2000

Soil-Moisture Preferences and Soil-Use Behaviors of Northern Pocket Gophers

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ABSTRACT: Factors affecting soil-contact and -manipulation behaviors of pocket gophers (*Thomomys* and *Geomys spp.*) are poorly understood. Delineation of these behaviors is crucial to development of new repellent systems that seek to exploit the fossorial activity of these rodents. In a laboratory study involving northern pocket gophers (*Thomomys talpoides*), I examined the effects(s) of gravimetric soil moisture (i.e., 0%, 5%, 10%, 15%, 20%, and 25%) upon soil-contact and -use behaviors. Six gophers received successive, 0.5 h/day exposures to one of the moist soils compared to dry (0%) soil in a 2-choice apparatus. Times in each compartment and observed behaviors were recorded. A chamber x moisture interaction was attributed to the avoidance of 25% moist soil. A qualitative description of 37 locomotor, postural, sniffing, grooming, feeding, and soil-manipulation responses is provided.

KEY WORDS: behavior, gopher, moisture, soil, *Thomomys talpoides*

(March 6-9, 2000, San Diego, California)

Proc. 19th Vertebr. Pest Conf. (T.P. Salmon & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. 2000.

INTRODUCTION

Pocket gophers (*Thomomys* and *Geomys spp.*) have both beneficial and detrimental effects on rangelands. Their burrow- and mound-building activity is believed to decrease soil compaction and increase moisture retention (Foster and Stubbendieck 1980); whereas, these same activities destroy lawns, reduce forage, damage harvest equipment, and weaken impoundments (Case and Jasch 1994; Luce et al. 1981).

The fossorial behavior of pocket gophers is probably exploitable. Their subterranean activity predisposes direct, prolonged, dermal contact with soil media and in-soil chemicals; however, little is known of either the factors affecting soil-use preferences or specific soil-manipulation behaviors of gophers.

This study examined soil-moisture preferences and identified diverse soil-use-related behaviors of northern pocket gophers. The null hypothesis was that the duration of soil contact would be equivalent for gophers exposed to soils containing 5%, 10%, 15%, 20%, and 25% water compared to dry soil (0%).

METHODS

Gophers

Northern pocket gophers (N=35) were live-trapped using hinged-door, Mason-jar traps in irrigated alfalfa fields near Wellington, Colorado (CO License 96-0621). Upon capture, gophers were dusted for ectoparasites and quarantined for a minimum of 14 days. The colony was maintained in a temperature-controlled (20°C to 23°C) room; humidity was uncontrolled (typically this was 10% to 30%). Each gopher was housed individually in either standard stainless steel rack cages (25 x 20 x 18 cm) or polycarbamate cages containing bedding material with clip-on stainless steel lids that held a plastic water bottle (46.9 x 26.7 x 20.3 cm; Allentown Caging, Allentown, NJ). The maintenance diet included fresh carrot, plus *ad libitum* Purina Rodent Biscuits (Ralston-Purina, St. Louis, MO), and water; food and water were not available during behavioral trials. Lights were kept "off" in the colony room, except during times of maintenance or transport of gophers for test.

Soil

A sandy loam soil was purchased from a local supplier (Hageman Earth Cycle, Fort Collins, CO). Chemical characterization showed that the soil had a pH of 7.6 and was composed of 60% sand, 27% silt, and 13% clay, with 3.1% organic matter (Agvise Laboratories, Northwood, ND). Soil was dried thoroughly (5 to 10 days) either by spreading it onto a large plastic tarpaulin in an unused green house (daytime temperature and relative humidity [RH] typically >26°C and <25% RH, respectively) or by placing it onto metal trays in drying ovens (>32°C).

Soil-exposure Apparatus

The soil-exposure apparatus consisted of two polycarbamate cages that served as soil chambers (46.9 x 26.7 x 20.3 cm; Allentown Caging, Allentown, NJ); to prevent gophers from escaping during trials, identical cages with the bottoms removed were inverted and clamped on top of each soil chamber. Soil chambers were connected by a 8.9 cm outer diameter (o.d.) polyvinyl chloride (PVC) T-pipe (22.8 x 14.0 cm) that served as the "start and chamber-connecting" tube. Separate plastic guillotine doors (19 x 8.9 x 0.3 cm) were inserted into slots located 2.5 cm from the ends of each leg of the T-joint; these were opened simultaneously to allow gophers access to the two soil chambers at the start of trials. The legs of the T-joint were inserted into respective soil chambers through a 9.1 cm o.d. hole in adjacent ends of the chambers (~11 cm above base).

