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Survey of Mammal Damage to Tree Fruit Orchards in the Okanagan Valley of British Columbia

Abstract

This study reports on the incidence of damage from vole, pocket gopher, and deer that feed on tree fruit orchards in the Okanagan Valley of British Columbia, Canada. A secondary objective was assessment of the relative use of various techniques for control of this mammal damage. An on-site sampling survey of 10% of orchardists recorded the intensity of damage with respect to fruit species as well as age and size of a given orchard. Rodent and deer damage, based on tree mortality or reduced growth and yield, was reported for more than 30% and 24% of the orchards, respectively. Some fruit production districts had 10% of orchards with severe (> 10%) losses from deer browsing. Young (< 10 years old) apple orchards, 8 ha or more in area were highly susceptible to damage by pocket gophers, voles, and deer. Soil texture had little effect on incidence of vole or pocket gopher attack. Toxicants were the most widely-used technique for reducing rodent populations. Fencing was the only reliable means of preventing deer browsing in orchards. Commercial deer repellents often provided inconsistent and unreliable protection for fruit trees.

Introduction

The Okanagan Valley produces most of the tree fruits and grapes in British Columbia. Prime agricultural land in this region occupies valley bottoms, low elevation benchlands, and southern-exposure slopes. Several mammal species native to the Okanagan interact with tree fruit production in this area.

Three species of voles, *Microtus montanus* (montane), *M. pennsylvanicus* (meadow), and *M. longicaudus* (long-tailed) reside within or adjacent to fruit orchards. Voles inflict serious feeding damage by barking and girdling trees during the winter season (Anderson 1980). The northern pocket gopher (*Thomomys talpoides*), a fossorial geomyid, is found in the subterranean orchard environment. Pocket gophers damage fruit trees by feeding on roots and underground bark and this damage may occur year-round (Anderson 1980). The negative impact of bark and associated vascular tissue removal on tree vigour and fruit yield has been clearly illustrated for apple orchards in New York state and related areas of the eastern United States (Pearson and Forshey 1978).

Rocky mountain mule deer (*Odocoileus hemionus hemionus*) are abundant in the Okanagan Valley. Northwest white-tailed deer (*O. vir-*

ginianus ochrourus) and Rocky Mountain elk (*Cervus elaphus nelsoni*) are also found in some areas of the Valley. Deer and elk traditionally migrate from high elevation summer ranges to low elevation, southern exposure winter ranges. The proximity, and in many cases overlap, of prime agricultural land and preferred winter range has resulted in serious browsing and antler rubbing damage to fruit trees by deer and elk. Newly planted trees and high-density plantings of semi-dwarf trees are particularly vulnerable to wild ungulate damage.

Intensive control programs (Byers *et al.* 1976) and surveys (Anthony and Fisher 1977) of mammal damage to orchards have been conducted in the eastern United States. However, there is virtually no information available on the extent and severity of mammal damage to tree fruit orchards in the Okanagan Valley. Thus, this study was designed to investigate the incidence of vole, pocket gopher, and deer damage to orchards in the Okanagan, and determine the relative use of various techniques for control of mammal damage.

Materials and Methods

An on-site sampling survey of 195 orchardists in the five tree fruit production districts of the Okanagan Valley (Fig. 1) was conducted during

