RELATIONSHIP BETWEEN SEASONAL CHANGES IN FORAGE QUALITY AND FEEDING PATTERNS IN MEADOW VOLES (MICROTUS PENNSYLVANICUS)

by Ronald J. Brooks and Stephen A. Struger*

ABSTRACT

Forage analyses revealed that mowed orchards provide a relatively high quality forage to meadow voles (*Microtus pennsylvanicus*), especially in the fall. Mowed forage was characterized by significantly higher protein and moisture content and significantly lower acid and neutral detergent fibre and lignin than forage from an abandoned orchard. Energy and fat were not significantly affected by mowing. However, vole numbers declined markedly in mowed regions in comparison to undisturbed areas. Voles preferred to inhabit areas with dense cover even though vegetative dieback had occurred. Voles did not exhibit any distinct preference for either cracked corn (rodenticide carrier agent) or available forage at any time during the study. Voles did not change rates of forage consumption over the 6-month study. We conclude that mowing will not reduce acceptability of cracked corn and that removal of dense ground cover from the orchard would be one of the most effective and economical ways to reduce numbers of voles and minimize tree damage.

INTRODUCTION

Control of meadow voles (*Microtus pennsylvanicus*) in Ontario apple orchards commonly involves application of rodenticide baits (especially zinc-phosphide-treated corn) in late autumn. However, success of this method is variable and unpredictable (Brooks and Struger 1982, 1983; Struger and Brooks 1984). There is some evidence that rodenticide baits might often be ineffective because the voles prefer their natural forage at the time of bait application (Pagano and McAninch 1983). If this is true, then the grower's management plan should include information to identify the most effective time to apply rodenticide bait, i.e. when the bait is relatively attractive to voles. In this study, we tested the hypothesis that changes in quality of forage species available to voles in both abandoned and maintained orchards would influence preferences of meadow voles between natural forage and cracked corn.

We are grateful to Paula Gignac for excellent field assistance and technical help. Funding was provided by the Ontario Apple Marketing Commission, Ontario Ministry of Agriculture and Food and Agriculture Canada. We especially acknowledge the valuable support of Bill Wheatstone of OAMC throughout the study.

METHODS

The study site in Hamilton-Wentworth regional municipality in southern Ontario was on a 15-hectare abandoned orchard. A total of six 50-m x 50-m plots were marked out in late May, 1984. Two plots were mowed at a height of 10cm (Short plots) and two were mowed at 20cm (Long plots) as required. Two Control plots were not mowed at all.

All six plots were simultaneously live-trapped approximately once a month using standard live-trapping techniques (Davis 1956, Krebs et al. 1969, Renzulli et al. 1980, Stockrahm et al. 1981) on a 6 x 6 grid with 10m between markers. Each trapping session, grids were trapped for four consecutive 24-h periods. Five sessions were completed between June and November. At each grid marker, a baited Sherman live trap was set. Captured animals were identified, marked with numbered ear tags, weighed, sexed and released. Their reproductive condition was also noted.

To collect plant samples, 10 sampling points were randomly selected and permanently marked in each of the six plots. At each sampling point, a 3-m x 3-m quadrat grid was permanently staked out, yielding nine 1-m square quadrats. Vegetation was collected monthly (N=60 samples per month) from every sampling

---

* Department of Zoology, University of Guelph, Guelph, Ontario, Canada N1G 2W1

point for June through November (N=360). Each month, at a randomly selected quadrat of each sampling point, enough vegetation was clipped at ground level to make up a 50-g (N=60) and a 30-g (N=60) sample. All samples were put on ice during the collection day to reduce moisture loss. The 30-g samples were used in laboratory feeding choice trials. The 50-g samples were weighed, placed in a freezer for 48 hours, then dried in a freeze dryer for 4 days. The dried samples were weighed immediately after removal from the freeze dryer. The percent moisture content was calculated using standard forage analysis techniques (Goering and Van Soest 1970). In addition, analyses were performed to measure amounts of crude protein, lignin, fats, energy (kcal), acid detergent fibre and neutral detergent fibre.

