Ontario. For example, the extent and degree of damage in relation to seasonal and regional differences, pest population levels and management practices was unknown. Accordingly, our research program has four basic objectives: first, to assess level of tree injury caused by mammalian pests and to determine the costs of this damage and of methods currently used to control the pest species; second, to identify the species causing damage; third, to identify biological indicators that could be used by growers to predict periods of potential high damage; fourth, to develop and recommend a cost-effective, long-range program to monitor and control pest species.

METHODS AND MATERIALS

1. QUESTIONNAIRE

In both 1981 and 1982, questionnaires were distributed by mail to approximately 1000 apple growers throughout Ontario. These questionnaires asked for information on: (a) tree composition (i.e., number, age, variety) and size of orchard (b) amount and extent of damage inflicted on trees by mammalian pests (c) methods (i.e., timing and frequency of use of herbicides, rodenticides, mowing, cultivation, etc.) of habitat management and mammalian pest control used by growers (d) cost ($/ha) of herbicide and rodenticide applications and (e) growers' attitudes towards various control measures. This questionnaire data base is valuable as a cost-effective and comprehensive method to sample the large and diverse apple-growing areas of Ontario in a short period of time. This information not only provides a picture of general trends but also will aid in formulating new damage control techniques that will be more acceptable to growers.

2. TRAPPING PROGRAM

Standard live-trapping techniques (Davis 1956, Krebs et al. 1969, Renzulli et al. 1980, Stockrahm et al. 1981, Webster and Brooks 1981) were used in 1981, 1982, and 1983 to identify the rodent species resident in apple orchards and to estimate population levels of these species. Trap grids were located in orchards in 3 regions: Haldimand-Norfolk, Prince Edward, and Grey (Brooks and Struger 1982). Four 0.21-ha live-trap grids were established in each of these 3 sample areas. During each trapping session, grids were trapped throughout 4 consecutive 24-hr periods. Baited Sherman live traps were set at each grid marker with 7.6 m between markers (49 traps). Traps were locked open for 24-h before each 4-day trap cycle began. Captured animals were marked with numbered ear tags, weighed, sexed, and released. Reproductive activity was also noted. Snap-trapping (Brooks and Struger 1982) was employed in 1981 to augment the live-trap data. Snap-trapping enabled us to sample more orchards, more quickly, and thus hasten the preliminary identification of the rodent species causing damage.

RESULTS

1. QUESTIONNAIRE

Responses to the questionnaire totalled 280 (23.3% return rate) in 1981 and 180 (19.0% return rate) in 1982. Of these, 103 responded in both years and this set of "repeat" orchards was examined in comparison to all orchards reporting. Data from the repeat orchards for the per cent of trees injured by hare/rabbits and deer agree closely with the total data sample in either year (Table 1). Deer damage in 1981, however, was calculated to be much higher (0.57% vs 0.27%) in the overall sample. A paired t-test for repeat orchards yielded significant differences in damage by hare/rabbits between 1981 and 1982. This trend is also described in the total sample (2.14% vs 0.53%). Generally, the incidence of damage to trees by deer was lower than that by hare/rabbits.

Trees damaged by meadow voles *(Microtus pennsylvanicus)* were divided into 2 categories - trees injured but not killed by girdling, and trees killed by girdling activity of voles (Table 2). In the total sample, a decrease in the per cent of injured trees was noted from 1981 to 1982 (0.65% to 0.50%). However, in the repeat orchards there was no change in the level of damage between years in either category (0.73%, $t = 0.04$; $P = 0.97$, d.f. $= 102$). These data indicated that approximately 1% of all apple trees in repeat orchards were injured or killed by meadow vole activity in 1981 and 1982. With a total of 2,750,000 apple trees in Ontario (O.M.A.F. 1982) it was estimated, using repeat orchard percentages, that meadow voles may have

Table 1. Reported percentage of apple trees damaged by Leporids and deer and 1981 and 1982. +

	Total Sample		Repeated Sample	
	1981 (280)	1982 (180)	1981 (103)	1982 (103)
Total % apple trees damaged by hare, rabbits	0.53	2.14	0.50	2.52*
Total % apple trees damaged by deer	0.57	0.50	0.27	0.61

+ Sample sizes given in parentheses
* Difference between years was significant: $t_{102} = 2.52; p < 0.05$; paired t test

damaged 20,000 trees in both 1981 and 1982. Tree mortality attributed to meadow voles was estimated to be 7,425 trees in 1981 and 4,400 trees in 1982. Mammalian pests, other than voles, damaged 0.8% (22,000 trees) and 3.1% (85,250 trees) of all apple trees based on repeat orchard percentages in 1981 and 1982, respectively. In total, all mammalian pests damaged 1.8% (49,500 trees) and 4.0% (110,000 trees) of all apple trees based on repeat orchard percentages in 1981 and 1982, respectively.

