THE EFFECTIVENESS OF ORCO MOLE BAIT IN CONTROLLING MOLE DAMAGE

by

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ABSTRACT

The tunneling damage caused by eastern moles (Scalopus aquaticus) and starnosed moles (Condylura cristata) is well known to professionals in lawn care, golfcourse maintenance, and turfgrass production, as well as many private landowners. Present damage control methods, including trapping, gas and smoke fumigants, and insecticide applications have a wide variety of limitations and prove impractical in some situations. An easily applied mole damage control method is needed that professional and nonprofessional applicators can use in a variety of environmental and physical conditions.

This study tested the effectiveness of Orco Mole Bait, a chlorophacinone pellet placed in active tunnel systems. The bait was tested on both mole species, three soil types (sand, loam and muck), and two watering regimes (irrigated and not irrigated).

Orco Mole Bait was equally effective in controlling the damage caused by both eastern and starnosed moles. Captive moles readily accepted the dry, hard bait pellets. The average time to control in field trials was 30.3 days following first application (21.5 days on dry soils, 38.7 days on irrigated soils). The bait was effective on all three soil types, but irrigation appeared to lessen effectiveness. On untreated control sites there was no correlation between precipitation, evaporation, or average maximum and minimum temperature and mole activity. Multiple occupancy and/or rapid reinvasion of abandoned tunnel systems and the use of tunnels by other fossorial species occurred on several study sites.

Human alterations to the environment encourage mole activity. Several individuals utilized the areas beneath patios, wood piles and mulched areas for activity centers, and frequented artificial feeding sites such as birdfeeders.

Orco mole bait was a practical, effective mole damage control agent that was more easily applied than present damage control methods.

INTRODUCTION

Professionals in lawncare, golfcourse maintenance, pest control,and turfgrass production, as well as many private landowners, are well aquainted with the damage that moles can do. This damage, from disfiguring lawns and greens to creating hazards for people and machinery, is well documented (Eadie 1954, Dudderar 1977, Marsh & Howard 1978, Henderson 1983). Over time, many techniques have been suggested to control mole damage (Hanawalt 1922, Henning 1952, Eadie 1954, Marsh & Howard 1978, Ware 1980, Dudderar 1983a, 1983b, 1985, Henderson 1983, Benjamin 1985, Corrigan 1987). The most popular of these methods include trapping, gas and smoke fumigation, and insecticide applications. These methods are subject to a wide variety of limitations and prove impractical in some situations. Traps are easily mis-set and are conspicuous. The most effective fumigants are not available to non-professionals, and there are restrictions on use areas. Insecticides seem less effective on dry and organic soils, and there are restrictions on area and vegetation use after application.

Professional and non-professional applicators need an easily applied mole damage control method that can be used in a variety of physical and environmental conditions. The primary purpose of this study was to test the efficacy of Orco Mole Bait and compare it to other mole damage control methods. Orco Mole Bait is manufactured by Oregon Rodent Control Outfitters and is licensed for distribution within the states of Oregon and Washington.

The development of an effective damage control technique requires a thorough understanding of the species' physiology, population dynamics, habitat requirements, and habits. In reviewing the literature it becomes more obvious why we do not have a consistently reliable mole damage control method despite numerous attempts. While there is a preponderance of information concerning the population dynamics, social habits, tunneling behavior, and food preferences of moles (Slonaker 1920, Hanawalt 1922, Jackson 1922, Hamilton 1931, Arlton 1936, Eadie 1954, Eadie & Hamilton 1956, Godfrey 1957, Conaway 1959, Brown 1972, Giger 1973, Funmilayo 1976, 1977, Harvey 1976, Hartman & Gottschang 1983, Hickman 1983), much of this information is contradictory. Therefore, a second goal of this study was to collect observations on the tunneling activity and social habits of the two mole species that occur in mid-Michigan: the eastern mole (Scalopus aquaticus) and the starnosed mole (Condylura cristata). Specifically, information was collected on multiple mole occupancy in tunnel systems, the use of mole tunnels by other fossorial species, tunneling habits, and habitat preferences. Relationships between tunneling activity and rainfall, evaporation, and average maximum and minimum temperatures were also investigated.