FRUIT PRODUCTION DISTRICTS - OKANAGAN VALLEY

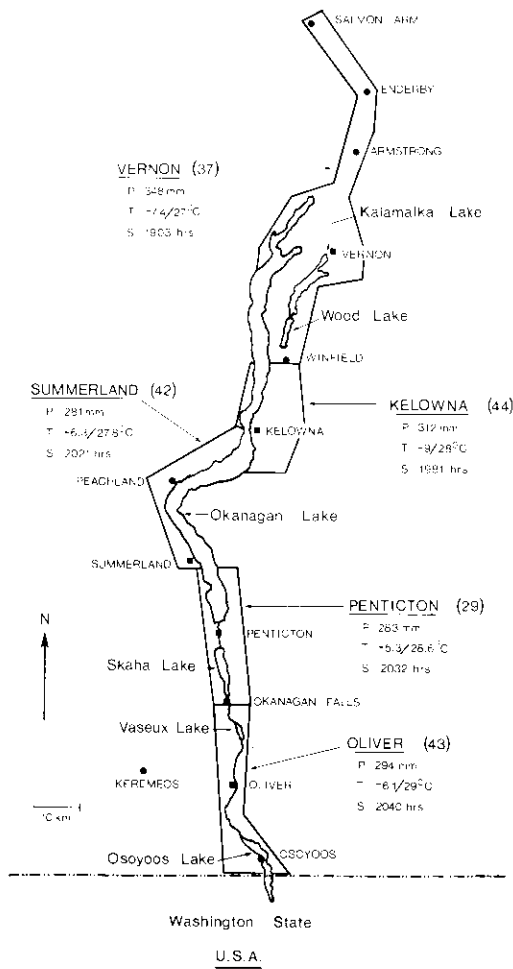


Figure 1. Map of study area showing the five fruit production districts, number of orchards sampled in parentheses, and climatic data: average annual precipitation (P), hours of sunshine (S), and average low (January) and high (July) temperatures (T).

May to August 1983. From a composite list of 2000 to 2200 growers, every tenth grower was selected for an interview. The number of orchards sampled in each district reflected the abundance of tree fruit growers in that area.

The species and variety, age of trees and area (ha) were recorded for each orchard. In many cases, an individual grower had several species

(e.g. apple, cherry, apricot) and ages of trees in blocks within the overall orchard. In terms of rodent habitat, soil texture was assessed on a scale of 1 to 6 (1 = clay, 2 = clay/loam, 3 = silt/loam, 4 = sand/loam, 5 = sand/gravel, 6 = clay/gravel). Vole and pocket gopher feeding damage to trees during the last five years was recorded as none, light (< 1% loss), moderate (1 to 10% loss) or severe (> 10% loss). Tree loss may be interpreted as mortality or reduction in growth and yield. Assessment of control techniques for voles included the proportion of growers using cultural practices (mowing between tree rows with herbicide along rows), poison baits (toxicants), and tree guards (wire mesh or plastic). For pocket gophers, techniques included trapping, poison placed in burrows, and use of an artificial burrow builder with poison bait. Browsing damage by deer and elk was recorded in the same manner as rodent damage. Control techniques included fencing, repellents, shooting, and various scare devices (including domestic dogs). Results from the survey are summarized according to the five fruit production districts in the Okanagan Valley (Fig. 1).

Results

Climate

Average annual precipitation and hours of sunshine as well as average low (January) and high (July) temperatures for each district in the Okanagan Valley are given in Fig. 1. A slight degree of cooling (1.6° to 2°C) and increase in precipitation (53 mm) occurs from south to north (Oliver to Vernon). However, there is generally little variation in these data with the general climate classified as semi-arid.

Rodent Damage

The incidence of damage by voles and gophers in each district during the last 5 years is illustrated in Fig. 2A. The Oliver district had significantly fewer orchards with pocket gopher damage than any of the other districts. Similarly, Oliver had significantly fewer orchards with vole damage than Vernon. The incidence of vole and pocket gopher damage was generally comparable in the Penticton to Vernon districts ranging from 31.8% to 40.5%. Overall, 2.6% of orchards had moderate and 1.5% had severe tree mortality

