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Understanding Vole Problems in Direct Seeding-Strategies for Management

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Crop fields can provide habitat to a variety of wildlife and crop damage can result (Wywialowski 1996, 1998; Conover 1998). Among the vertebrates, damage can occur from numerous species of birds and mammals. Worldwide concern, however, has focused on rodents and a large number of species cause substantial agricultural losses each year (Witmer et al. 1995). After the advent of effective herbicides and "clean farming" practices in North America, however, many rodent problems became insignificant (Hines and Hygnstrom 2000). This is, in large part, because the fields were plowed each year, disrupting burrows and removing ground cover. The fields often lay bare a lengthy part of the year. The use of herbicides, plowing, and burning prevented the fields from developing the vegetative cover that wildlife needed for year-round food and shelter.

This situation has been changing in recent years. The use of conservation tillage or no-till agriculture is increasing across much of North America, in part because these methods conserve soil and water resources. Many problems can arise, however, and an integrated pest management strategy is needed to deal with weed, insect, and vertebrate pests that can proliferate and cause substantial damage in the no-till agriculture setting (Holtzer et al. 1996). When the ground is not plowed each year, crop residues are maintained, and surrounding areas provide good harborage for rodents, the potential exists for substantial increases in rodent populations and subsequent crop damage.

The microtine species group (Subfamily Microtinae, Nowak 1991) contains many species that are serious pests throughout the northern hemisphere. In North America, many of the pest species belong to the genus *Microtus*, commonly called voles or meadow mice. In this paper, we review the literature and provide background information on voles and the damage they cause. We also discuss management strategies that can help reduce agricultural damage by voles.

Vole Populations

The biology, ecology, characteristics, and distribution of voles have been summarized by Johnson and Johnson (1982) and by O'Brien (1994). Most species of voles live in colonies. They occupy a variety of habitats, but are mostly associated with grasslands. Voles are semi-fossorial with elaborate burrow systems. The burrows provide shelter from inclement weather and predators, a place to raise young, and a place to store food stuffs. The open holes to the burrows are golf ball-sized and are connected by a series of surface runways that are about 2.5-5 cm wide. Careful examination of the runways will often reveal clipped plants and fecal droppings.

Voles are active year-round and have many foraging bouts throughout the 24 hour day. They feed on a variety of plant materials and their feeding preferences shift through the seasons. Succulent grasses and forbs are used when first available in the spring and throughout the summer. From late summer through the fall, seeds are heavily used. During the winter, voles primarily feed on woody species as herbaceous foods are not readily available. Roots and tuberous materials are fed on throughout the year.

Voles have a high reproductive potential. They reach sexual maturity in a few months and females can have several litters of 3-6 young per year. On the other hand, annual mortality rates are quite high with 70+% of all voles dying within a year of birth. A large variety of mammalian and avian predators prey upon voles and vole survival rates are lowest where abundant, dense cover is not available. Vole densities vary, often dramatically, throughout the year. Low densities are common in the winter and spring and then increase substantially through summer and fall due to annual reproduction and recruitment. Dispersal by young animals into surrounding areas, including and crop fields, often occurs at this time. Over-winter survival depends greatly upon weather severity and food availability. Across a variety of habitats, densities of about 10-100 per ha are common (O'Brien 1994).

Superimposed upon the annual cycles of voles are multi-year cycles, often called irruptions, that occur in various parts of the world. Not all populations exhibit these cycles and they are not necessarily synchronized in neighboring regions. Peak densities occur every 3-5 years and ecologists are not sure just what causes them, despite intensive research efforts (Krebs 1996). Food and cover availability may drive the cycles, allowing very high densities to occur every few years. Weather patterns and nutrient cycles may be the causal agent(s) of food and cover availability. Predation pressure also plays a role and may depress low densities for a period of years between peak densities. Social behavior and spacing, and possibly genetics, may also play roles in the cycles. Johnson and Johnson (1982) describe some of the irruptions that have occurred in western states, including the substantial damage that resulted to agricultural crops, orchards, and rangeland and forest resources. Densities during these irruptions often exceed several thousand per ha (Johnson and Johnson 1982, O'Brien 1994).

