Florida Field Naturalist

PUBLISHED BY THE FLORIDA ORNITHOLOGICAL SOCIETY

VOL. 22, NO. 1 FEBRUARY 1994 PAGES 1-28

Fla. Field Nat. 22(1): 1-7, 1994.

PERCEPTIONS OF GOPHER TORTOISE BURROWS OVER TIME

HENRY R. MUSHINSKY[1] AND LAURA A. ESMAN[2]

[1]*Department of Biology and Center for Urban Ecology, University of South Florida, Tampa, Florida 33620 and*

[2]*Archbold Biological Station, Box 2057 Lake Placid, Florida 33852*

Abstract.—We address some of the problems associated with surveying gopher tortoise burrows to determine the number of tortoises present at a site. We monitored 50 gopher tortoise burrows for two months at Archbold Biological Station and recorded the number of times a burrow changed its perceived condition. Burrows first judged to be active were active on more days than those first judged to be inactive or abandoned. Rainfall on the day of a survey caused more burrows to be judged inactive. The physical structure of the microhabitat immediately outside a tortoise burrow reflects the perceived condition of the burrow.

Unlike many fossorial reptiles, gopher tortoises (*Gopherus polyphemus*) excavate burrows, which reveal their presence at a given location. Using tortoise burrows to assess tortoise abundance is problematic, however. Assessments are based on assumptions regarding the relationship between the physical appearance of a burrow and the presumed inhabitant of that burrow (Auffenberg and Franz 1982). Two salient features of burrows are their widths and their perceived conditions. A positive correlation of tortoise carapace length with burrow width (Alford 1980, Martin and Layne 1987) facilitates using burrow widths to assess the frequency of tortoise size classes (Alford 1980).

Counts of burrows that are likely occupied or could be occupied by individual tortoises often are used to estimate the size of a tortoise population (e.g., Cox et al. 1987). Auffenberg and Franz (1982) suggested that one could multiply the number of active and inactive burrows in a population by a "correction factor," 0.614, to determine the number of tortoises in a population. They categorized the condition of a burrow to be "active" if the soil at the burrow opening recently had been disturbed, "inactive" if the soil was undisturbed but the burrow appeared to be maintained, and "old" (abandoned) if the mouth had been washed in or was covered with debris.

Gopher tortoises spend much of their lives underground in burrows. Auffenberg and Iverson (1979) found that during a 13-month period, one adult male gopher tortoise left his burrow slightly more than half the days. Tortoises also are known to use several burrows over relatively short time periods. Several studies document use of more than one burrow by a gopher tortoise (Wilson et al. in press, Diemer 1992), but no published studies address the frequency of changes in the condition of a tortoise burrow over time. We collected data to address the following questions. 1. How frequently do gopher tortoise burrows change condition? 2. Does the rate of change vary among burrows initially perceived as active, inactive, or abandoned? 3. Does rainfall on the day before, or the day of, sampling influence burrow condition? 4. Does the microhabitat surrounding the burrow mouth vary according to the burrow condition?

Materials and Methods

From 4 June through 3 August 1990, we monitored 50 gopher tortoise burrows on a small portion of Archbold Biological Station, Highlands County, Florida. We used the first 50 tortoise burrows that we encountered in a scrubby flatwoods portion of the Station. Our study area was partially confined by railroad tracks on one side and seasonal wetlands surrounding the remainder of the site. Tortoises, however, could move into or out of our study site. We used the presence of footprints or plastron abrasions in the opening of a burrow as an indicator of an active burrow and the lack of these signs in an otherwise usable (maintained) burrow as an indicator of an inactive burrow. We classified a burrow abandoned if the opening of the burrow was overgrown with vegetation or collapsed and in need of some excavation by a tortoise prior to occupancy (Mushinsky and McCoy in press).

Initially, we classified the condition of each burrow and made a visual estimate of the amount of bare ground, number of living plants, and the amount of litter covering the burrow mound immediately outside each burrow (about 1 m^2). All burrows were reclassified every second or third day, or about 25 times each during the two months of the study. We noted the occurrence of rainfall the day before, and the day of, each visit to the burrows in the study area. We measured burrow width at a depth of 50 cm (Martin and Layne 1987) to compare the initial size distribution of burrows of different conditions used in our survey.