INCIDENCE OF RODENT DAMAGE

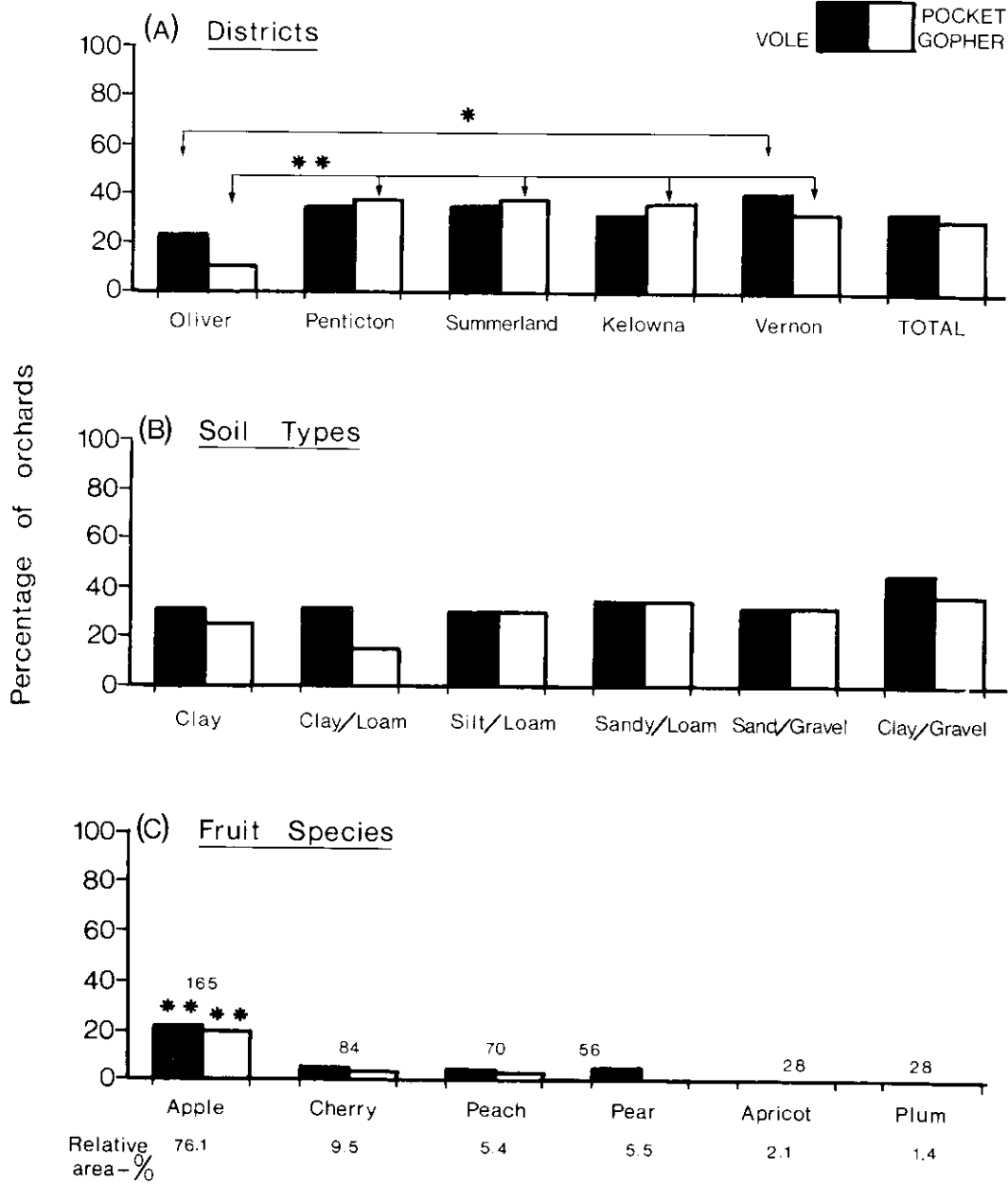


Figure 2. Percentage of orchards with feeding damage by voles and pocket gophers in: (A) five fruit production districts; (B) various soil types; and (C) various fruit tree species. * $p < 0.05$, ** $p < 0.01$; significant difference by chi-square.

from vole attack. These attack rates were 2.1% and 0.5% respectively, for gophers.

To determine if soil texture limits the distribution of voles, and particularly pocket gophers, this variable was related to the incidence of damage (Fig. 2B). Except for the clay/loam soil type which had fewer ($p = 0.058$, chi-square) orchards with pocket gopher damage than the sand/loam type, soil texture appeared to have little effect on supporting vole and pocket gopher populations in an orchard environment.