Vole Damage

Most vole damage concerns center on agriculture and forestry. Voles do cause other kinds of damage, such as the undermining of dikes, levees, and irrigation ditches by burrowing; gnawing on cables and plastic tubing; and destroying lawns, golf courses, and vegetative ground covers. Although voles are susceptible to a number of diseases, they rarely pose a health threat to people, pets, or livestock.

In the course of their winter foraging activity, voles can cause substantial damage to berry bushes, orchards, woody ornamentals, Christmas tree plantations, and reforestation efforts. Damage to woody species may not be readily noticed because the roots are gnawed over time and stem girdling often occurs under snow cover.

Voles are often implicated in damage to certain field crops such as alfalfa, grains, soybeans, and sprouting corn. Voles and other rodents can dig up seeds, but damage often involves foraging on newly-emergent seedlings several weeks after planting (Hines and Hygnstrom 2000). In some cases, these rodents cause significant damage to root vegetables (carrots, sugar beets, and potatoes) especially in small gardens that border good vole habitat. During peak density years, voles may deplete forage on livestock pastures and rangeland. Clark (1984), Johnson and Johnson (1982), and O'Brien (1994) describe the nature of vole damage and give examples of substantial economic losses to apple and alfalfa production. Several researchers have described the substantial loss in corn yield and other crops that can occur when vole and other rodent populations are large (Clark 1984, Hines 1993, 1997; Hines and Hygnstrom 2000; Hygnstrom et al. 1996, 2000).

Population Monitoring

The importance of pest population monitoring or "scouting" as a component of integrated pest management (IPM) has received considerable attention in recent years (Matthews 1996). This certainly applies to vole populations because of their high reproductive potential and because once high densities (≥ 200/ha) are achieved, substantial damage is generally inevitable. A variety of methods have been developed for monitoring vole populations: use of live- or snap-traps along grids, use of apple slices or other food removal methods, and the counting of active colonies per acre (Clark 1994; Hines 1993, 1997; Hines and Hygnstrom 2000; Tobin et al. 1992; Tobin and Richmond 1993). Vole populations should be monitored in late winter or early spring, after snow-melt, and again just prior to planting. General guidelines indicate that vole population or damage management activities should commence if trap success is ≥ 10% or if ≥ 12 active colonies per ha are observed.

Management of Vole Populations and Damage

The traditional approaches to vole population and damage management have relied on direct reduction of the vole population using rodenticide baits or rodent traps, and the reduction of habitat carrying capacity for voles by habitat manipulation (Table 1; Clark 1984, Johnson and Johnson 1982, O'Brien 1994). Other approaches have been tried and research continues on new approaches (Table 1; Witmer et al. IN PRESS). The use of vole management techniques are described by Hines and Hygnstrom (2000) and by O'Brien (1994). Additionally, most cooperative extension services at state universities have booklets available on rodent control.

The rodenticides most commonly used in the United States for field rodent control are zinc phosphide (an acute toxicant) and chlorophacinone and diphacinone (anticoagulant toxicants). For vole control, rodenticide baits may be broadcast over entire fields, or just near burrows and runways, or may be placed in bait stations. Bait stations are often used to reduce the non-target hazard of these toxicants and to help protect the bait from weathering. The rodenticides are available in pelleted and grain formulations. Unfortunately, the use of rodenticide baits is greatly restricted on food crop fields once the plants are growing. It is important to check a database (such as PEST-BANK Pesticide Products Data, Purdue Research Foundation, West Lafayette, IN) or the state department of agriculture for the current status of rodenticide registrations in a particular state.

In recent years, zinc phosphide pellets (4.5-6.75 kg per ha) have proven effective in reducing rodent populations in no-till corn when applied in-furrow before planting or at planting time, and some EPA registrations for its use in corn, milo, and soybeans have been obtained (Hygnstrom et al. 2000, PEST-BANK Pesticide Products Data Base). It should be noted, however, that zinc phosphide is known to sometimes cause "bait shyness" in rodents. Consequently, bait efficacy can be improved by pre-baiting with a formulation that is very similar to the toxic bait, but does not contain the toxicant (Sterner 1999). Alternatively, one can switch the toxicant used if efficacy decreases or is too low. Ecologically-based baiting strategies have been developed and are thoroughly discussed by Ramsey and Wilson (2000), who have studied Australian rodent irruptions which have become a serious problem in grain and other crops.

