

Vigilance in the golden-mantled ground squirrel (*Spermophilus lateralis*): effect of age and distance to human-created structures.

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## ABSTRACT

Animals are expected to maximize feeding success while minimizing predation risk; however, foraging and vigilance behaviors often conflict. I studied this trade-off in Golden-mantled ground squirrels (*Spermophilus lateralis*), with respect to human-created structures in Gothic, CO, site of the Rocky Mountain Biological Lab. Structures such as cabins and outhouses obstruct the view of predators but may also be used as cover. This observational study was done to determine how vigilance was affected by the structures. For each individual, observations were taken at 10-s intervals for one min and distance from the squirrel to nearest structure was measured. Amount of time spent vigilance increased with distance to nearest structure. Age class was taken into consideration because several litters of ground squirrels emerged during the study. Juveniles exhibited less vigilant behaviors and more non-vigilant behaviors but were mostly observed within 10 m of a structure. Adult ground squirrels exhibited vigilant behaviors more frequently than non-vigilant but had a wider range in which they were observed from the nearest structure (about 30 m). This study shows distance to human-created structures affects the activity and behavior of Golden-mantled ground squirrels in human-occupied habitats.

Keywords: distance to cover, obstruction, vigilance, age, *Spermophilus lateralis*

## INTRODUCTION

Many animals face fitness trade-offs in the time spent exhibiting anti-predatory behaviors and time spent foraging (Hannon et al., 2006). The trade-off between vigilance (an anti-predatory behavior) and foraging is influenced by factors such as reproductive status, social factors, environmental factors and individual perception (Tchabovsky, 2001). Other anti-predator

behaviors include foraging close to refuge, hiding to avoid detection, and individual vigilance or group vigilance in social species. In relatively heterogeneous habitats, animals may alter time spent vigilant in response to predation risk of foraging, depending on the amount of cover (Sharpe and Van Horne, 1998).

An animal foraging in tall vegetation faces the trade-off of increased coverage from predators but increased obstruction of view (Sharpe and Van Horne, 1998). Previous studies indicate that preferred vegetation cover varies among species. The fat sand rat (*Psammomys obesus*) favors dense vegetation cover as a shelter from predators even though there is an obstruction of view (Tchabovsky, 2001). The Townsend's ground squirrel (*Spermophilus townsendii*) spent more time in the bipedal (i.e., more vigilant) posture in medium vegetation than in low sagebrush vegetation (Sharpe and Van Horne, 1998). Obstruction by tall vegetation may alter the reaction time of predator response behaviors (Whittingham, 2004). In lone chaffinches (*Fringilla coelebs*), there were no changes in the head-up rate or food-search period in obstructed habitat versus open habitat; also vigilance was not a useful predictor of response time of the bird to predators (Whittingham, 2004). In over-wintering grey partridges (*Perdix perdix*), vigilance in individuals increased during short-term exposure to predatory birds, but long-term effects of vigilance led to decreased fitness from lack of foraging or possible longer exposure to raptors (Watson et al. 2007). In yellow-bellied marmots when view was obstructed in a feeding box the marmots would travel in and out of the box, masticating while outside the feeding box; when the feeding box had no visual obstructions the marmots remained in the box while feeding and masticating (Bednekoff 2009).

Perception of risk in various amounts of cover is likely to be vital for the golden-mantled ground squirrel (*Spermophilus lateralis*). This rodent has similar caloric demands to survive

hibernation over winter as does the Townsend's ground squirrel, requiring the accumulation of enough fat storage for the productive summer season and hibernation during the winter months (Sharpe and Van Horne 1998). Golden-mantled ground squirrels are active from late April to late August. In this time the females must gain enough weight to produce and raise a single litter of approximately 4-6 young (Hannon et al. 2006). Golden-mantled ground squirrels are fairly solitary rodents with no cooperation besides a female with her young and alarm calling (Bartels 1993). These ground squirrels often compete for resources such as burrows, food, shelter and mates (Bartels 1993). Golden-mantle ground squirrels, as a non-social species, are likely to change individual vigilance in various cover and not exhibit group vigilance behaviors.