Assessment of which species of fruit trees were attacked by voles and pocket gophers is illustrated in Fig. 2C. Apple trees were readily attacked by these rodents with more than five times as many apple orchards with damage compared with cherry and peach. It should be stressed that apple orchards (76.1% of production area) dominate the Okanagan Valley and this may in part explain their higher frequency of attack than the other fruit species.

In general, voles and pocket gophers attacked young (1- to 10-year-old) fruit trees in all districts with totals of 75.9% and 92.9%, respectively. In terms of size, large orchards were more susceptible to vole ($r = 0.93$, $n = 6$; $p < 0.01$) and pocket gopher ($r = 0.98$, $n = 6$; $p < 0.01$) damage than small orchards (Figs. 3A and 3B). There was little difference in the percentage of orchards with vole damage between the 4- and 8-ha size classes. Orchards > 12 ha had comparable vole damage (52.2%) to that in the 8.1-12 ha class (total of 56.3%) and these classes combined had significantly ($p < 0.01$, chi-square) more damage than those orchards < 8 ha in area. Pocket gopher damage to orchards increased significantly from the 4- to 8-ha classes at Vernon and overall ($p < 0.01$; chi-square). In a similar manner to vole damage, pocket gopher feeding (36.5% overall) increased significantly ($p < 0.01$; chi-square) from the 8- to 12-ha class (75% overall). However, damage declined ($p < 0.05$; chi-square) to 43.5% in orchards > 12 ha.

In summary, vole populations occupied and damaged approximately 30% of all orchards up to 8 ha and 54% of orchards > 8 ha in area. Pocket gopher populations damaged more trees in large than small orchards up to 12 ha in area.

The percentages of growers using various types of control measures for rodent damage are

presented in Table 1. Cultural practices involving grass mowing and herbicide treatments along tree rows were used by 83.8% of growers overall (range of 76.7 to 90.0%). The main function of these practices is to reduce vegetative competition, thereby enhancing tree growth and yield. They are considered to be of secondary importance for controlling vole damage at the present time. However, experimentation with mowing and herbicides as a means of habitat manipulation may provide significant reduction of vole and pocket gopher populations.

The use of acute and/or anti-coagulant poison baits to reduce vole populations was the most common and widespread control technique. More than one-third of growers used poison with particularly heavy use in the Summerland (45.2%) and Kelowna (50.0%) districts. The proportion of growers with damage who use poison but continued to have a problem with voles was 54.2% (39/72). This measurement reflects the generally poor long-term efficacy of poison in suppressing vole populations. Conversely, the proportion of growers who did not have a damage problem but still used poison was 45.8% (33/72). Tree guards were used by 9.2% of growers.

Poison was also the major technique employed by growers to reduce pocket gopher populations and damage (Table 1). Nearly one-half (48.7%) of all orchards had baits placed in gopher burrows either by hand-probe injection or by mechanical burrow builder. Penticton and Summerland districts had particularly high user rates for pocket gopher poison (62.1% and 66.7%, respectively). Oliver had the lowest use at 25.6% which corresponds with their significantly low incidence of pocket gopher damage (see Fig. 2A). However, 46.3% (44/95) of those growers using poison continued to have damage. This also tends to reflect the inability of poison to maintain pocket gopher populations at a consistently low level in the orchard environment. The proportion of growers without a damage problem but who still used poison in pocket gopher burrows was 53.7% (51/95). Kill-traps were used by 27.2% of growers overall and 32.1% of these also used poison. The burrow builder was used in 10.8% of orchards and was usually accompanied by hand-probe placement of poison. Only 13.3% of orchards had both vole and pocket gopher damage.