We used ABSTAT (Anderson Bell, Inc.) for statistical analyses. Exact probabilities are given if $P > 0.001$. We used Mann-Whitney U Tests to evaluate differences in widths of burrows by condition category, changes of classification over time, and differences in the microhabitats surrounding burrows of different conditions. Chi-square goodness of fit tests were used to compare burrow classification frequency data in response to rainfall (Sokal and Rohlf 1981).

Results

Initially we classified 15 burrows as active, 25 burrows as inactive, and 10 burrows as abandoned. Burrows were monitored for a total of 1277 burrow observation days, during which we recorded 147 burrow condition changes. Burrow classifications varied among surveys. Table 1 illustrates several examples of our burrow surveys. We judged between

Table 1. Selected examples of surveys of burrow condition (1 = active, 2 = inactive, 3 = abandoned) from a single or two-day survey interval. A = the occurrence of rainfall on the day of, but prior to, our survey(s); B = rainfall within the previous 24 hours. Percentages are shown in parentheses.

	Burrow condition			Rainfall	
Date(s)	1	2	3	A	B
12 June	14 (28)	26 (52)	10 (20)	no	yes
14 June	17 (34)	23 (46)	10 (20)	no	no
20-21 June	26 (52)	15 (30)	9 (18)	no	yes
29-30 June	15 (30)	26 (52)	9 (18)	yes	yes
6-7 July	18 (36)	23 (46)	9 (18)	no	yes
9-10 July	18 (36)	23 (46)	9 (18)	yes	yes
15 July	18 (36)	23 (46)	9 (18)	no	yes
19 July	24 (48)	17 (34)	9 (18)	no	yes
26 July	17 (34)	24 (48)	9 (18)	no	yes
3 August	16 (32)	25 (50)	9 (18)	no	yes

14 and 26 of 50 burrows to be active during our study. Burrows that were first classified as active changed classification (Table 2) more often than inactive burrows ($Z = 2.59$, $P = 0.005$) or abandoned burrows ($Z = 3.85$, $P < 0.001$). Inactive burrows also changed classification more often than abandoned burrows ($Z = 2.28$, $P = 0.011$). One of the 10 burrows first judged to be abandoned changed categories. Once it became an active burrow, it alternated between the active and inactive condition. All (15) burrows first judged to be active and 15 of 25 (60%) inactive burrows changed categories at least once during our surveys. Nine of 15 active burrows (60%) and 7 of 25 (28%) inactive burrows changed categories five or more times during our study. Burrows first classified as active were active on significantly more days than were initially inactive ($Z = 3.38$, $P < 0.001$) or initially abandoned ($Z = 4.13$, $P < 0.001$) burrows. Also, burrows first classified as inactive were subsequently classified as active on more days than burrows first classified as abandoned ($Z = 2.35$, $P = 0.009$). Hence, the frequency of burrow condition changes forms a hierarchy such that active burrows change more often than inactive burrows, which change more often than abandoned burrows.

Because most rainfall occurred in the late afternoon after our surveys, our sample of burrows on rainy days is relatively small (Table 3). Nevertheless, when we compared the frequency of burrow categories on days it rained with those on days it did not rain (prior to our survey), we found fewer burrows were classified as active on days with rain than on days without rain ($\chi^2 = 10.27$, $df = 2$, $P = 0.006$). No difference in burrow condition category frequencies was associated with rainfall on the day before our sample ($\chi^2 = 0.48$, $df = 2$, $P = 0.78$).

Table 2. Gopher tortoise burrows monitored at Archbold Biological Station. Data presented are mean values ± 1 SE.