METHODS

SITE DESCRIPTION

All studies were conducted in Meridian Township, in Ingham County, Michigan. Topographically, the county lies on a broad glaciated plain lying 200-600 feet above Lakes Michigan, Erie, and Huron. It is characterized by smooth or gently undulating topography, though some regions are choppy and comparatively hilly. Swamps and lakes are widely distributed. Originally the area was entirely forested, except the 3-4% of marshland and water (Sommers, 1977). The climate in the county is characterized by fairly cold winters and mild summers. The mean annual temperature is 46.9 degrees Farenheit (24.2 in winter, 68.6 in summer). The average length of frost free season is from May 3 to October 10 (160 days), but this period is shorter on muck lands. Normal annual precipitation is 31.43 inches, including melted snow. Yearly snowfall averages 47.4 inches (Michigan Weather Service, 1974).

Study sites were scattered throughout the county and grouped into three major soil types: 1) muck (Carlisle), 2) loam (Hillsdale sandy loam, Granby sandy loam, Walkill loam, Bellfontaine sandy loam), and 3) sand (Berrien loamy sand, Belfontaine loamy sand, and unknown backfill sands).

BAIT EFFICACY

Efficacy testing of Orco Mole Bait (active ingredient: chlorophacinone) was conducted July 10 to September 16, 1986. Testing was also attempted February 10 to March 15, 1987, but sporadic mole activity made testing impossible. Only tunnels currently active were used for study. Mole activity was determined by creating "activity assessment points" every 10 to 15 ft along all visible tunnels. The method by which the activity assessment points were created depended on the characteristics of the damage on a particular site. In shallow systems (designated eastern mole systems as described by Dudderar (1985)) the mole tunnels just below the surface of the ground, leaving raised ridges on the turf. These tunnels were marked by depressing short sections of tunnel or by poking a 1" hole in the top of the tunnel. In deep systems (identified as starnosed mole systems) the moles tunnel 4 to 20 inches below the ground surface, pushing the excavated earth up to the surface through vertical shafts. This results in large, coneshaped mounds on the surface of the turf. Deep systems were marked only by poking holes in the top of the tunnel, either directly in the middle of one mound or between two mounds. Activity assessment points were marked with spray paint for easy identification on subsequent visits. A tunnel was declared "active" if the activity assessment points on that tunnel were repaired 3 times in 5 days.

Ten starnosed mole sites and ten eastern mole sites were identified by the tunneling characteristics described previously. The sites were randomly assigned to control and treatment groups.

Bait application varied with the species of mole creating damage. In eastern mole systems, a small hole was poked in the top of the tunnel with a blunt probe. A teaspoonful of bait was put into the tunnel, and the hole plugged with a clod of dirt, wad of grass, or a piece of paper towel. Care was taken to keep the bait free of human scent and soil during application and hole plugging so the attractiveness of the bait was not reduced. Bait was applied in this manner every 10 to 15 ft. in all active tunnels. Starnosed tunnels were treated by driving the blunt probe through the soil between two mounds until the tunnel was located. A length of rubber tubing was then inserted into the tunnel and the bait was fed into the tunnel through the tubing. The tube was removed and the hole blocked in the same manner as eastern mole systems.

The same process was followed on control sites of both species, but no bait was applied before the holes were plugged.

Activity was monitored on all sites every 2 to 4 days after initial bait application. New damage was baited as soon as it was detected. Bait was reapplied to the entire treatment site if activity did not stop within 10 days. If activity did cease, activity points were monitored as usual for the remainder of the study.

WEATHER-ACTIVITY CORRELATION

Data to test for correlation between mole activity and average maximum and minimum ambient temperature, evaporation, and precipitation were collected July 1 to September 15, 1986. Nine control sites from the bait efficacy study were used to test for correlation. Activity was measured by using activity assessment points as described in the BAIT EFFICACY section. Ambient temperatures, evaporation, and precipitation data were obtained from the East Lansing post of the National Weather Service.

DATA ANALYSIS

As the study progressed, it appeared that soil type and watering regime affected bait efficacy. Therefore, the number of days until zero damage occurred on each site was compared by Analysis of Variance to determine bait efficacy and to detect effects of species type, soil type, and watering regime. Multiple regression analysis tested relationships between weather factors and level of activity. An Alpha level of .05 was used to test for significance in all cases.