EFFECT OF ORCHARD SIZE ON DAMAGE

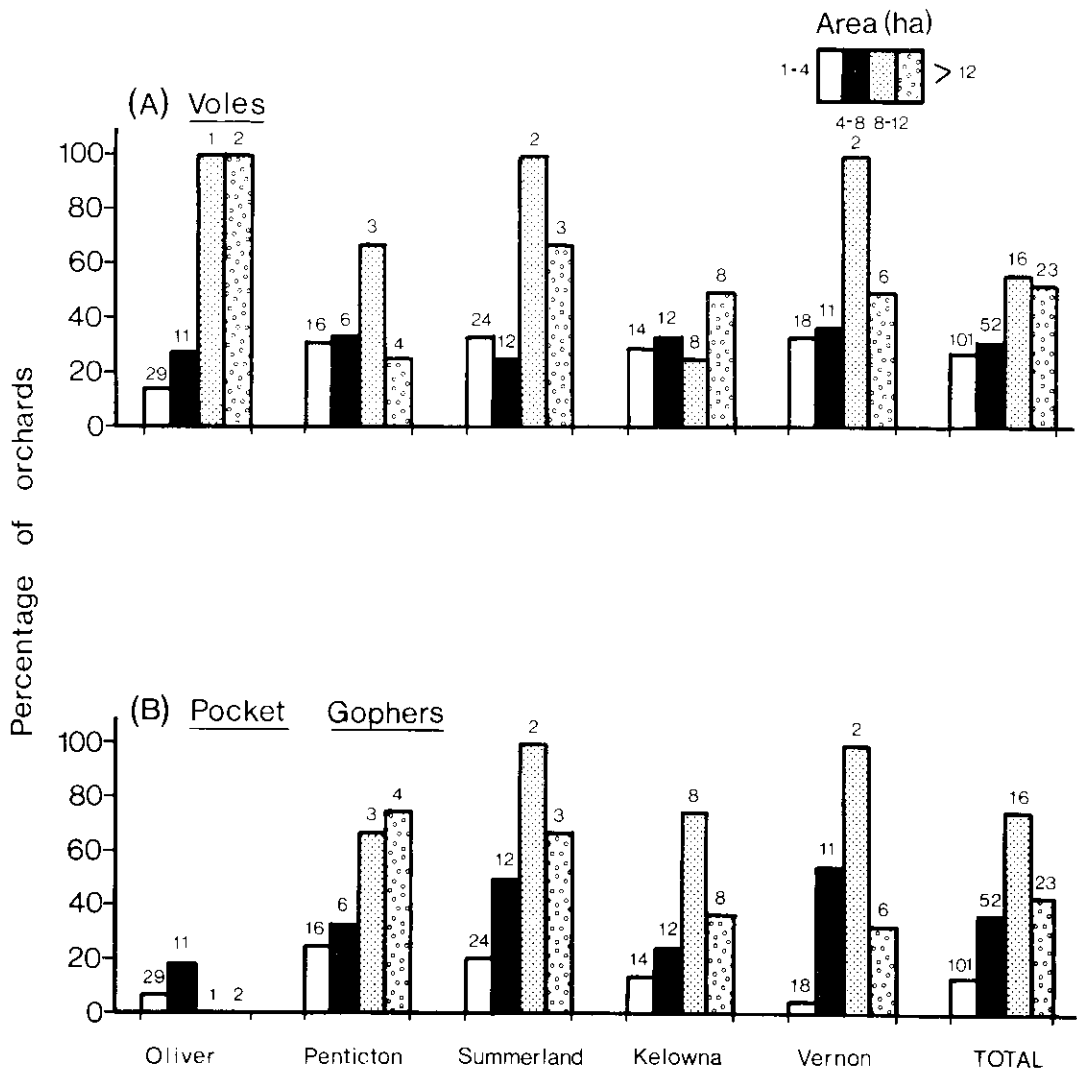


Figure 3. Percentage of orchards with (A) vole and (B) pocket gopher feeding damage in four size classes for the five fruit production districts. Sample size above each histogram.

Deer Damage

The incidence of browsing damage by deer in each district is illustrated in Fig. 4A. The Oliver district had significantly fewer orchards with deer damage than in Penticton, Summerland, or Vernon. In addition, Kelowna district (18.2%) had

fewer orchards with browsing damage relative to Penticton (41.4%). All districts except Oliver had orchards with serious tree damage or loss (> 10%). This was particularly evident in Penticton (10.3%) and Vernon (10.8%). A total of 6.2% of orchards had serious damage from antler rubbing (Harder 1970) on young trees.