Food preferences were tested monthly on 60 voles. Ten days before each monthly trial, we live-trapped at least 30 voles from a remote part of the orchard, and maintained them in the laboratory with fresh forage administered twice daily. These 30 voles, along with 30 laboratory voles, maintained continuously in the laboratory on Purina Rabbit Chow (unmedicated), comprised the 60 experimental animals. All voles were weighed prior to the experiment. On the day of the preference trial, the 60 test voles were deprived of food for 3-4 hours. At the start of each trial, each vole was placed in a clean cage (water - ad libitum, substrate - three paper towels) with 30g of wet-weight forage (collected that day and kept cool) and 30g of wet-weight cracked corn. The voles were then left undisturbed for a minimum of 2 hours. At this point, all voles were transferred to their regular cages, and the wild-caught voles were released at their point of capture. The leftover forage and corn were freeze-dried to determine respective final dry weights. The estimates of percent dry weight obtained from the 50-g final samples were used to estimate the amount of dry weight forage available to each vole at the start of the experiment. The amount of forage consumed by each vole equalled the initial (estimated) dry weight minus the final dry weight.

RESULTS

Analysis of variance (ANOVA) for each month indicated that mowing (Short, Long, Control treatments) had a significant effect on moisture content of forage in all months except July (Table 1). In early June, moisture was significantly lower in the Short plots, but from August through November, forage on both mowed plots contained significantly more moisture than that in the Control plots (Table 1).

Similar analysis of crude protein content revealed that forage from both

Table 1. Comparison by month of protein (P) and moisture (M) content (%) of forage under three mowing regimes*.

Forage Treatment	June P	June M	July P	July M	August P	August M	September P	September M	October P	October M	November P	November M
Short (10 cm)	8.6^{B}	62.4^{A}	9.3^{B}	62.4^{A}	11.6^{A}	68.2^{A}	10.3^{A}	62.7^{A}	12.1^{A}	65.0^{A}	10.2^{A}	44.5^{A}
Long (20 cm)	9.2^{A}	72.0^{B}	10.1^{A}	65.1^{A}	9.9^{B}	67.8^{AB}	10.8^{A}	63.8^{A}	10.8^{B}	62.5^{A}	10.4^{A}	45.4^{A}
Control (unmowed)	8.8^{AB}	73.2^{B}	6.3^{C}	61.2^{A}	7.1^{C}	63.7^{B}	8.5^{B}	53.4^{B}	8.3^{C}	52.0^{B}	7.5^{B}	34.7^{B}

* Means within a month followed by a different letter (protein and moisture analyzed separately) are significantly different from each other at $p < 0.05$ (ANOVA).

Table 2. Comparison by month of lignin (L), acid detergent fibre (ADF) and neutral fibre (NF) content (%) of forage under three mowing treatments.*

Mowing Treatment	Month																	
	June			July			August			September			October			November		
	L	ADF	NF	L	ADF	NF	L	ADF	NF	L	ADF	NF	L	ADF	NF	L	ADF	NF
Short (10 cm)	4.0^{B}	36^{AB}	58^{A}	4.3^{B}	40^{A}	64^{A}	4.1^{B}	37^{C}	58^{C}	4.4^{B}	42^{A}	65^{B}	4.8^{B}	38^{B}	56^{C}	5.6^{B}	41^{B}	62^{B}
Long (20 cm)	4.1^{B}	37^{A}	60^{A}	4.3^{B}	38^{B}	60^{C}	5.2^{A}	40^{B}	62^{B}	4.3^{B}	39^{B}	63^{B}	4.8^{B}	35^{B}	58^{B}	7.6^{A}	41^{B}	62^{B}
Control (unmowed)	5.1^{A}	36^{B}	55^{B}	4.9^{A}	38^{B}	62^{B}	6.0^{A}	43^{A}	65^{A}	5.2^{A}	44^{A}	69^{A}	7.1^{A}	43^{A}	68^{A}	7.4^{A}	46^{A}	72^{A}

* Means within a month followed by a different letter (each fibre type analyzed separately) are significantly different from each other at $p < 0.05$ (ANOVA).

mowed areas had a higher percent protein than did forage from the Control plots from July through November, whereas there was no significant difference in protein content among forage samples from the three plot types in June (Table 1). In June and July, forage from Short plots had lower protein levels than from Long plots, but in August and October, Short plots had the highest levels of protein (Table 1).