RESULTS AND DISCUSSION

Species of mole treated was removed from overall data analysis for two reasons. First, there was no significant difference in time to control or percent activity between designated eastern and starnosed moles systems (Pr>F = 0.51). Secondly, the study showed that in Mid-Michigan one cannot correctly identify the species of mole in a tunnel system by the physical characteristics of that system as was previously thought (Dudderar 1985). On two occassions an eastern mole was collected from a designated starnosed system, and once a starnosed mole was captured in an designated eastern system. There are two explainations for this phenomenon. 1) These systems were originally constructed by the designated species then reinvaded by the "opposite" species, or 2) these moles constructed tunnels in response to soil type or soil condition, as Slonaker (1920), Hamilton (1931), and Harvey (1976) found, rather than to species type. Both of these situations are beneficial from an energy use perspective. Hisaw (1923), Arlton (1936), and Giger (1973) refer to the the tremendous amounts of energy that moles expend. Any energy conservation would be to the mole's advantage. It would require less energy to invade a vacated system than to construct a new one. Maintaining surface tunnels where the soil surface is regularly compacted by mowing, rolling, or freezing would be extremely energy intensive. In cases of such disturbance it would seem more energy efficient to construct a deep tunnel system one time rather than rebuild surface tunnels every 2-3 days.

Orco Mole Bait was effective. An average of 21.5 days was required to achieve zero damage on treated dry soils; 38.7 days on treated irrigated soils. On untreated dry soils and untreated irrigated soils activity continued for 50 days and 42.3 days respectively. There was a significant difference in the number of days to zero damage on muck (Pr>F = 0.0351), loam (Pr>F = 0.0453), and sand (Pr>F = 0.0351) (Table 1).

TABLE 1. Average number of days to zero damage

	TREATMENT			CONTROL		
	MUCK	LOAM	SAND	MUCK	LOAM	SAND
DRY	20	24	20.5	50	50	50
IRR.	34	32	50	36	50	41

*total number of observation days = 50

Analysis of Variance shows that irrigation significantly affects bait efficacy on sandy soils (Pr>F = 0.0026) but not on loam soils (Pr>F = 0.6477). Irrigation factors on muck could not be tested because of insufficient sample size. It should be noted that because the study was not originally designed to test for soil or water factors, small sample sizes make statistical analysis results of these factors questionable.

The authors suspect a significant difference between number of days to zero damage on irrigated and non-irrigated soils would occur with more repetitions within soil and irrigation types. An increase in number of days to zero damage due to high soil moisture might occur for two reasons. First, more earthworms and other natural food items would be present at the depth where foraging moles cause detectable soil disturbance. Therefore, the moles may not consume as much bait as they would when natural food items are less abundant. It should be noted that in limited laboratory bait acceptance tests, moles ingested lethal quantities of bait even when given free choice between the bait and ad libidum earthworm supplies. A second reason that excessive soil moisture may increase the length of time to reach control is that under these conditions the bait may become less palatable and therefore not be consumed. When bait was placed in a container of soil and left outside in an unprotected area for ten days, it was still intact but quite mushy.

Multiple mole occupancy or extremely rapid reinvasion of tunnels increased the number of days to zero damage. On two study sites activity persisted the day after moles were physically removed from the systems. On one of the sites an eastern mole was removed and activity continued at all activity points. This suggests that either more than one mole was concurrently using all parts of the tunnel system, or extremely rapid reinvasion occurred. At another site a starnosed mole was removed, and 2 days later an eastern mole was removed from the same site, approximately 20 ft from the point of the first capture. Following the removal of this second mole the system remained active but a consistent subset of points was not used again for 14 days. This suggests that the second mole may have had an established territory within the larger tunnel system, similar to Giger's (1973) findings with Scapanus. Multiple occupancy within a species has been confirmed by several studies (Hamilton 1931, Arlton 1936, Eadie & Hamilton 1956, Mellanby 1966, Harvey 1976), particularly if individuals are part of a family group or early pairs for the next breeding season. To the best of our knowledge, this is the first report of two different mole species occupying the same tunnel system, ruling out family grouping and early pairing for the breeding season. Rapid reinvasion of the systems is a possible but unlikely explaination for this situation. While reinvasion of vacated tunnels occured on several occassions (supporting Hartman & Gottschang's (1983) findings), no site in this study was clearly reinvaded for at least 14 days after the system was vacated.

In several instances a few sporadic activity points would be used after a system was evacuated. These intermittant, low levels of activity appear to be exploratory actions to determine the possibility of reinvasion. If this mild damage appeared soon (< 10 days) after the system was vacated, damage would cease without treatment. If the system had been empty more than two weeks, damage would dramatically increase after 2-3 days, indicating successful reinvasion.