Table 2. Reported percentage of apple trees damaged by meadow voles in 1981 and 1982. +

	Total Sample		Repeated Sample	
	1981 (280)	1982 (180)	1981 (103)	1982 (103)
Total % apple trees damaged by voles	0.65	0.50	0.73	0.73
Total % apple trees killed by voles	0.42	0.20	0.27	0.16

+ Number of questionnaires given in parentheses

The mean loss in fruit production ($) was estimated by growers in 1982 to be 1.2% of their output. Growers sold (farm-gate value) $36,000,000 worth of apples in 1981 and $30,000,000 worth in 1982. Thus the estimated loss was approximately $430,000 in 1981 and $360,000 in 1982. These figures break down further to $65.48/ha in 1981 and $54.51/ha in 1982.

A regression of herbicide and rodenticide costs on the level of damage attributed to meadow voles yielded no significant trend ($F = 0.88$, d.f. = 2,137, $P = 0.4176$). Herbicide costs amounted in 1982 to $54.77/ha with $39.24/ha towards product cost and $14.53/ha towards labor. Rodenticide costs were $25.48/ha with $17.25/ha towards product cost and $8.23/ha towards labor.

In both years, the lowest reported per cent of trees damaged by meadow voles (between 0.51 and 0.73%, Table 3) occurred in orchards in which zinc-phosphide treated corn was applied. Grower estimates of damage indicated poorer performance with diphacinone (Ramik Brown) products, especially in 1982 (Table 3).

Orchards with high levels of damage (greater than 2.5% of apple trees damaged) attributable to meadow voles were smaller than the average orchard. Thirty-

Table 3. Reported percentage of apple trees damaged by meadow voles (*Microtus pennsylvanicus*) in orchards treated or not treated with rodenticide. +

	Rodenticide Program			
	Zinc-phosphide treated corn	Zinc-phosphide and diphacinone	Diphacinone	No Rodenticide
Total % apple trees damaged 1981	0.73 (195)	1.22 (12)	0.88 (9)	0.87 (64)
Total % apple trees damaged 1982	0.51 (140)	1.40 (8)	3.07 (8)	1.58 (24)

+ Sample size given in parentheses

eight orchards with high levels of damage in 1981 averaged 1428 apple trees, well below the mean of 3552 trees for the total sample from the 1981 questionnaire. In 1982, 18 orchards with high levels of damage reported a mean of 3067 trees, lower than the mean of 4629 apple trees for the total sample from the 1982 questionnaire. Consistent in both years was the extreme variability of levels of damage in orchards of 3000 trees or less. In larger orchards, the damage levels varied less and were almost never above 2.5%.

2. TRAPPING

Meadow voles *(Microtus pennsylvanicus)* and deer mice *(Peromyscus maniculatus)* were the only species of rodent captured throughout the study. Deer mice were present in low numbers (Brooks and Struger 1982) until August 1983 when a sharp increase occurred throughout our plots in all areas. Trapping changes in the minimum number alive (MNA) per ha are described for meadow voles in each of the regions in Ontario for 1981-1983 (Fig. 1). Meadow vole populations were high in Haldimand-Norfolk and Prince Edward orchards in 1981, but were reduced substantially by the regular (annual) application of rodenticide (zinc-phosphide treated corn) in the fall. All three regional population estimates have remained low since Nov. 1981 (less than 20 voles/ha). Rodenticide (zinc-phosphide treated corn) was applied to trap grids in Haldimand-Norfolk and Prince Edward in October, 1982. In these trap grids, the density fell to low levels, similar to the pattern in 1981. Though the Prince Edward and Haldimand-Norfolk populations recovered moderately in 1982, they have remained low throughout 1983. During the winter of 1982-83 no persistent snow cover was established in either Haldimand-Norfolk or Prince Edward due to the abnormally mild winter which was characterized by little snow and alternating periods of rain and freezing temperatures. However, the Grey area is a snow-belt region, and the grids in Grey were covered by snow from late December through late March. Though the Grey population appears to have fared better in 1983 perhaps due to the insulative properties of snow cover, it should be noted that rodenticide wasn't applied in these grids until after Nov. 25, 1982. This lateness of application may have resulted in accelerated spoilage of the rodenticide bait, thus effecting a poor control before winter.

DISCUSSION

From the questionnaire, it was apparent that voles were the most significant mammalian pest causing injury and especially mortality of Ontario apple trees. Trapping results indicated that *Microtus pennsylvanicus* was the only microtine species present (Brooks and Struger 1982, 1983; Siddiqi and Blaine 1982). Leporids and deer also damaged a significant number of trees. Groundhogs *(Marmota monax)* occasionally were identified as problems. In the past, growers in some northern areas had indicated that porcupines *(Erethizon dorsatum)* destroyed a large number of fruit trees, but there was no evidence of this during our surveys.

Damage caused by hare/rabbits and deer is usually confined to the tips and buds of trees and the resultant production loss may be very small. However, losses will rise quickly when hare populations peak or when deer yards are adjacent to or near orchards. Losses also increase when young trees are grazed upon by hare or deer since the setback to growth may delay production 1-3 years under these circumstances.