	Initial burrow category		
	Active	Inactive	Abandoned
Number	15	25	10
Burrow width (cm)	24.0 ± 1.3	23.9 ± 1.6	18.0 ± 3.8
Days monitored	54.7 ± 1.1	55.7 ± 0.7	57.6 ± 0.9
Times monitored	25.0 ± 0.9	25.4 ± 0.6	26.9 ± 0.8
Condition changes	5.1 ± 0.7	2.6 ± 0.6	0.4 ± 0.4
No change	0	10	9
Days active	38.8 ± 3.8	14.9 ± 3.9	0.7 ±0.7
Days inactive	16.2 ±3.6	38.5 ±4.3	3.4 ±3.4
Days abandoned	0	2.3 ±2.3	53.5 ±4.1

Abandoned burrows were associated with more litter (Table 4) than were active burrows ($Z = 2.86$, $P < 0.002$) or inactive burrows ($Z = 1.99$, $P < 0.023$). Active burrows differed from inactive burrows in amounts of litter found at the burrow opening ($Z = 2.23$, $P < 0.013$). No difference was found in the percent of ground covered by living plants near active or inactive burrows ($Z = 0.50$, $P = 0.30$). Abandoned burrows were associated with more living plants than inactive burrows ($Z = 2.28$, $P < 0.011$), but not more than active burrows ($Z = 1.53$, $P < 0.063$). Abandoned burrows were associated with less bare ground than active ($Z = 2.97$, $P < 0.002$) or inactive ($Z = 2.68$, $P < 0.004$) burrows.

Discussion

Gopher tortoise burrow condition shows considerable day-to-day variability. Burrow condition changes frequently, more so in burrows that are first judged to be active. During June and July one would expect a high level of tortoise activity. Gopher tortoises, especially young individuals (Wilson et al. in press), are known to visit and maintain several nearby burrows; therefore, frequent burrow status changes appear to be natural rather than induced by our presence or disturbance.

By monitoring changes in burrow condition over a two-month period, we found that 100% of the burrows first classified as active subsequently showed signs of tortoise activity. About 60% of tortoise burrows first judged to be inactive later showed signs of activity during our study; hence, one must be cautious about the presumed vacancy of inactive burrows. With one exception, abandoned burrows remained unchanged.

Our perception of the condition of a burrow on our initial survey was a reasonable representation of what was to follow. Burrows first classified as active also were judged active for 71% of our observation period,

Table 3. Percent frequency of burrows judged to be active, inactive, or abandoned and the occurrence of rain on the day of a survey (rain today) or the day before (rain yesterday) our sample. *N* = number of burrow observation days in each category.

	Rainfall categories			
	Rain today	No rain today	Rain yesterday	No rain yesterday
N	127	1150	701	576
Active	22.8	35.5	33.2	35.5
Inactive	60.6	45.1	48.1	44.6
Abandoned	16.5	19.5	18.7	19.8

and initially inactive burrows were judged active for about 27% of the same period (Table 1). We believe that our findings partly reflect movements of individuals among the burrows we surveyed. Our findings underscore the value of habitat-specific correction factors which reflect accurately the relationship between tortoises and burrows (Burke 1989, Witz et al. 1992).

Recognizing our stringent definitions of burrow condition categories, we cannot determine whether rainfall curtails daily tortoise activity and/or obliterates the signs of tortoise activity we used to judge a burrow to be an active one. More burrows were judged to be inactive on days it rained than on days it did not rain prior to our surveys. We suggest that researchers recognize that rainfall on the day of sampling will cause a reduction in the estimated number of active burrows, regardless of the cause (McCoy and Mushinsky 1992).

The physical structure of the microhabitat immediately outside a tortoise burrow reflects the perceived condition of the burrow. Less litter is found outside an active burrow than outside inactive burrows or abandoned burrows. The amount of litter that accumulates near a burrow is habitat-specific. In a given habitat, however, relatively high amounts of litter accumulation near the mouth of a burrow may be used to verify classification as abandoned.

Table 4. Visual estimates (mean ± 1 SE) of the percent of bare ground, living plants, and litter found on the spoil mounds surrounding the burrow mouths. Estimates were made during the initial survey of each burrow.