Procedures

Six gophers (gender unknown) having a mean (±SD) weight of 160.5 (±24.4) g at the start of trials were randomly selected from the available pool of gophers. Each gopher was observed during five consecutive, 30-min daily, soil-exposure trials. Trials were conducted

under low light (a small lamp with 25 watt bulb was positioned behind the "start" tube). A 2-choice paradigm was used to compare the gophers' behavior in each of the five mixtures (i.e., 5%, 10%, 15%, 20%, and 25%) versus dry (0%) soil; presentations of the five soil mixtures were varied across gophers to control for possible odor effects.

Immediately prior to soil-exposure trials, soil was reconstituted with appropriate amounts of water to either 0%, 5%, 10%, 15%, 20%, or 25% (wt:wt; 1 ml=1 g) moisture. Approximately 8 kg of dry soil afforded a 11 cm depth in a soil chamber. Briefly, thoroughly dried soil (dried for 5 to 10 days) was placed in a large food-type mixer bowl (Hobart, Troy, OH) with the paddle rotating at slow speed (~80 rpm), and the water was then added gradually until the mixture appeared uniform (~3 min). The apparatus was then positioned on top of a platform (30.5 cm high); the position (left or right) of the dry soil was assigned randomly. The soil-exposure apparatus was washed with soap and water using a commercial cage wash between trials; this reduced possible effects of conspecific odors affecting behaviors.

Following set up of the soil-exposure apparatus, a gopher was placed into the top of the T-shaped "start" tube. To begin the trial, an investigator pulled the dual guillotine doors releasing the gopher; cumulative time (sec) that the gopher spent in each chamber was recorded using separate stop watches. Discrete behaviors were identified using a sequential sampling approach (each occurrence of a behavior was recorded).

Cumulative time (sec) on each soil mix was analyzed as a mixed model analysis of variance (ANOVA) using PROC MIXED, with gophers considered a random effect (SAS Institute, 1992). The ANOVA involved a two-way, completely-crossed design (2 chambers x 5 moisture values) (Winer 1971). Significant sources of variance were further assessed using Tukey or Tukey-Kramer post-hoc mean comparisons at the 0.05 level of significance (SAS Institute 1987).

RESULTS AND DISCUSSION

Soil Preferences

The ANOVA for soil-contact time yielded a chamber x moisture interaction [$F_{4,40}$)=4.26; p=0.0057] (Figure 1); none of the main effects were significant [chamber: $F_{1,10}$=0.11; p=0.7492; moisture: $F_{4,40}$=0.08; p=0.9879]. While gophers spent between 89% and 94% of the 30-min trials in soil chambers (remainder of time spent in "T-tube"), post-hoc Tukey-Kramer tests indicated that the interaction was due to the reversed chamber preference in the 25%- versus 0%-moisture condition—a mean 668.3-sec difference in favor of dry soil (see Figure 1). These moisture x chamber cells of the design yielded much greater contact times for "dry" soil. Typically, the gophers sank partially into the 25% "slurry," then spent considerable time in the "dry" chamber grooming the mud from feet and pelage. Still, this soil contact was not a "one time" event; most gophers made several trips into the "slurry" during the trial.

The null hypothesis was rejected—northern pocket gophers avoided the extreme soil-moisture condition, displaying less soil contact with the 25% "slurry." Northern pocket gophers preferred contact with soils containing 10% to 20% moisture and avoided soil having 25% moisture. Miller (1964) described this species as more adaptable to a wider range of soil conditions (i.e., composition, moisture) than *Geomyidae*.

