Field Tests of a Warfarin Gel Bait for Moles

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Abstract: This paper discusses the more common methods of mole control used in the U.S. Field efficacy data are presented with a new product, Kaput® Mole Gel Bait, containing 250 ppm warfarin. Initial field studies in St. Louis, MO with a 500-ppm warfarin bait in 1998 yielded 50% efficacy within 5 days. The following year, a 250-ppm warfarin gel bait yielded 85% efficacy after 7 days of application. Field tests conducted in Ohio resulted in 90% control of eastern moles. Results from a field test in Oregon using warfarin alternate formulation and diphacinone gel baits demonstrated 47% and 80% control of Townsend's mole within 15 and 7 days respectively.

Key Words: mole, efficacy, warfarin, diphacinone, field study

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INTRODUCTION

Moles have been a menace to lawns and turf for many years by the damage inflicted by their burrowing activity and mound building. These small mammals are rarely seen. However, the effects of their burrowing habits are evident in the form of mounds and feeder tunnels beneath the ground surface that often result in damage to turf and lawns.

Seven species of moles are found in the U.S. These include the eastern mole *Scalopus aquaticus*, star-nosed mole *Condylura cristata*, hairy-tailed mole *Parascalops breweri*, broad-footed mole *Scapanus latimanus*, coast mole *S. orarius*, Townsend's mole *S. townsendii*, and shrew-mole *Neurotrichus gibbsii* (Gorman and Stone 1990). Of these, the eastern mole is the most wide-ranging (northeastern Colorado to the East Coast, down into Florida) and most damaging. Although 7 species of moles inhabit the Americas, compared to other small mammals the natural history of the mole remains relatively obscure.

BIOLOGY

Moles are solitary animals. Most U.S. species have a brief breeding season (February-March) with the female going into estrus only over a 36-hour period. During the brief mating, in which both male and female may occupy the same burrow system for only several days, the two then separate and occupy separate tunnels.

The gestation period on the average for the mole is 40 days. Following birth in the deeper tunnel nest, the female will care for the pups, 3-6 in total, for approximately 90 days, after which the juveniles disperse in search of vacant territory to construct their own network of tunnels. It is during this period that moles are most vulnerable to predation by domestic animals, such as dogs and cat, and wildlife, including foxes, coyotes, weasels, owls, and hawks. In studies on owl pellet research, juveniles comprised over 85% of mole remains found (B. Colvin, pers. comm.).

The life span of moles varies depending on the species and region of the world. About 50% of all juvenile moles die within the first 6 months of life. A study by Hartman (1995) on eastern moles showed that based on tooth wear, the mean and median of ages of trapped moles was about 2 years. The oldest mole trapped in this study was in its 7th year of life. Females lived up to 6.2 years and males 5.9 years.

Food habits in moles vary depending upon habitat and available of edible items. For the most part, moles rely on earthworms and grubs as the dietary staple. The Townsend's mole, however, has been report to eat vegetable matter, such as from gardens, which may sometimes comprise 20% of the diet (Kuhn 1979). A study by Hartman et al. (2000), however, found the diet of the eastern mole in South Carolina consisted of only 3% earthworms. The remaining most important foods were scarabaeid beetle larvae, ants, and centipedes. Ants (29 species) comprised 15% of the total diet volume. Data were obtained from 374 stomach contents.

Density estimates for moles vary between species and as with most wildlife is dependant on the density of prey items and social behavior of the species. Hartman and Krenz (1993), via extensive modeling, estimate that the average density of eastern moles was only 1 mole per acre. Kuhn (1979) stated that Townsend's mole may attain a density of 6 animals per acre. Regardless of the density, the aggressive nature of moles tends to limit the number of animals per unit area. There is no correlation between the number of mounds per unit area and mole density.