Another factor that confounds damage control with Orco Mole Bait is the presence of other fossorial species in active and evacuated mole tunnel systems. Thirteen lined ground squirrels (Citellus tridecimlineatus), meadow voles (Microtus pennsylvanicus), short-tailed shrews (Blarina brevicauda), and two species of Peromyscus were live-trapped in either deep or shallow mole systems during this study. Hickman (1987) caught Microtus in Condylura systems, but this was the only reference to other species' use of mole tunnels found. When moles and other species were concurrently using the tunnel systems, it was difficult to detect the other species' presence and catagorize damage by species. Only upon closer inspection of root damage and length of time that activity occurred was there any indication of additional species' damage. After several bait applications the nature of the damage changed slightly, indicating that moles were eradicated from the system but non-target species were not.

Where shrews were co-occupying mole systems tunnels got smaller, more shallow, with more small (<1") holes in the tops of tunnels, and had more concentrated foraging areas. Where ground squirrels remained in previous mole tunnels, the tunnel diameters increased slightly and deep travel tunnels were very well maintained without the mounding typical of mole maintenance. There is some question why these non-target species were not eradicated during treatment. Non-target species may not find the bait attractive or palatable and therefore not ingest it. They may consume some bait, but not get a lethal dose either because there is an ample supply of preferred natural food items, they cache the bait, or they require a higher dose of bait than is applied for mole control. Shrew population levels may be high enough that while some individuals die, damage continues due to the remainder of the population. Rapid reinvasion of non-target species may occur. Whatever the case, the bait controlled mole damage with no apparent effect on non-target organisms utilizing treated tunnel systems. It is important to identify all species using these tunnel systems when treating damage, and damage control methods for these other species may need to be applied simultaneously or in succession to mole damage control with Orco Mole Bait.

Regression analysis showed no relationship between precipitation, average minimum and maximum temperatures, or evaporation and level of activity on 7 of 9 sites. A correlation between minimum average temperature ($Pr>F = 0.000$, $r^2 = 0.7147$) and negative correlation between maximum average temperature ($Pr>F = 0.000$, $r^2 = 0.6918$) and activity on one irrigated sand site, and between evaporation and activity on an irrigated muck site ($Pr>F = 0.001$, $r^2 = 0.6489$). However, because of the insufficient sample size we question these results and would assume type II errors in these cases.

Although moles prefer wooded, shady, moist areas (Arlton 1936, Godfrey 1957, Funmilayo 1977, Henderson 1983), they easily adapt and seem to be somewhat attracted to human alterations of the environment. Moles used some sort of microhabitat on 17 of 19 sites included in this study. Of the two sites that did not include microhabitats, one individual migrated to a vacated system with microhabitats, and the other succumbed to treatment within 4 days. These microhabitats are created by natural features such as the areas under trees, bushes, and rocks, and man-made features such as gardens and mulched areas, beneath decks and fences, under wood piles, and along building foundations and driveways. Several other authors found stumps, logs, etc. included in mole systems (Hamilton 1931, Arlton 1936, Henderson 1983, Corrigan 1987). These microhabitats are attractive to moles because of their higher soil moisture content and less compact soils, a combination that provides optimal foraging and tunneling conditions. Moles were highly attracted to the ground beneath birdfeeders and fruit trees. Under the fruit trees they were probably foraging on invertebrates that were attracted to rotting fruit on the ground. Moles were observed on several occassions foraging under birdfeeders and eating the seed that had fallen to the ground.

CONCLUSION

Generally, creating and maintaining a nicely landscape lawn is creating and maintaining good mole habitat. By creating protected areas under trees, shrubs, and wood piles, and easy travel routes next to foundations and driveways, prime nesting cover and forage areas are provided for moles. One way to control the damage of any species is to alter the habitat to make it less attractive to the animal. Few homeowners or groundskeepers would be willing to extensively alter lawn areas to make them less attractive to moles, so they need an easily applied, effective mehtod to eradicate moles. This study shows that Orco Mole Bait is a highly effective, easily applied mole control technique. However, there are disadvantages. Two or more successive treatments are often required, particularly where there is multiple occupancy and/or wet soil conditions. Damage must be correctly identified because the bait does not appear to be effective in controlling other fossorial species. Also, it is a toxicant which is hazardous if consumed by children or pets. On the other hand, the bait is inconspicuous and therefore more aesthetic and tamper resistant than traps. Unlike fumigants and insecticides, there are no restrictions on use areas and it appears to pose minimal hazard to non-target species.

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