Lignin content of forage was higher in the Control plots than on the mowed plots, especially when compared to forage from the Short plots, in all months of the study (Table 2). Lignin levels in forage of Short and Long plots were similar, but were higher in the Long plots in August and particularly in November (Table 2).

Both analyses of detergent fibre content of forage indicated that in June and July, fibre content was lowest in the Control forage (Table 2). However, from August to November, both types of fibre were present at significantly higher levels in forage on the control plots compared to either of the mowed plots (Table 2). Detergent fibre content was generally similar between the two mowed plots throughout the study (Table 2).

Energy content (kcal per g) of forage samples from all three types of study plots was not significantly different ($P > 0.05$) throughout the 6-month study period. Similarly, monthly analyses of fat content (%) of forage showed no significant patterns or differences among the three plot types throughout the study.

Population density was higher on the Control plots during all sampling periods except in late July (Table 3). Changes in number were small on all plots until early October when numbers on the Control plots increased sharply. Numbers remained high on the Control plots throughout October (Table 3).

As measured in terms of dry weight consumed per feeding trial, no significant differences were observed in the amount of forage versus cracked corn for forage from each of the three types of plot (Table 4). High coefficients of variation in the measured values precluded a more detailed analysis of these data. A test for correlation (r) between the amount of forage consumed and the amount of corn consumed was performed using each month against each treatment group (Table 4). The test statistics (range - 0.320 - 0.389) in all 18 groups were not significant ($P > 0.05$) indicating that the meadow voles were not favoring the natural forage over the cracked corn at any stage in the study.

DISCUSSION

Mowing, especially on Short plots, produced a significant effect in most months on most forage parameters measured. Both moisture and protein content of forage remained significantly

Table 3. The density* of voles (per hectare) live-trapped under three mowing regimes from June to November, 1984.

Treatment	Trapping Session				
	June 2-7	July 31- Aug. 3	Aug. 27- Sept. 7	Oct. 3-6	Oct. 23-26
Short (10 cm)	ND	10	4	6	2
Long (20 cm)	ND	18	6	6	10
Control (unmowed)	39	20	18	72	44

* Number of voles per hectare is based on minimum number alive on two 2500-m^2 trap plots per treatment.

Table 4. Consumption rates (g/trial, N=19 or 20 for each value) of voles for Short forage and cracked corn, Long forage and cracked corn, and Control forage and cracked corn.*

Treatment	Voles	June	July	August	September	October	November
Short (10 cm)	Forage	2.875	-1.196	0.076	-0.029	0.612	1.714
	Corn	1.507	1.413	1.483	1.435	1.829	1.612
Long (20 cm)	Forage	-0.813	-0.686	0.186	-0.311	0.167	1.510
	Corn	1.844	1.210	1.667	1.641	1.910	1.409
Control (unmowed)	Forage	-0.226	-0.427	-1.184	0.798	0.931	2.052
	Corn	1.527	1.473	1.871	1.827	1.860	1.712

* No differences among treatments within months were significant ($p > 0.05$).

higher in mowed areas through late summer and fall, especially in November, whereas on the unmowed Control plots the forage species had already senesced. Mowed forage also had lower levels of lignin and fibre than did uncut grass. Therefore, mowing promoted new forage growth and retarded senescence significantly.

Belovsky (1984) has pointed out that protein or caloric content are good indicators of forage suitability for voles. Also, when voles are restricted to high fibre diets, they apparently suffer increased rates of mortality (Keys and Van Soest 1970). Our results show that mowing provides voles going into winter with forage that is higher in protein and moisture and lower in fibre and lignin; all advantageous to the voles in terms of foraging efficiency. Nevertheless, we observed no influx of voles onto the mowed plots, and in fact the only substantial increase in numbers occurred on the undisturbed plots. The major factor distinguishing Control from mowed plots is the availability of structural cover (Steele 1977) on the former. Dense cover (up to 120 cm in height) on the

Control plots reduces risk of predation for foraging voles and may also provide protection from climatic extremes. Even though the mowed plots were surrounded by large areas of undisturbed orchard that presumably harbored large numbers of voles, no voles moved into the mowed areas up to the end of October. It appears that meadow voles, given a choice between good cover and better quality forage choose the former. Orchards that have areas of good structural cover will retain higher numbers of voles, especially if a food resource base is available until November. Under these circumstances, there will certainly be a greater risk of winter damage. Cover quality may be the most important factor in attracting voles to the orchard environment.