R. Leftwich (pers. comm.) stated that the eastern mole is extremely aggressive and will consume voles or mice that mistakenly enter its tunnel system. The exception lies with juveniles of the same litter before dispersal from the tunnel system of birth. Lawns with excessive mound-building activity may not necessarily mean the presence of numerous moles. The nature of the building is not completely understood. Observations with species from the Northwest seem to support the premise

that fewer surface feeding tunnels are necessary, since the depth of the rich food-laden soil makes tunneling only in the surface root system necessary. Digging at great depths also reduces the exposure to potential predators. An example of extreme density in mound-building was observed in Mary Moore Park, Bellevue, WA where one mound was observed every approximate 2-3 m.

CONTROL METHODS

Marsh (1962, 1996, 1999) discussed control methods used for species along the West Coast of the U.S. Trapping has been the most successful means of mole removal, however, experience at setting traps, such as the Out O' Site® scissor trap and the harpoon trap, is a necessity to ensure success. Traps have been used for many decades and a variety of designs and patents have been developed. Trapping was banned for use in trapping moles in Washington during 2001. The state of North Carolina lists moles as wild, non-game animals under game laws and no open hunting or trapping seasons are set up for these animals. There, moles are subject to applicable state laws and regulations and a landowner is required to purchase a permit to control moles (San Julian et al. 1984). The permit may authorize the use of firearms or traps but not toxicants.

Fumigants, such as carbon dioxide-generating cartridges, are available on the market. These are ineffective and labor intensive. Unpublished results from field test of several types demonstrate the inability of the smoke to penetrate sufficiently into the tunnel system. Field tests showed the maximum penetration of 5.5 m with a single cartridge (unpublished Genesis Laboratories data). Considering that the average mole may occupy a tunnel network of some 1,100 m length, the number of smoke cartridges along with labor required would make the undertaking cost prohibitive.

Repellents such as castor oil have limited success in terms of long-term damage control. Such products may force the mole into an adjacent tunnel system, or to the far end of its home range, until the effect of the repellent wears off within a matter of days. Although the effort may seem to benefit the homeowner, the problem has at best been relocated, and no control of numbers has been implemented.

Toxicants have been used for years, but with little success. Products containing chlorophacinone or zinc phosphide are commonly used. Unfortunately, these baits are available only as pellets or cracked grain. Since moles are primarily insectivorous animals, these baits are seldom consumed and consequently control may be minimal at best. Zinc phosphide may serve more as a temporary repellent, with the fumes driving the moles away for a brief time period. The possibility of moisture in the tunnel reacting with the zinc phosphide to form phosphine gas, the killing agent of the product, would negate the probability of horizontal penetration of the gas to achieve effective control.

A new product was approved by the EPA for mole control during 2001 and is marketed under the name Kaput® Mole Gel Bait (Scimetrics Ltd. Corp, Fort Collins, CO). The active ingredient is warfarin, formulated at 250 ppm in a thick water-based gel. The product is packaged in a 110-ml syringe. The tip of the syringe is inserted into the roof of the feeder tunnel near the surface or directly into the tunnel once dug open. If the tunnel system is opened, the bait may be injected on both sides and the opening covered carefully, so as not to cover the bait. The approved application rate is one syringe for each 0.1 ha of surface area.

During 1998 and 1999, and also during 2002, field studies were conducted to determine the efficacy of the formulations. For eastern moles, punching a 1-2 cm hole with the blunt end of a metal rod or wooden stick opened near-surface feeder tunnels. Holes were punched at about 7-8 m intervals in mole tunnel systems. Where no surface tunnels were evident but mound activity was apparent, a shovel was used to dig down into the systems (normally 5-25 cm beneath the ground surface). Two days later the holes were examined. If these were plugged closed by moles, each system was scored as active. An attempt was made to mark active 20 tunnel systems for control and treatment plots.

Kaput® Mole Gel Bait was then injected into the tunnels following label instructions. Six 14-cc injections, spaced at about 10-m intervals, were made in each active mole tunnel system. Each tunnel system was marked and numbered on maps. Surveyors flagging were used to label individual tunnel systems on the ground. Seven and 14 days later, the tunnels systems were examined for activity using the hole-punch method or burrow opening as during the pre-treatment phase. If activity remained, then a second application was made. When possible, the final index was established a minimum of 2 weeks after the initial application.