My study examined the effect of human-created structures on vigilance in golden-mantled ground squirrels. This species is frequently established in human-occupied areas where structures such as cabins, outhouses, cars, porches and dumpsters obstruct the squirrel's view of predators. Although the human-created structures obstruct view of the ground squirrels, in many cases the ground squirrels have dug burrows under cabins, outhouses and dumpsters, as well as use decks and cars as cover. Other studies have been done on species living in well-developed areas occupied by humans. A study on vigilance in American Crows (*Corvus brachyrhynchos*) in an urban environment found distance to cover to be a more reliable predictor of vigilance than group size of crows (Ward and Low 1997). I expected to find a direct correlation between distance to cover and head-down, non-vigilant, behavior. In this study, I also expected that in an open environment, golden-mantled ground squirrels would spend the majority of time in an alert posture thus minimize non-vigilant, head-down behavior such as foraging. I also expected juvenile ground squirrels to be less vigilant than adults, as well as exhibit behaviors specific to

growth such as foraging and eating in order to grow and gain enough weight to survive their first winter.

## METHODS

### *Study area.*

My study area was located in Gothic, CO, the site of the Rocky Mountain Biological Laboratory (N 38.959, W 106.989, 2885 m elevation), in Gunnison County, Colorado. There are currently more than 60 buildings along with other structures such as outhouses, dumpsters and vehicles. Vegetation includes sagebrush, meadow, aspen and conifer forests and alpine tundra. The study area was mapped out in 5 m square grid by previous researchers in the area.

### *Trapping and marking individuals.*

Small mammal live traps were used in various locations throughout the day. Set traps were monitored throughout the day to minimize the ground squirrel's time in trap. Ear tags and black hair dye were used to mark the individuals. Dye marks on the individual's fur fade over the season from molting and were re-dyed when trapped.

### *Behavioral observations.*

Golden-mantled ground squirrels were observed as I saw them when walking a set route throughout the townsite. As soon as an individual was spotted, observations were noted in 10 second intervals for 1 minute. Date, time of observation, animal ID number, grid label, activity and nearest structure were recorded on the observation sheet. In areas of the townsite where cars were present the location of the car was noted. Activity was categorized into head-up posture and head-down posture. Vigilant behavior consisted of head-up postures such as alert bipedal

posture, alert quadrupedal posture, and eating in bipedal posture. Eating in the bipedal position allows the individual to view predators while mastication. Non-vigilant behavior consisted of head-down postures such as foraging, running, grooming, dust bathing/stretching and playing. For each individual activity type, location and nearest cover were noted in 10-sec intervals during the observational period.

#### *Cover and Obstruction of View.*

Nearest distance to cover was measured by using a meter tape and estimating the distance from the individual to the nearest structure. Structures included buildings, outhouses and dumpsters. Throughout the one-minute observational period the individual may have moved locations between 10 second intervals, for each location the ground squirrel was observed distance to nearest cover was taken. To account for the mobility of the ground squirrels, mean distance to cover was calculated by taking the average of distance to nearest structure within the observational period. Statistical analyses were conducted using JMP v.8 (SAS Institute, Cary, NC). A linear regression analysis was run for vigilance as a function of distance to structure. A two-way ANOVA run for time spent vigilant as a function of sex and age class. Data of age class and distance to cover was also analyzed by using a binomial logistic regression. Significance threshold  $\alpha=0.05$ .

## RESULTS

Relationship between amount of time spent in vigilant behavior and distance of ground squirrel to structure were shown to be marginally significant. Amount of time spent vigilant increased as average distance from structure increased ( $F=3.57$ ,  $P=0.06$ ,  $R^2=0.03$ ; Fig.1). 47 of

the 50 individual were observed exhibiting vigilant behavior greater than or equal to 50% of the time during observation at any given distance to structure; the 3 individuals observed non-vigilant over 50% of the time were within 6 meters of a structure (Fig. 1). Average percent of vigilant behavior categorized into sex and age showed juvenile ground squirrels to have lower percent vigilance than adult ground squirrels ( $F= 3.78, P=0.06$ ) and males to have a greater difference between juvenile and adult levels of vigilance than females (Table 1).