TABLE 1. Percentage of growers using various types of control measures for rodent damage to orchards in the Okanagan Valley. Proportion of growers with damage who use poison but still have a problem is indicated in parentheses. a-a, b-b, c-c, d-d, $p < 0.05$; e-e, f-f, g-g, $p < 0.01$; significant difference by chi-square.

Control measures	District					Total
	Oliver	Penticton	Summerland	Kelowna	Vernon	
<i>Voles</i>						
Cultural practices	85.3	90.0	77.8	87.5	76.7	83.8
Poison baits	25.6 ^a (5/11)	27.6 (4/8)	45.2 (9/19)	50.0 ^a (13/22)	32.4 (8/12)	36.9 (39/72)
Tree guards	2.3	10.3	11.9	9.1	13.5	9.2
<i>Pocket Gophers</i>						
Poison baits	25.6 ^{bef} (1/11) ^{cdg}	62.1 ^e (10/18) ^c	66.7 ^f (13/28) ^d	47.7 ^g (13/21)	45.9 (7/17)	48.7 (44/95)
Traps	20.9	20.7	30.9	36.4	24.3	27.2
Burrow builder	4.7	3.4	11.9	13.6	18.9	10.8

The incidence of damage by deer to the various fruit species is illustrated in Fig. 4B. Deer attacked apple trees (19.4%) more readily than cherry (5.9%) or other fruit trees (0.0%). As with the selection for different trees by voles and pocket gophers, apples are the major crop in the Okanagan and this factor may have some influence on the lack of feeding damage to other fruit tree species.

Young (1- to 5-year old) trees (73.1%) were particularly susceptible to deer attack. Ninety-six percent of all deer-damaged trees were < 15 years old.

Large orchards were generally more susceptible to deer browsing ($r = 0.97$, $n = 7$; $p < 0.01$) than small orchards (Fig. 4C). In specific districts, orchard damage from deer declined in the > 12 ha size class in Summerland and Vernon, and was the same as the 8.1-12 ha class in Kelowna. Overall, orchards > 8 ha had significantly ($p < 0.01$; chi-square) more browsing than those < 8 ha in area.

The percentages of growers using various types of control measures for deer damage are presented in Table 2. Fencing of orchards was highest (20.7%) in the Penticton district which is predictable based on the levels of serious browsing (Fig. 4A). The total percentage of orchards with fencing was 7.2%. Repellents, both commercial and home-made, ranged from 2.3%

use in Oliver to 16.7% in Kelowna. Use of shooting and scare devices ranged from 0% to 4.8%. Those growers using repellents were generally dissatisfied with efficacy.

Discussion

Our data clearly substantiate the detrimental effects of mammal damage to orchards as viewed by commercial orchardists. These results are comparable to those from other studies (McDowell and Pillsbury 1959, Anthony and Fisher 1977). Although moderate to severe damage (based on tree loss and reduced growth and yield) levels were generally low (< 3%) among the approximately 30% of growers with feeding injuries from voles and pocket gophers, any degree of tree replacement on an annual or multi-annual basis can have a significant economic impact. Laidlaw (1982) has provided a cost-benefit analysis of the potential dollar value of tree loss in orchards and its importance to orchard management. Severe (> 10%) losses to deer browsing are clearly of great significance to a given grower in terms of current and future production loss and tree replacement.

The consistency in vole and pocket gopher damage through the various districts from Oliver to Vernon is not surprising if the low variation in climatic parameters and intensive orchard irrigation and cultivation methods are considered.