RESULTS AND DISCUSSION

Results of the field tests are presented in Tables 1 - 3. Control of eastern moles was easiest, since this species has more linear feet of near-surface tunnel systems to apply bait. Individual injections take no more than 1-2 minutes each. Once the tip of the syringe is removed, the small opening made by the tip is pinched closed with the thumb and forefinger. A 500-ppm warfarin bait attained 50% efficacy after 1 week of treatment. A subsequent study using 250-ppm warfarin yielded a 80% reduction in activity when used against eastern moles.

In 2002, field tests were conducted in Cincinnati, OH (G. Pancuck, pers. comm.). Kaput® Mole Gel Bait was applied to active tunnels as described in the use directions on the label. Ten separate lawns were baited and activity monitored pre and post treatment. Control of moles was in excess of 90% after 7 days. A second formulation, coded as Kaput-D, was also tested on 10 separate properties and the results were similar. The results are presented in Table 2.

Table 1. Results of eastern mole control field test in Missouri using Kaput Mole Gel Bait.

	Pre-Treatment Index	*Post-Treatment Index*	*Percent Activity Reduction*
Control	20	17	15
Treat 550 ppm	26	13	50% (5 days)
Treat 250 ppm	24	4	83% (7 days)

Table 2. Results of Townsend's mole control in Oregon using Kaput Mole Gel Bait (Gates and Mach 2002).

	Pre-Treatment Index	*Post-Treatment Index*	*Percent Activity Reduction*
Control	11	15	+18.2
Treatment (warfarin)[a]	15	8	-46.7
Treatment (diphacinone)[b]	10	2	-80.0

[a] 15 days after application
[b] 7 days after application

Table 3. Results of eastern mole control in Ohio using Kaput Mole Gel Bait.

	Pre-Treatment Index	*Post-Treatment Index*	*Percent Activity Reduction*
Treatment (warfarin)	16	1	94%
Treatment (diphacinone)	9	1	89%

During the spring of 2002, a field study was completed near Salem, OR. Two formulations of Kaput® were tested against 10 active Townsend's mole systems each. Since the mole species in the Northwest have different burrowing behavior, these are more time-consuming to control. A shovel was used to carefully open as a cross-section of the mole tunnel, and bait was applied to both sides of the tunnel. The dirt was carefully replaced and activity monitored. In a similar fashion, tunnel systems were excavated much the same as when setting an Out O' Sight® scissor trap. A 10-cm diameter plastic pipe, approximately 25-cm long, was carefully placed to connect the tunnels at opposite ends of the hole dug. The ends of the pipe when joining the soil was carefully filled to prevent blockage of the tunnel. This provided an artificial tunnel for a short section of the system. A 1-cm hole was drilled into the pipe at the top and center of the pipe. Kaput® Mole Gel Bait was then injected at a rate of 14 cc per placement. A piece of duct tape was secured over the opening to allow for future examination of bait acceptance and need to replenish when necessary.

Initial data showed a 50% reduction in mole activity after 7 days. Warfarin remains an effective compound; however, diphacinone and chlorophacinone may prove to be equally effective. Moles remain difficult pests to control. The mole gel baits offer another option for reduction of moles in areas of concern. These baits are easy to apply, safe when used correctly, and can be efficacious when used properly. Bait has to be injected directly into the tunnel to be effective. If the tunnel system is opened and injections made at both sides, then care must be taken not to cover the bait with soil when filling in the hole.

The use of plastic pipe as a bait station has utility. These can be used as bait stations around the perimeter of property, and they can be maintained monthly as with rodent bait boxes. Treatment of eastern mole tunnels is easier and fast. Species from the Northwest are a bit more time-consuming to bait and require that the burrows be dug open. Observations indicate that if a mole inhabits a tunnel system, the entire bait will be consumed with 1 - 3 days.

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