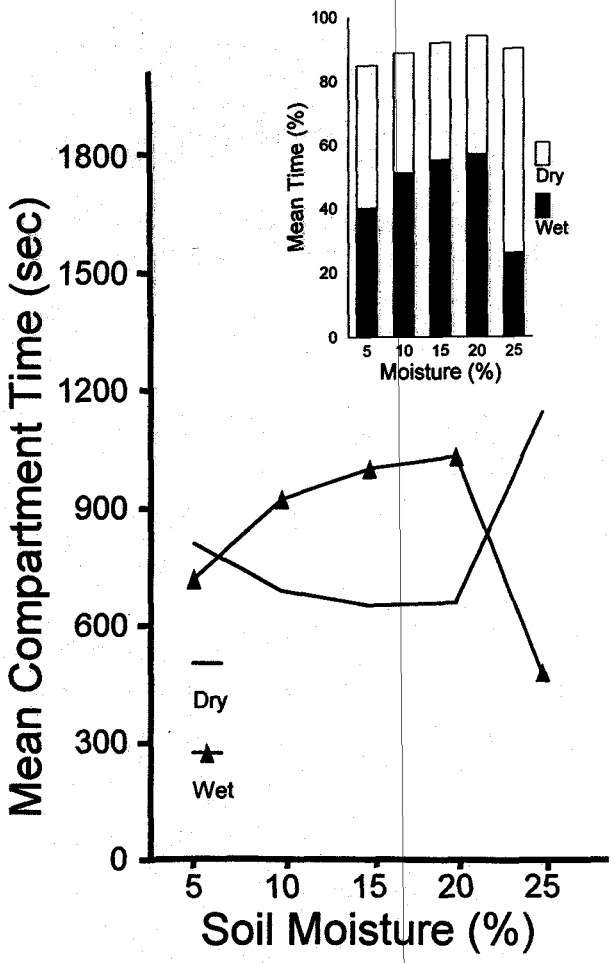

Figure 1. The chamber x moisture interaction for compartment times of gophers exposed to choices of 0% versus 5, 10, 15, 20, and 25% soil moisture during separate 30-min trials. Note: The inset shows the mean percent time that gophers spent in soil and the relative time in the wetter chamber relative to the total trial duration (i.e., inset plots do not add to 100% because gophers spent the remaining time in the chamber-connecting tube).

In soil containing ≤20% moisture, most gophers attempted to burrow, then pushed volumes of soil away from potential sites using their forelegs and breast in "bull dozer" fashion. Upon depositing soil, the animals tamped it lightly. Soils containing 5% and 25% gravimetric moisture proved difficult for the gophers to "work"; tunnels collapsed or could not be formed in these soil conditions. The 25%-moist soil also adhered to the gophers' fur which increased grooming activity.

Soil-use Behaviors

Six main behaviors (37 specific responses) linked with potential soil exposure were observed: locomotion, body

posture, sniffing, grooming, feeding, and soil manipulation (see Table 1). All gophers showed rapid acclimation to the apparatus and soil in the laboratory; initial exploration of soil chambers and release tubes occurred within 5 min of release and soil-manipulation behaviors occurred invariably within 10 min of exposure.

Table 1. List of soil-use behaviors observed for the northern pocket gopher.

Behavioral Category and Description
Locomotion
quadrupedal
walking
running
bipedal hop
Body Posture
sitting prone
legs/nose withdrawn
legs/nose extended
sitting (rear legs)
standing (rear legs)
Sniffing
air
objects
soil
Grooming
licking fore paws (left or right)
licking rear paws (left or right)
scratching
mouthing pelage
left hip
right hip
wiping hip pelage with fore paws
left hip
right hip
wiping face with fore paws
overhead major (left and right)
overhead minor (left and right)
Feeding
food handling (fore paws)
biting
chewing
cheek-pouch filling
Soil-manipulation
dig
fore paws
rear paws
dirt throw (rear paws)
soil moving ("bulldozing" with forelegs)
tamping
fore paws
fore paws-rear paws
"moonwalking"

Locomotion. Three types of locomotor movements were noted: quadrupedal walk, quadrupedal run, and bipedal hop. Typically, the gophers would walk on all fours, but running was often observed as the animals removed soil during tunneling, pushed some soil out of the way, and then ran back to the spot to remove more soil. The bipedal hop occurred as the gophers would raise themselves against the sides of the soil chambers, then bound laterally along the cage wall; the gophers were able to hop without support across the soil surface for short distances (<30 cm).

