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Voles Are Attracted to Fertilizer in Field Experiments

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Abstract

We estimated the abundance of voles, or vole nests, in four different experiments in the Boreal forest understory in the southwestern Yukon to test if voles were attracted to fertilizer. In one experiment we counted vole nests in plots that had been fertilized or not fertilized for 4 years; in a second we counted trapped voles in plots that has been fertilized, or not, for 13 years; and in two others we counted the number of vole visits to Longworth traps baited with fertilizer. There were significantly more over-winter nests in the fertilized plots. In a June trapping session, more voles were captured in fertilized plots than unfertilized plots and voles entered locked-open traps and removed fertilizer. The results demonstrate a relationship between fertilizer and voles. Whether voles are attracted to the fertilizer alone or the higher quality feed it produces remains unclear. A plausible, yet untested, hypothesis is that the voles were consuming the fertilizer as a source of micro- or macronutrients.

Introduction

Since 1986, a number of field experiments have been conducted in the boreal forest understory near Kluane Lake in the southwestern Yukon (Krebs et al., 2001). Many of these studies involved testing the relative importance of competition and herbivory in influencing the composition and abundance of the herbaceous and shrubby species (Turkington et al., 1998, 2002). Treatments in many of these studies involved the application of fertilizer and manipulations of herbivore densities, principally snowshoe hares and voles. There has been relatively little work done on the effect of fertilizer addition on the vole populations. Most work has focused on changes in the quality of plant food with increased fertilizer. For example, laboratory experiments have shown that fertilized plant material is more palatable to *Microtus* spp. than unfertilized feed (Rousi et al., 1993; Hartley et al., 1995). Similarly, *Clethrionomys rufocanus* voles in tundra plant communities preferred to feed and live in fertilized areas than unfertilized areas (Grellmann, 2002). However, in one of the few field experiments that examined the effect of fertilizer addition on the herbivore community, and microtines specifically, Ball et al. (2000) reported that there was a decrease in observed tracks and usage of fertilized plots during their winter sampling. Boonstra et al. (2001) also reported a decrease in *Clethrionomys* populations due to fertilization; however, *Microtus* spp. had an opposite response and increased with fertilization. This pattern was also observed in a field plant competition experiment where there was increased grass growth in the fertilized plots and more over-winter nests were observed in these plots (Treberg, 2007). Two obvious explanations for these observations are that voles may prefer nesting in fertilized plots because they offer a higher quality and abundance of food, and provide better cover and protection (Nams et al., 1993; Turkington et al., 1998). Alternatively, voles may be attracted to fertilizer and it is this hypothesis we test here.

Methods

SITE DESCRIPTION

The experiments were conducted near Kluane Lake in the southwestern Yukon (61°02′N, 138°25′W). The research was conducted in open and closed stands of white spruce (*Picea glauca*) which also has some balsam poplar (*Populus balsamifera*) and aspen (*Populus tremuloides*) in the overstory. The shrub layer is dominated by willows (various *Salix* spp.) and dwarf birch (*Betula glandulosa*). The understory is dominated by grass (mostly *Festuca altaica*), some low-growing woody species such as twinflower (*Linnaea borealis*) and bearberry (*Arctostaphylos uva-ursi* and *A. rubra*) and mixed herbaceous vegetation. The site is described in detail in Krebs et al. (2001) and Turkington et al. (2002).

The most common microtine rodents in the Kluane region are the northern red-backed vole (*Clethrionomys rutilus* although *C. gapperi* may also be in this range) and various *Microtus* spp., of which the meadow vole, *M. pennsylvanicus*, is the most abundant (Boonstra et al., 2001). Deer mice (*Peromyscus maniculatus*) were rarely captured. While every effort was made to identify all captured voles and mice to species, all are grouped together for the subsequent analyses. Of all the 210 captured voles and mice, approximately 58% were identified as *Microtus* spp., 39% *Clethrionomys* spp., 2% *Peromyscus maniculatus*, and 1% were unknown either because they escaped before identification or we couldn't identify them to species. Hereafter, all species will be referred to as voles.