Amount of damage caused by voles was much more variable among small orchards than among large orchards. Many small operations experienced high levels of vole damage, whereas others suffered no damage even when no rodenticide program was in place. This apparent effect of size on variability in damage levels probably occurred because large orchards were more likely to be genuine commercial operations in which cost/benefit factors were more critical in the management of the orchard. In the large orchards we observed, vole control was more stringent and consistent and hence there were fewer instances of high levels of damage. In small orchards, however, there was a large diversity of management practices used in vole control. Some small orchards were operated without vole control measures whereas other were similar to large operations. Voles are known to invade orchards from surrounding habitats (Pagano and Madison 1982). Reinvasion should be faster in smaller orchards since they have a larger perimeter/area ratio than do large orchards. This effect would be increased if the orchard was surrounded by areas of low-intensity agriculture, such as old fields and hayfields (Brooks and Struger 1982). We feel that growers with small operations must be more flexible and quicker to respond to vole population changes than growers with large operations.

Usually, the most serious mammalian pest in Ontario orchards is the meadow vole. Our experience indicates that in most Ontario locations, an orchard will be seriously damaged by voles within 2 to 5 years if a control program is not applied. For example, we have observed orchards, abandoned for only 3 years, with a

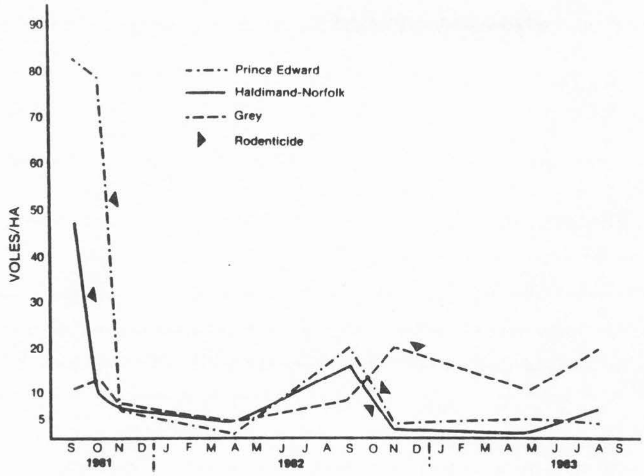

Figure 1. The number of meadow voles (Microtus pennsylvanicus) per ha live trapped in apple orchards in three regions of Ontario. the approximate time period during which rodenticide bait (zinc-phosphide treated corn) was applied is represented by ▼.

20% tree mortality rate and 80% damage rate caused by voles. Most experienced growers recognize that failure to apply any control measures could lead to serious problems and they do not expect to escape these costs. On the other hand, most growers are very concerned when they are employing a control program and annually applying rodenticide in the fall, only to discover a significant number of trees girdled the following spring. Growers estimated that they lost \$65.48 and \$54.51 per ha in actual production in 1981 and 1982, respectively, due to vole damage. These estimates could actually be higher because long-term effects of damage are not visible and are difficult to estimate.

The importance of controlling voles at an acceptably low population level is a major concern of growers. Fully 55% of Ontario growers, in 1982, stated that voles were either as serious or more serious than insects and diseases as a cause of fruit production loss (Brooks and Struger 1983). Estimated losses in fruit production in Ontario caused by voles (\$433,000 in 1981, \$360,000 in 1982) also provide evidence that the growers' concern is real. This concern and knowledge that voles can be a major problem indicates that growers are willing to adopt new strategies to improve control of vole populations.

Simply to spend more money on a rodenticide or herbicide program holds no guarantee for long-term control. What is important, is to improve the timing and location of rodenticide and herbicide applications and of mowing regimes. Any grower with a serious vole problem must aim for adequate long-term control and not resort to stopgap measures from year to year just because damage is noticeable. The goal of maintaining production at its highest level should necessitate a serious effort by growers to control populations at a level such that any losses will be minimal. Only by planning long-term strategies will growers avoid being surprised by outbreaks of vole damage.

We feel that long-term control can be achieved only if the rodenticide programs (annual) are combined with an efficient habitat control program. In conjunction with these efforts, a grower must monitor vole population changes (trends) in the orchard. As well, it is important to identify problem areas such as adjacent forage crop fields, wet moist areas within the orchard, and areas where herbicide applications have not succeeded. Proper monitoring of these and similar situations should result in action being taken to maintain vole populations at an acceptably low level.

One major problem in formulating new recommendations is that although meadow voles may damage 1% of all apple trees every year, the damage may be highly localized, and at present, location of these sites is difficult to predict. Regional generalizations, therefore, often bear no resemblance to specific orchards. The diverse array in timing and types of cultural practices requires each grower to understand the uniqueness of their orchard and to apply control techniques accordingly. Rather than make broad generalizations to growers, we feel growers should be made more aware of all the available information concerning mammalian pest control in order that they can individually respond as they see fit. Basic guidelines are necessary, but flexibility is the key to any control program. An informed grower who utilizes this information should be able to achieve adequate long-term control. The techniques are there, what remains is for growers to absorb and apply them to their own situations.

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