The use of rodenticides is less restricted for rangelands, orchards, along fencerows, on right-of-ways, and in and around buildings. This is important to no-till agriculture because many of these areas have dense vegetation and serve as refugia for vole and other rodent populations. Due to the heavy reliance on herbicides in no-till agriculture and because there is relatively little organic debris or stubble on the ground, these croplands do not provide good year-round habitat for rodents. Rodent populations subsist in the bordering habitats and "invade" the cropland each year when the crops begin to grow, providing food and protective cover. Dispersing young animals are especially likely to invade, hence, strategies to keep rodent densities low in refugia can help reduce crop damage. Rodenticides should be applied to these areas in late winter or early spring (after snow-melt) when vole populations are low and reproduction has not yet commenced.

Snap traps can be used to reduce vole populations, but are labor-intensive and not very practical over large acreages. They are used mostly for population monitoring and for research purposes. They can be used, however, where the use of rodenticides is not allowed or desirable. Traps should be placed throughout the area of active vole colonies with a trap spacing of about 3 m between traps.

Encouraging predation is another way to reduce vole populations. This has been done in orchards by placing raptor perch poles and nest boxes at various locations (Askham 1990). While this approach may help reduce the problem, it will not be effective by itself.

Habitat manipulation has long been used as a way to lower the carrying capacity for voles. Voles need tall, protective vegetative cover. Mowing, burning, grazing, plowing and herbicide spraying have all been used effectively to reduce vole populations. Some of these methods could be applied to no-till agriculture fields. Additionally, these techniques could be used to manage or eliminate rodent refugia surrounding the no-till cropland.

Excluding voles from large areas is difficult and rarely practical, although wire-mesh barriers placed both above and below ground have been used in gardens and around individual trees. Some chemical repellents are registered for vole damage control, but these are only partially effective and not practical over large areas. Additionally, their use on food crops is usually restricted or not allowed. Some researchers have suggested, however, that predator odors (from urines, feces, or anal glands) may help exclude rodents from areas, although success rates are dependant upon cover availability and other factors (Merkens et al. 1991). Some electronic and magnetic devices have appeared on the commercial market, but these have not been found effective in eliminating rodents from fields or buildings. Some researchers have been investigating the use of unpalatable plants to reduce rodent populations in some settings. Endophytic fescue and perennial rye grasses may reduce rodent carrying capacity, but further investigation is needed (Fortier et al. 2000). Considerable research is underway in the area of wildlife fertility control (e.g., Miller et al. 1998), but it will probably be many years before a registered, commercial product is available.

A final method to consider that has proven effective in reducing vole damage in no-till corn and soybeans is the use of broadcast whole or cracked corn (or soybeans where they are to be planted) as a supplemental food source for the voles. This can be applied at a rate of about 125.5 kg per ha at the time of planting or several weeks post-planting, depending on when serious damage is anticipated (Hines and Hygnstrom 2000, Hygnstrom et al. 2000). The broadcast corn serves as a "lure crop" that diverts the feeding behavior from planted corn and the resultant seedlings.

Management Recommendations

Recommendations put forward by several researchers to reduce rodent damage in no-till agriculture include: 1) mow fields low in the fall, 2) check fields for rodent activity in late winter or early spring, 3) plan a damage prevention program if $\geq$ 12 active colonies are found per ha or $\geq$ 10% of traps have captures, 4) with high rodent activity levels, use an early pre-plant herbicide treatment about 30 days prior to planting, 5) if high rodent activity levels are still evident one week before planting, apply an alternative food (corn or soybeans) or in-furrow zinc phosphide pellets. An IPM strategy should be developed and implemented that includes assessment of predictive factors, a pest monitoring program, determination of damage management methods appropriate for the situation, and a reassessment and documentation of the results of the strategy used (Engeman and Witmer 2000).

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Table 1. Methods to reduce damage by voles.

Population Management	Habitat Management	Other Approaches
Rodenticide baits	Eliminate vegetative cover	Physical barriers
Traps	Manage or eliminate refugia	Repellents
Encourage predation	Disrupt burrows	Frightening devices
	Plant unpalatable vegetation	Supplemental feeding
		Fertility control

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