	Burrow status		
	Active	Inactive	Abandoned
Bare ground	88.0 ± 3.6	80.9 ± 4.4	49.5 ± 10.3
Live plants	9.8 ±3.4	9.8 ±3.3	21.2 ± 7.5
Litter	2.2 ±0.7	9.2 ±2.7	29.3 ± 8.8

Kaczor and Hartnett (1990) monitored plant species richness on gopher tortoise burrow mounds in a sandhill community in central Florida and found that old (abandoned) mounds contained a larger number of species per square meter than did recently abandoned (inactive) burrows. In scrub habitat, we found that abandoned burrows were associated with more living plants than were inactive burrows; however, the percent of a burrow mound covered with living vegetation did not differ between active and inactive burrows nor between active and abandoned burrows. As there is no distinct boundary between the inactive and abandoned burrow condition, the amount of vegetation growing on the burrow mound may serve as a habitat-specific indicator of this transition.

ACKNOWLEDGMENTS

We thank Earl McCoy for stimulating conversation regarding tortoise burrows, Paige Martin and Jennifer Walcott for their assistance with the field work, and Dawn Wilson, Peter Meylan, and Earl McCoy for reading previous versions of this manuscript.

LITERATURE CITED

ALFORD, R. A. 1980. Population structure of *Gopherus polyphemus* in northern Florida. J. Herpetol. 14: 177-182.

AUFFENBERG, W., AND R. FRANZ. 1982. The status and distribution of the gopher tortoise (*Gopherus polyphemus*). Pages 95-126 *in* North American Tortoises: Conservation and Ecology (R. B. Bury, ed.). U. S. Dept. Interior, Wildl. Res. Rep. 12, Washington, D. C.

AUFFENBERG, W. AND J. B. IVERSON. 1979. Demography of terrestrial turtles. Pages 541-569 *In* Turtles: Perspectives and Research (M. Harless and H. Morlock eds.). John Wiley and Sons, New York.

BURKE, R. 1989. Burrow-to-tortoise conversion factors: comparison of three gopher tortoise survey techniques. Herp. Rev. 20: 92-94.

COX, J., D. INKLEY, AND R. KAUTZ. 1987. Ecology and habitat protection needs of gopher tortoise (*Gopherus polyphemus*) populations found on lands slated for large-scale development in Florida. Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Technical Report No. 4, Tallahassee.

DIEMER, J. E. 1992. Home range and movements of the tortoise *Gopherus polyphemus* in northern Florida. J. Herpetol. 26: 158-165.

KACZOR, S. A., AND D. C. HARTNETT. 1990. Gopher tortoise (*Gopherus polyphemus*) effects on soils and vegetation in a Florida sandhill community. Amer. Midl. Nat. 123: 100-111.

MARTIN, P. L., AND J. L. LAYNE. 1987. Relationship of gopher tortoise body size to burrow size in a southcentral population. Fla. Sci. 50: 264-267.

MCCOY E. D. AND H. R. MUSHINSKY. 1992. Studying a species in decline. gopher tortoises and the dilemma of the "correction factors." Herpetologica 48: 402-407.

MUSHINSKY, H. R., AND E. D. MCCOY. In press. A comparison of gopher tortoises, *Gopherus polyphemus*, on islands and the, mainland in Florida, *in* Biology of North American tortoises. North American Fauna (R. B. Bury and D. J. Germano, eds.). U. S. Fish and Wildlife Serv., Washington, D. C.

SOKAL, R. R., AND F. J. ROHLF. 1981. Biometry. W. H. Freeman and Co., San Francisco.
WILSON, D. S., H. R. MUSHINSKY, AND E. D. MCCOY. In press. Home range, activity, and burrow use of juvenile gopher tortoises (*Gopherus polyphemus*) in a central Florida population, *in* Biology of North American tortoises. North American Fauna (R. B. Bury and D. J. Germano, eds.). U. S. Fish and Wildlife Serv., Washington, D. C.
WITZ, B. W., D. S. WILSON, AND M. D. PALMER. 1992. Estimating population size and hatchling mortality of *Gopherus polyphemus*. Fla. Sci. 55: 14-20.