As the average distance to cover increased there was a greater probability that the ground squirrel observed was an adult than a juvenile ( $\chi^2 = 3.13, P=0.07$ ). The majority of the juvenile ground squirrels observed remained within 10 m of a structure, though there was one juvenile observed at 28.3 meters from a structure (n=19). The one juvenile observed at almost 30 meters from a structure was observed near an adult. The adult at 30.2 meters from a structure was observed in the alert bipedal posture at 5 of the 6, 10 second intervals. While the juvenile was observed running in the direction of the adult, stopped near the adult to forage and then ran away from the adult in the direction of the nearest structure; both individual were male. Four out of 31 adult ground squirrels were observed in locations over 10m from the closest structure. Juvenile ground squirrels exhibited vigilant behavior less than 67% of the time observed within 1.5 to 3.6 m distance to man-made structure, while adult ground squirrels within 1 m of structures tend to spend 33% or 100% of their time toward vigilant behavior (Fig. 2).

Behaviors of ground squirrels varied between age groups. Of the various activities exhibited by juvenile ground squirrels at near distances to structure behaviors such as alert bipedal (1.9 m 0.42), eating (1.0 m 0.39) and playing (0.5 m 0.0) were observed, unlike at further distances from structures running (8.2 m 2.3) was observed (Fig. 3a). In adult ground squirrels dust bathing (1.7 m 0.77) and playing (0.6 m 0.0) were behaviors

observed closest to man-made structures while the alert bipedal (8.1 m ± 1.0), eating (8.6 m ± 2.3) and foraging behaviors (8.3 m ± 2.0) were seen at distances further from structures (Fig. 3b).

## DISCUSSION

Distance to human-created structures affects the activity and behavior of Golden-mantled ground squirrels in Gothic, CO. The results supported the prediction of increased vigilance of the ground squirrels in an open environment. Similar to a study of house sparrows which suggests scanning (vigilance) to increase with distance to cover to detect predator earlier and increase probability of escape (Lima 1987). The majority of the ground squirrels observed exhibited vigilant behavior half of the time or more, regardless of the distance to structure. This could be similar to Slotow and Rothstein (1995) that found vigilance to be unaffected by distance to cover in White-crowned sparrows but suggest vigilance to be maintained in response to increased conspecifics at higher densities of sparrows. Decreased vigilance in ground squirrels near cover was like Lima's study (1987) that suggests scanning (vigilance) could decrease when obstruction of view is present due to increased effort of scanning compared to an open environment, effort could include extending neck raise level of view.

Results show the distribution of juvenile age class to remain within 10 m of a structure while ground squirrels in the adult age class will travel further than juveniles. This was to be expected, as several ground squirrels have burrows near structures that provide cover and ground squirrel pups remain close to the burrows for quick refuge. The one juvenile observed over 10 m away from a structure may not have traveled as far without the adult there exhibiting vigilant behavior in an alert position able to view predators (Bartels 1993). Although it is unknown

whether these two males were related, the vigilant adult male most likely would have alarm called if a predator was in sight, alerting the non-vigilant juvenile. There appears to be a 10-m buffer around structures in which juveniles remain for growth and protection as well as less vigilant behaviors observed by adults. Similar results were found in tits (*Parus*) a non-linear relationship between distance to cover and bird-abundance suggested a threshold distance to protective cover (Walther 2001).

Differences in behaviors exhibited by adults and juvenile ground squirrels reflects the distribution of the age class in the population. In juvenile ground squirrels remain at near distances to structure exhibit and behavior valuable to survival such as alert bipedal, eating and playing. Juvenile observed at further distances to a structure, running although a non-vigilant behavior could be considered a predator escape behavior in an open environment. Adult non-vigilant behavior consists of play and dust bathing near structures and quadrupedal alert postures at further distances. These findings are similar to juvenile marmots that value foraging more than the adults (Bednekoff 2009).

This study shows general trends in how golden-mantled ground squirrels have used human-made structures to their advantage despite the obstruction of view. Not only do the ground squirrels use structures as cover but often make burrows and keep litters near structures. Future studies should measure distance of burrow to structure, increase sample size and lengthen observational periods. It would also be beneficial to integrate an experimental component to a future study such as testing optimal foraging by using poor quality food versus high quality food in various distances to cover and in various densities.