VOLE NESTS OBSERVED IN FERTILIZED PLOTS

In 1999 an experiment was designed to determine the role of density dependence and increased productivity on the structure of the understory plant community. The experimental treatments included the manipulation of density from 1/16× the naturally observed density up to 2× the normal plant density crossed with

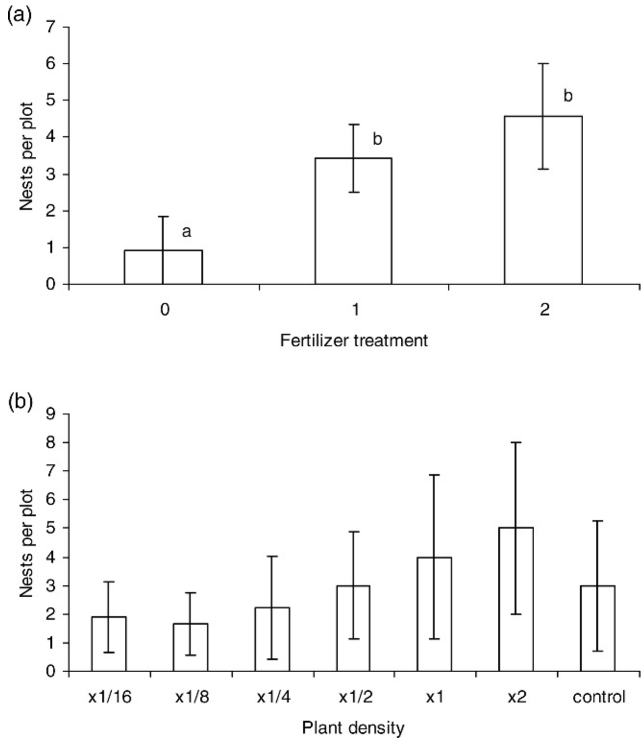

FIGURE 1. The mean number of nests per plot and 95% confidence interval as a function of (a) fertilizer treatment (averaged over all plant densities) and (b) plant density (averaged over the three fertilizer levels) in the field competition experiment. In (a), columns sharing the same letter are not significantly different ($P < 0.05$, Student's *t*). The control shown in (b) are those plots that did not undergo density manipulation but did have the three fertilizer treatments.

three levels of fertilizer addition. The fertilizer used in this study, and all of the following experiments, was a standard N-P-K granular fertilizer (Circle H Farms, 21-7-7 Spring Lawn Fertilizer, Nu-Gro Corporation, Woodstock, Ontario, Canada) applied after snowmelt, at the end of May or early June each year. Fertilizer was added at a rate of 13.1 g N m^{-2} yr^{-1}, 4.4 g P m^{-2} yr^{-1} and 4.4 g K m^{-2} yr^{-1} for the medium fertilizer treatment and double this rate for the high treatment. The low fertilizer treatment (control) had no fertilizer added. These rates of applications are within the range of other studies in this area that demonstrated a significant effect of fertilizer addition on plant growth (John and Turkington, 1997; Turkington et al., 1998, 2002; Dlott and Turkington, 2000; Arii and Turkington, 2002). In June 2002, all over-winter vole nests were counted in each plot. The number of nests per plot was analyzed using ANOVA with density and fertilizer addition as treatments.