Lack of a strong correlation between the amount of bait and amount of natural forage consumed in the laboratory experiments was surprising as we expected to observe shifts from natural forage to corn as the natural forage senesced (Pagano and McAninch 1983). The lack of apparent preference by the voles could have several causes, but most likely the presentation of a heterogenous mixture of plant species and parts in a confined area interfered with the normal foraging pattern of the test animals. Voles preferentially consume specific parts of specific plant species at different times of the year (Belovsky 1984). It is also possible that the measurable decline in forage quality was not sufficient to cause the voles to shift preferences to cracked corn. Future studies of this problem will require field tests of food preference and examination of stomach and fecal contents.

SUMMARY

Mowing increased moisture and protein content of forage species and reduced lignin and acid and neutral detergent fibre of forage. Fat and energy content of forage were not affected by mowing. Regular mowing greatly reduced numbers of voles compared to numbers in unmowed sample plots. These results suggest that structural cover is an important factor in attracting meadow voles to an orchard environment. Voles did not prefer natural forage over cracked corn throughout the nonwinter months, even when the forage had high levels of protein and moisture and low levels of indigestible fibre.

LITERATURE CITED

BELOVSKY, G.E. 1984. Herbivore optimal foraging: a comparative test of three methods. Am. Nat. 124:97-115.

BROOKS, R.J., AND S.A. STRUGER. 1982. A current assessment of vole damage and numbers and of methods used to control voles in Ontario apple orchards. Pages 3-11 in R.E. Byers, ed.. Proceedings of the Sixth Eastern Pine and Meadow Vole Symposium, Harpers Ferry, W.V.

______, AND ______. 1983. Economics and control of damage caused by low-density populations of meadow voles in Ontario apple orchards. Pages 48-56 in R.E. Byers, ed. Proceedings of the Seventh Eastern Pine and Meadow Vole Symposium, Harpers Ferry, W.V.

DAVIS, D.E. 1956. Manual for analysis of rodent populations. Edward Bros. Inc., Ann Arbor, Mich. 82pp.

GOERING, H.K., AND P.J. VAN SOEST. 1970. Forage fibre analysis. ARS, USDA Agr. Handbook 379. 20pp.

KEYS, J.E., JR., AND P.J. VAN SOEST. 1970. Digestibility of forages by the meadow vole (*Microtus pennsylvanicus*). J. Dairy Sci. 53: 1502-1508.

KREBS, C.J., B.L. KELLER, AND R.H. TAMARIN. 1969. *Microtus* population biology: demographic changes in fluctuating populations of *M. ochrogaster* and *M. pennsylvanicus* in southern Indiana. Ecology 50: 587-607.

PAGANO, R., AND J. McANINCH. 1983. The efficacy of several broadcast rodenticides in the mid-Hudson Valley, New York. Pages 25-41 in R.E. Byers, ed. Proceedings of the Seventh Eastern Pine and Meadow Vole Symposium, Harpers Ferry, W.V.

RENZULLI, C.B., J.F. FLOWERS, AND R.H. TAMARIN. 1980. The effects of trapping design on demographic estimates in the meadow vole, Microtus pennsylvanicus. Amer. Midl. Nat. 104:397-401.

STEELE, R.W. 1977. A demographic study of Microtus pennsylvanicus in relation to habitat structure. M.Sc. Thesis, University of Guelph, Guelph. 124pp.

STOCKRAHM, D.B., J. McANINCH, AND J.D. HARDER. 1981. Comparison of sampling designs for vole population studies. Pages 25-34 in R.E. Byers, ed. Proceedings of the Fifth Eastern Pine and Meadow Vole Symposium, Gettysburg, Pa.

STRUGER, S.A., AND R.J. BROOKS. 1984. The influence of orchard management practices on vole populations and damage levels. Pages 8-15 in R.E. Byers, ed. Proceedings of the Eighth Eastern Pine and Meadow Vole Symposium, Millbrook, N.Y.