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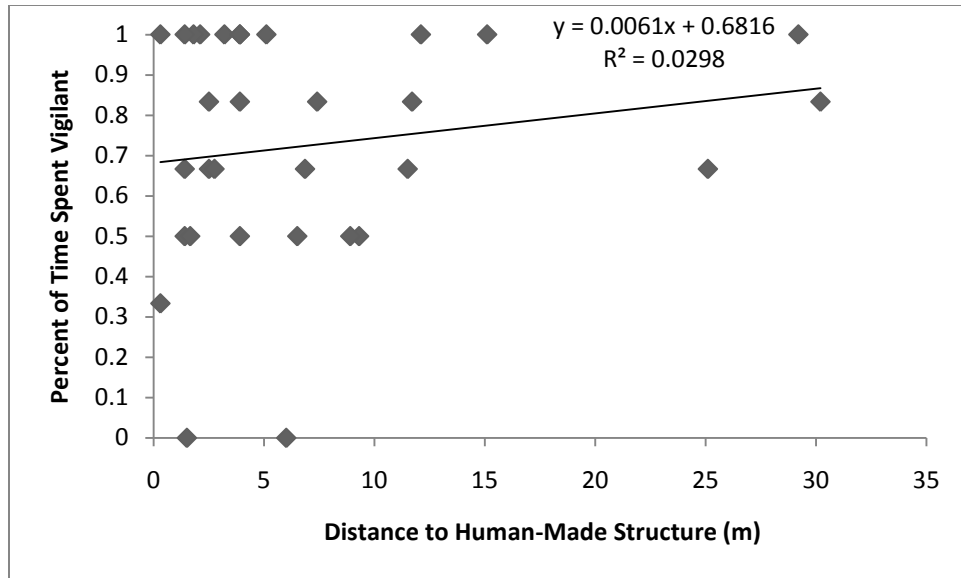
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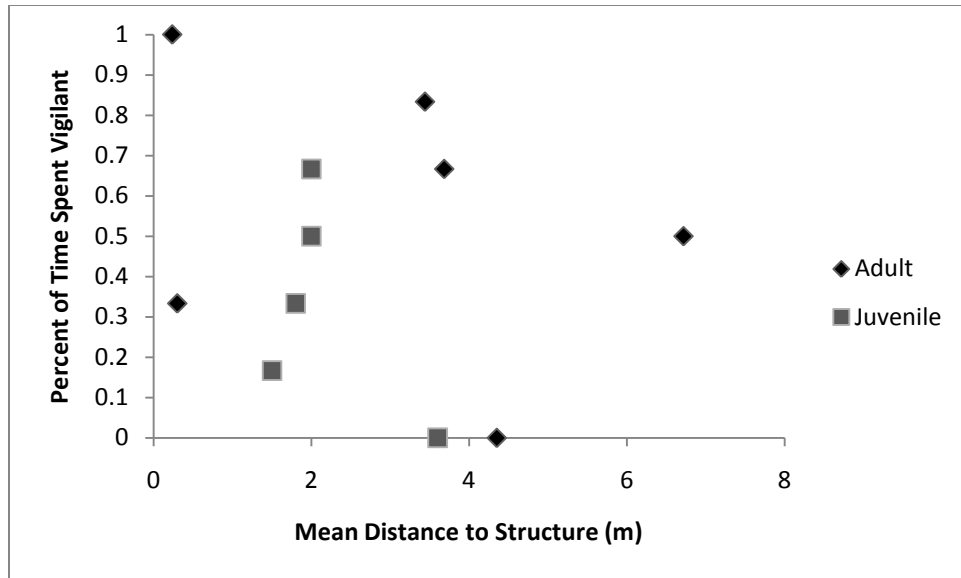
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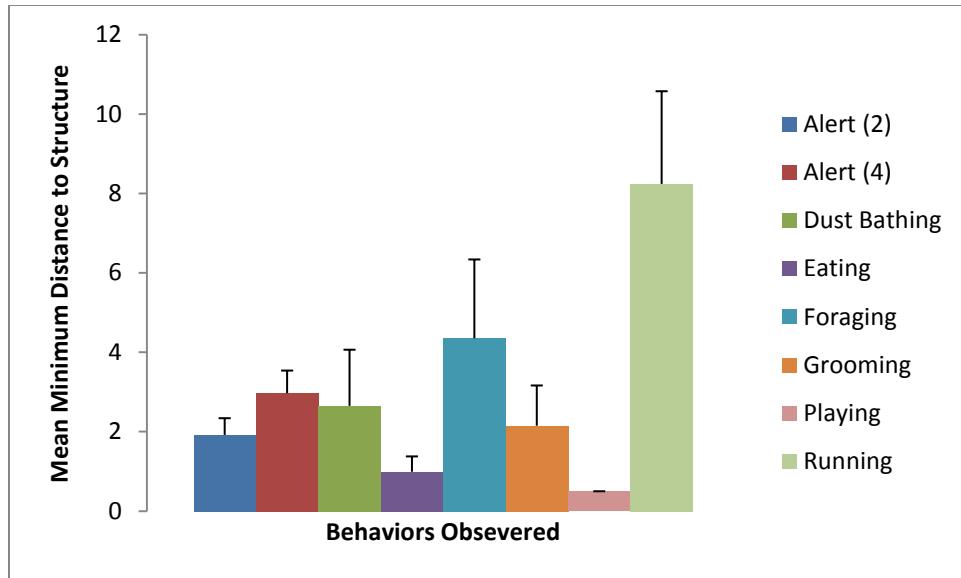
**Figure 1.** Percent of time Golden mantled ground squirrel expressed vigilant behavior within one-minute observational period in relation to mean distance to nearest human-made structure (m) ( $F=3.57$ ,  $P=0.06$ ). Each point represents an individual Golden-mantled ground squirrel  $n=50$