INCIDENCE OF DEER DAMAGE

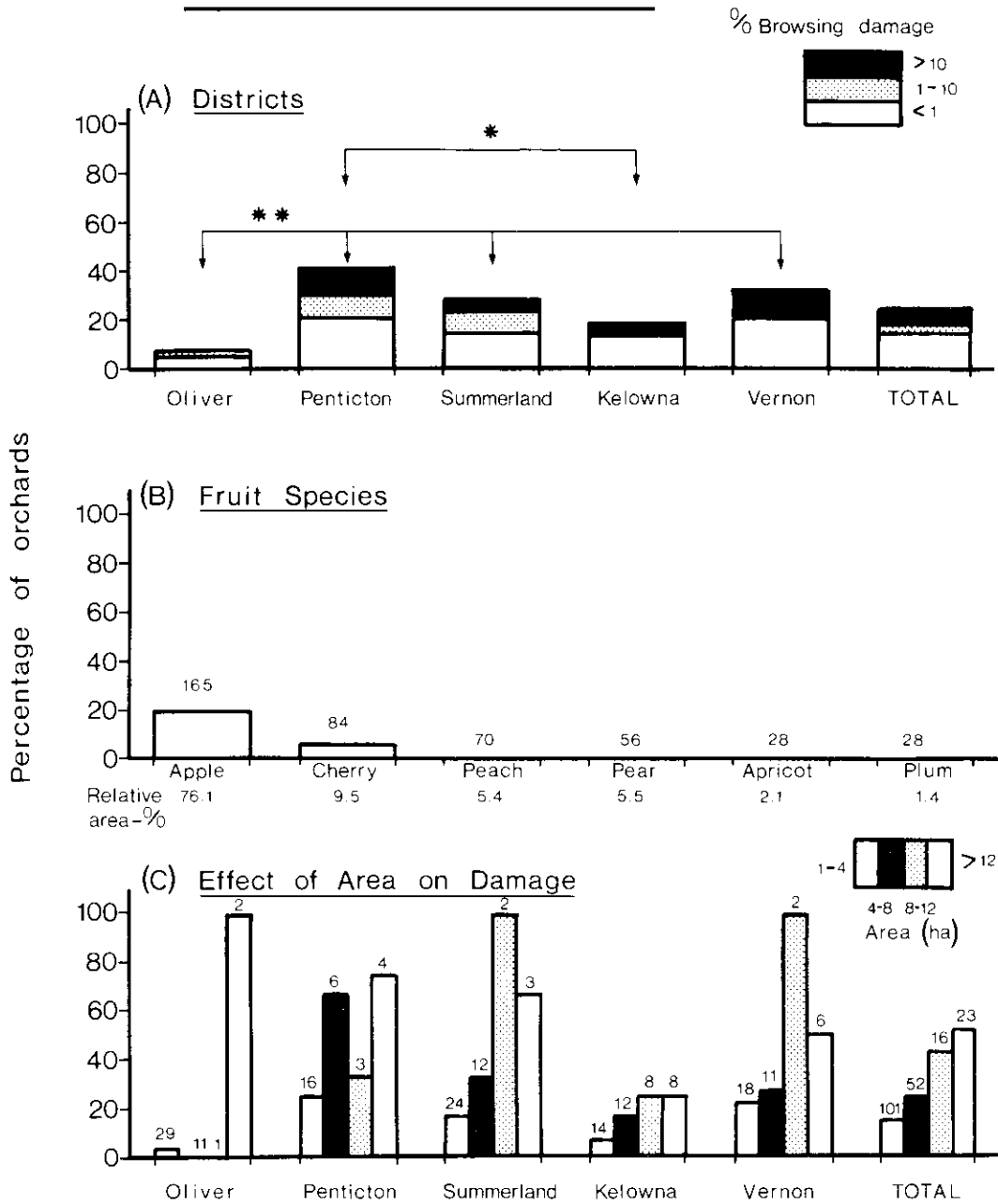


Figure 4. Percentage of orchards with feeding damage by deer in: (A) five fruit production districts; (B) various fruit tree species; and (C) four size classes (sample size above each histogram). * $p < 0.05$, ** $p < 0.01$; significant difference by chi-square.

TABLE 2. Percentage of growers using various types of control measures for deer damage to orchards in the Okanagan Valley. a-a, b-b, c-c, $p < 0.05$; d-d, $p < 0.01$; significant difference by chi-square.