VOLES CAPTURED ON LONG-TERM FERTILIZED PLOTS

A 2 × 2 factorial experiment (±fertilizer and ±fences; $n = 4$) using 5 m × 5 m plots at 2 sites has been running since 1990 (Turkington et al., 2002). In 2002 we trapped voles in these plots in mid-June. A Longworth mouse trap was placed at opposite ends of each plot (but more than 1 m in from the edge) in wire cages (to prevent squirrels from disturbing the traps). Prebaiting was done for 3 days before traps were set. Traps were baited with barley and a small slice of apple and were stuffed with a wad of cotton batting. Traps were set in the evening, checked and reset if necessary the next morning, checked and reset in the evening, and

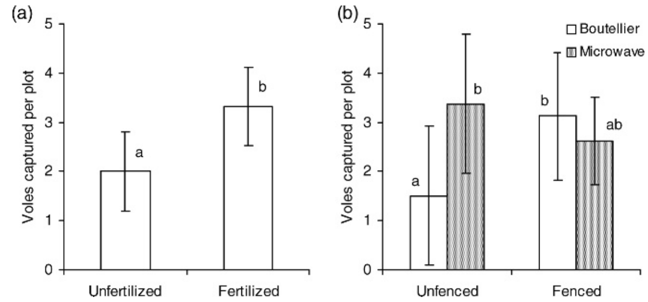

FIGURE 2. The mean number of voles captured per plot and 95% confidence interval during the June trapping session in (a) the fertilized and unfertilized plots and (b) the fenced and unfenced plots at the Boutellier Summit and Microwave Road sites. Columns sharing the same letter are not significantly different (Student's *t*, $P < 0.05$).

checked the last morning and then removed. All voles were identified to species and sex, were tagged, and then released. The number of voles caught per treatment was analyzed using ANOVA in JMP 4 (SAS, 1995).

VOLES CAPTURED IN TRAPS WITH FERTILIZER AS BAIT

To test if voles were attracted to fertilizer, 2 sets of 24 Longworth traps were set out at each of three different locations in July 2002. Traps were placed approximately 10 m apart in a grid, alternating between traps with regular bait and traps with regular bait + a small amount of fertilizer added (<1.0 g) to the bait. Traps were set for 3 consecutive days. All voles were identified to species and sex, tagged, and released. The number of voles caught per treatment was analyzed using ANOVA, and all species were combined. Site was considered as a treatment effect.

VOLES ENTERING LOCKED-OPEN TRAPS TO REMOVE FERTILIZER

In an additional test of whether voles are attracted to fertilizer, 10 Longworth traps containing no grain or apple bait, but only fertilizer, were set out for a 2 week period during July 2002, placed 10 m apart along a transect. The traps were locked open to allow the voles to enter and leave freely. Each trap contained 5 g of fertilizer and in the entrance to each trap, a small plastic plate covered with a thin smear of vegetable oil and dusted with talcum powder was placed to determine how many times voles entered and left the trap. Traps were checked twice daily for activity and categorized as "low" activity (trap entered 1 or 2 times), "medium" activity (entered 3 or 4 times), and "high" activity (entered more than 5 times). If a trap had been entered, the remaining fertilizer was weighed to determine how much fertilizer was removed.

Results and Discussion

In this study we observed a significant response by voles to the addition of fertilizer to vegetation both in terms of over-winter nests and more voles captured early in the season in fertilized vegetation plots. We also observed that voles remove fertilizer from traps that were locked open to provide unrestricted access, although we can not determine if the voles ate the fertilizer, or if they simply removed it.

No data were collected on the amount of fertilizer cached in the competition experiment plots. It was evident, however, that

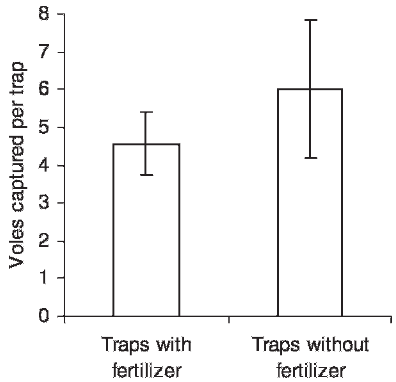

FIGURE 3. The mean number of voles captured per trap and the 95% confidence interval for traps with and without fertilizer included in the standard barley + apple bait.