**Table 1.** Percent of time spent exhibiting vigilant behavior (mean  $\pm$  SE) during the one-minute observation, by sex and age class. Sample size of males; juvenile n=8, adult n=6. Sample size of females; juvenile n= 11, adult n= 25.

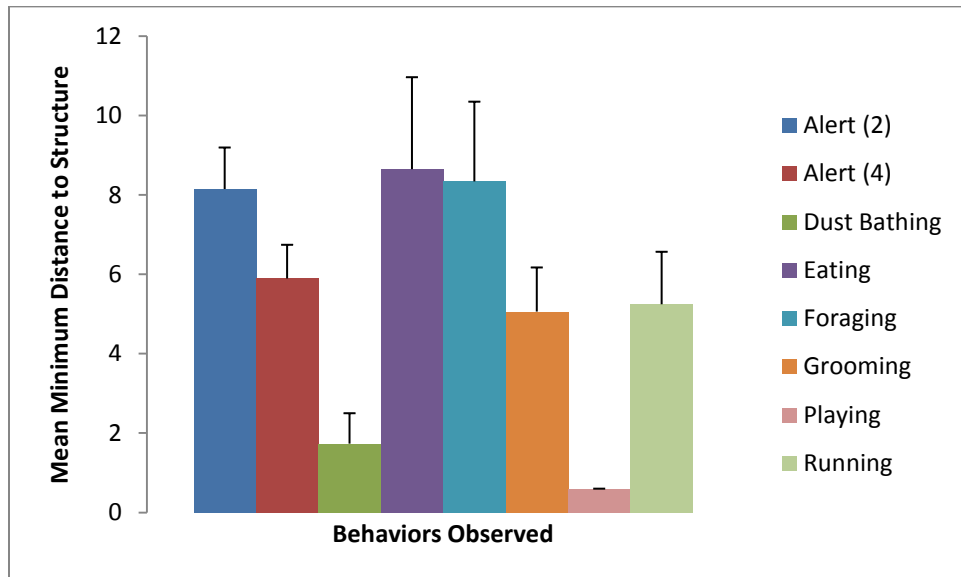
|        | Juvenile        | Adult           |
|--------|-----------------|-----------------|
| Male   | 0.52 $\pm$ 0.12 | 0.81 $\pm$ 0.08 |
| Female | 0.59 $\pm$ 0.08 | 0.71 $\pm$ 0.06 |



**Figure 2.** Adult versus juvenile Golden-mantled ground squirrel relationship of percent of time devoted to vigilant behavior throughout the one-minute observational period and mean distance to the nearest human-made structure (m). Adult n=31. Juvenile n=19.



**Figure 3a.** Mean minimum distance to cover (m) for each type of behavior observed ( $\pm$ SE) in juvenile Golden-mantled ground squirrels. Alert (2) is the head-up alert behavior in the bipedal position and Alert (4) is the head-up alert behavior in the quadrupedal position. n=19.



**Figure 3b.** Mean minimum distance to cover (m) for each type of behavior observed ( $\pm$ SE) in adult Golden-mantled ground squirrels. Alert (2) is the head-up alert behavior in the bipedal position, Alert (4) is the head-up alert behavior in the quadrupedal position. n=31.