Control measures	District					Total
	Oliver	Penticton	Summerland	Kelowna	Vernon	
Fencing	4.7 ^a	20.7 ^{abd}	9.5	4.5 ^b	0.0 ^d	7.2
Repellents	2.3 ^c	10.3	16.7 ^c	11.4	8.1	9.7
Shooting	2.3	3.4	4.8	2.3	2.7	3.1
Scare devices	2.3	3.4	4.8	2.3	0.0	2.6

In an essentially dry climate, irrigated orchards in Vernon, Summerland, and Oliver are likely to provide productive grassland/forb habitat for voles and pocket gophers as well as excellent winter forage for deer. Our assessment of soil texture and distribution of rodent damage indicated little difference among the various soil types. Pocket gophers and the semi-fossorial pine vole (*M. pinetorum*) of eastern North America are known to have specific soil requirements (Miller 1964, Best 1973, Fisher and Anthony 1980). Thus, the lack of soil preference by either voles or pocket gophers in the Okanagan may be a result of the irrigation and fertilization regimes which make the orchard environment attractive regardless of soil texture. This explanation is further supported by studies of pocket gopher activity in natural habitats where sandy soils are clearly preferred to those with clay-dominated soils (T. P. Sullivan, unpublished). Soil texture would not be a reliable criterion upon which to base a control program since location of new orchards on certain soils may not reduce pocket gopher damage.

The low proportion (13.3%) of orchards with both vole and pocket gopher damage suggests that each rodent has specific requirements to occupy an orchard habitat and maintain a population level high enough to result in feeding attacks to trees. These requirements could not be identified on the basis of our survey. However, neither species showed a "preference" for a given fruit species (other than apple) or for soil type. Other factors which might be important include distance from natural habitats which may act as source areas for rodents to colonize orchards.

The Oliver district had the most intensive and widespread area of available land in fruit pro-

duction and this may explain the lower incidence of rodent damage in that area. The quality and quantity of grass species with respect to food and cover in orchard blocks and the relative proportions of herbs, forbs, and grasses may influence the distribution and abundance of voles and pocket gophers, respectively (Ward and Keith 1962, Thompson 1965; Vaughan 1967, Grant and Morris 1971, Birney *et al.* 1976).

Unfortunately, orchards which appear to be particularly susceptible to mammal damage cover a wide range of situations in the Okanagan Valley where there has been a trend towards producing more compact fruit trees. High-density plantings of semi-dwarf trees are commonly found in new orchards, interplantings, and orchard renovations (replacement). These trees are especially sensitive to deer and elk damage during the early non-productive years when careful pruning and shaping is essential for maximum production in later years. In addition, they will remain vulnerable to mammal damage throughout most of their productive years.

Toxicants are widely used to control vole and pocket gopher populations in the Okanagan Valley. However, their efficacy was uncertain because approximately 50% of all growers using toxicants continued to have damage problems. In these cases, the use of poison for the purpose of population reduction provides only short-term success in controlling rodent damage. In addition, many growers without rodent damage continue to use poison baits even though their use may not be required in many orchard situations.

Intensive study of the population dynamics of voles and pocket gophers is essential to the development of successful control techniques. The existence of multi-annual and annual

fluctuations in vole abundance makes predictability of feeding damage difficult. An integrated control strategy could reduce or eliminate damage more effectively than the widespread use of toxicants. Intensive studies in this direction are presently being conducted in the Okanagan Valley.

Deer damage is clearly of the greatest significance to growers at the present time. A substantial effort is now being made to rehabilitate winter range in the Okanagan Valley. This is a sound management approach to damage reduction but it must be coupled with specific protection for orchards which continue to attract deer.

Permanent fencing, either conventional or electric, can be installed to physically exclude deer from orchards. Conventional woven (page) wire fencing is prohibitively expensive in most cases. High-tensile, high-voltage electric fencing has been demonstrated to be an effective and economical alternative to conventional fencing. However, many growers may prefer the option

of applying a chemical repellent to provide temporary protection for fruit trees during times of heavy deer pressure.

Commercial repellents have been developed with little regard for their biological significance to deer or durability in the field. It is not surprising that the vast majority of growers find commercially available repellents to be ineffective. A reliable repellent system with biologically significant origins such as predator odours (Melchior and Leslie 1985, Sullivan *et al.* 1985) released from a weather-proof dispenser is urgently needed.

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