Body Posture. Four postures were observed—three sitting (i.e., sitting prone with legs/nose withdrawn, sitting prone with legs/nose extended, or sitting on hind legs with front legs extended in support of the trunk); and one standing posture (i.e., standing, raised on hind legs). Gophers would frequently sit in an apparent restive manner with their legs/paws drawn beneath them and their jaw placed low on their fore paws and extending onto the soil. A related version of this posture occurred subsequent to the more restive posture, as the animal prepared to walk/run or showed arousal to sounds, odors, etc.; this involved simple extension of the limbs and nose as the gopher became more alert. Sitting on the hind legs using the forelegs (extended) for support was a common grooming posture. Finally, standing, raised on hind legs occurred as gophers prepared to display the bipedal hop, but several animals displayed this rearing behavior without hopping.

Sniffing. Sniffing was noted frequently during exploration of the soil chambers. Sniffing of the air usually occurred early in trials during exploration of the soil and apparatus; this often involved standing (hind legs) posture. Sniffing the soil occurred frequently; this involved close, intense olfactory sampling of 2 to 5 cm areas of soil. (Note: Soil was dried and reconstituted prior to tests; cages were washed and dried between trials.) On several occasions, gophers sniffed (close, intense) and ate debris that was present in the soil (e.g., roots, twigs).

Grooming. Six main grooming responses were identified, with three of these involving bilateral movements on either side of the body or head. Preening of the fore paws and rear paws was noted (gophers dislodged moist soil from between their claws using incisors and mouth). Scratching of the pelage, especially in the vicinity of the left and right hip, was observed. Mouthing of the pelage was noted (mostly over the left and right hips), with forepaw manipulation of the pelage behind the incisors performed by some gophers; the pelage over the hips was also stroked with the fore paws. Wiping the head and nose with the fore paws was similar to the "overhead major, left, and right" and "overhead minor, left, and right" responses described by Fentress (1972) for mice. These movements involved animals moving the left or right fore paw over the left or right ear, respectively, and down the length of that side of the head; "overhead minor" responses start near the left or right eye and proceed to the nose (see Fentress 1972).

Feeding. Four distinct feeding responses were observed. Food handling with the fore paws was serendipitous; numerous gophers found and investigated small bits of plant roots, bark, insects, etc., present in the soil. These items were usually manipulated with both fore paws and then sniffed and nibbled. Biting of food objects involved the incisors, while chewing involved the premolars and molars. Cheek-pouch filling was difficult to detect, but some gophers definitely moved food objects into the cheek pouch and later redeposited these onto the soil surface.

Soil-manipulation. Soil-manipulation behaviors involved four distinct responses. Digging involved predominantly fore paw scratching motions, but some digging with the rear paws occurred. Canine-like, dirt-throw (rear paws) responses accounted for only a minor portion of the digging behavior. By far, the most impressive soil-manipulation behavior observed was the "bulldozing-like" action of the gophers using the fore paws and breast—a behavior previously noted for both gophers and rats (see Case and Jasch 1994; Barnett 1963); loosened soil was literally scooped against the breast with the fore paws and pushed out of the way—some as far as the other chamber (60 to 80 cm). After pushing soil away from dig sites, animals frequently spent 10 to 30 sec tamping the soil with the fore paws or both fore paws and rear paws. Finally, a unique behavior best described as "moonwalking" (i.e., several gophers appeared to move forward while actually walking backwards) was observed; this behavior could possibly be a form of tamping or else backing related to getting out of confined tunnel spaces without turning.

CONCLUSIONS

Northern pocket gophers displayed a transitive increase in preference for soils containing 10% to 20% gravimetric moisture. A chamber x moisture interaction was attributed to their avoidance of 25% moist soil. A total of 37 discrete locomotor, postural, sniffing, grooming, feeding, and soil-manipulation responses were observed for the animals. Soil-manipulation behaviors for this species were greatly reduced under conditions of both 0% and 25% gravimetric (wt:wt) moisture.

ACKNOWLEDGMENTS AND DISCLAIMER

I thank Albert Dale and the Animal Care Staff for maintenance of the gopher colony; Stanley Gaddis for assistance with the conduct of trials; and Bruce Kimball and Kathleen Fagerstone for helpful critiques of the manuscript.

Use of trade names does not constitute endorsement by the Federal Government.

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