there was higher winter activity and significantly more over-winter nests in the fertilized plots ($P < 0.001$) in the field competition experiment than the unfertilized plots (Fig. 1a). In fact, many of the vole nests contained caches of undissolved fertilizer that had been applied the previous spring. There was a trend towards increased nests with increased plant density but this was only marginally significant ($P = 0.058$; Fig. 1b). In addition, on long-term fertilized plots, more voles were captured in the fertilized plots than the unfertilized plots ($P = 0.017$; Fig. 2a). There was also a significant fence $\times$ site interaction effect ($P = 0.028$) in which fewer voles were captured on unfenced plots at the Boutellier site (Fig. 2b).

Adding fertilizer to the standard barley + apple bait had no effect on the mean number of voles captured ($P = 0.123$; Fig. 3), and the voles that went into a "fertilized" trap were just as likely to be recaptured in a "non-fertilized" trap and vice versa. In 2002, vole abundance was the highest recorded at Kluane since population surveys began in 1973 (39.5 voles ha^{-1}, C. J. Krebs, personal communication). It is possible that we may not have observed any of these patterns if it were not for the exceedingly high abundance of voles that year.

Traps that were locked open, with known masses of fertilizer, were entered beginning the first day they were set up (Fig. 4). The total amount of fertilizer removed, either by consumption or by being carried away, was not related to the number of traps entered (Fig. 4; $r = 0.356$, $P = 0.212$) and the mean mass of fertilizer removed per trap was not related to the estimated number of times that the traps were entered (Fig. 5; Wilcoxon Test, $P = 0.471$).

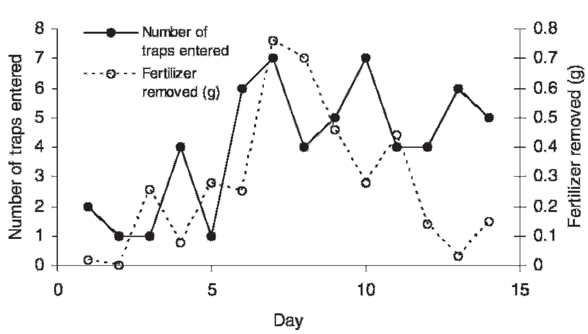

FIGURE 4. The number of traps entered per day (solid line and solid circle) and the total fertilizer removed (g) per day (dotted line and open circle). There was no correlation between number of traps entered and total mass of fertilizer removed ($r = 0.356$, $P = 0.212$). If only the first 9 days are used for analysis, then $r = 0.616$ and $P = 0.077$.

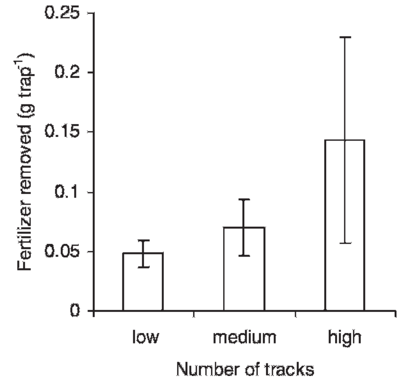

FIGURE 5. Mean mass of fertilizer removed (g trap-1) and 95% confidence interval depending on the number of tracks going into and out of the traps. There is no statistical difference between these classes (Wilcoxon Test, $P = 0.471$).

The removal of fertilizer from these traps suggests that the voles were influenced by more than quality food alone. A plausible, yet untested, hypothesis is that the voles were consuming the fertilizer as a source of micro- or macronutrients. One nutrient that many mammals require, including microtine rodents, is sodium (Robbins, 1993). In a field experiment, sodium soaked sticks were actively sought out and chewed by meadow voles (Hansson, 1990, 1991). There should not be excessive quantities of sodium in commercial fertilizer; however, other mineral constituents may attract the voles to the fertilizer.

These results demonstrate a relationship between fertilizer and voles. Whether voles are attracted to the fertilizer alone or the higher quality feed it produces remains unclear.

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