An examination of time and location on foraging frequency of the eastern grey squirrel, *Sciurus carolinensis*

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The eastern grey squirrel (*Sciurus carolinensis*) is a diurnal mammal occupying much of the eastern United States. Studies have shown that artificial light can impact animal foraging and behavior, but research has not yet been conducted on the eastern grey squirrel. We compared foraging frequencies in the absence and presence of artificial light as well as time of day at McKeldin Mall and Paint Branch Trail on the University of Maryland, College Park campus. Plates with a mixture of peanut butter and oats were placed near and far from an artificial light source and half hour trials were conducted at night and during the day. We hypothesized that *S. carolinensis* would forage later in the night hours in the presence of artificial light. A two-way ANOVA test determined that the presence or absence of light did not alter the forging frequency of *S. carolinensis*. This research has implications in mammalian ecology as artificial light becomes more prevalent worldwide.

Keywords: *Sciurus carolinensis,* eastern grey squirrel, artificial light, foraging

Mammals obtain food based on their preferred diets, physiologies, ecologies, and habitats. Although their individual foraging strategies differ, all species are united in that they rely on optimal foraging to determine food preference, time spent foraging, and their limitations. A tradeoff exists between time spent foraging and energy availability, and the animal must decide which is most important while also potentially evading predators and remaining vigilant (Feldhamer et al. 2007).

A mammal's circadian rhythm is a 24-hour series of patterns that influence the animal's activity cycle. Examples of activity cycles include diurnal (active during the day) and nocturnal (active at night). These patterns are determined by a photoperiod, known as a zeitgeber, which triggers certain behaviors of the animal's biological clock (Feldhamer et al. 2007).

The Eastern Grey Squirrel (*Sciurus carolinensis*) occupies much of the nearctic zone of North America, ranging from the southernmost United States to southern Canada with higher prevalence in wooded areas. Their natural diet includes large seeds, nuts, flowers, fruits, and some insects (Sandro 2008). Eastern grey squirrels, like other squirrel species, engage in caching as a means of food storage. By hoarding a food stock in the soil or in tree trunks, the squirrels are able to establish a long-term supply of energy for the cold winter months (Feldhamer et al. 2007). The eastern grey squirrel exercises diurnal behavior (Thorington Jr et al. 2012) and exhibits decreased antipredator behavior in areas of higher human activity (Cooper et al. 2008)

Artificial light is light that is not produced by the sun and comes from an electronic source. It has been demonstrated that artificial light can change animal behavior in a nighttime environment (Rydell 1992). In birds, it was shown that nighttime artificial light impacted the timing and distribution of foraging in northern Europe (Dwyer et al. 2013). Artificial light is increasing by 6% each year in the global setting (Davies et al. 2013), therefore, it is important to understand the effects of this change on mammals in order to anticipate changes in their foraging patterns and behaviors in the future.

Our research sought to examine the impact of artificial light on *S. carolinensis* and it's foraging habits. We predicted that time (day or night) as well as location (presence or absence of artificial light) would show an interaction effect on *S. carolinensis* foraging frequency; more specifically, that foraging frequency would increase in the night hours when location of food is under an artificial light source.

MATERIALS AND METHODS

We used peanut butter and oats on paper plates as a food source to measure our data. To control for the presence of humans, two sites were used. McKeldin Mall was used as a site of high human activity and Paint Branch Trail was used as a site of low human activity. Both sites are located on the University of Maryland, College Park campus. At each site, the peanut butter and oat food was placed for half hour intervals and the number of squirrels that ate from the plate was noted. An incidence of foraging was recorded when the squirrel ate from the plate. At each location, one plate was placed near a source of artificial light and the other was placed away from any artificial light source. Three daylight trials were conducted (9:00am, 1:00pm, and 4:00 pm) on different days. Three nighttime trials (8:00pm, 9:00pm, and 10:00pm) were also conducted on different days. The 10:00pm data was not included in the final results because it was found to be too late for the squirrels to be foraging. In its place, two trials were conducted at 7:30pm for each of the sites. The variables were the distance from artificial light source (near or far) and the number of squirrels foraging. The data was analyzed using a two-way ANOVA statistical test.

RESULTS

Eighty trials were conducted on *S. carolinensis* foraging frequency with a total of 40 hours of data. 18 trials were conducted for daytime experiments in the presence of an artificial light source at McKeldin Mall and Paint Branch Trail. An additional 18 trials were conducted for daytime experiments in the absence of an artificial light source in the same locations. Additionally, 22 trials were conducted for nighttime experiments in the presence of an artificial light source at McKeldin Mall and Paint Branch trail. An additional 22 trials were conducted for nighttime experiments in the absence of an artificial light source.

A two-way ANOVA test was used to analyze the interaction between day and night times as well as the presence and absence of artificial light sources. The ANOVA test determined a significant effect with time of day (df=1, F= 7.807112, p=0.006755) (Table 1). Although average foraging frequency at night in the absence of artificial light was higher than average foraging frequency at night in the presence of artificial light (Figure 1), no significant interaction between time and location was denoted by the ANOVA test (df=1, F=0.279436, p=0.598792) (Table 1).

Table 1 Two-Way ANOVA results.

Effect	*df*	*F*	*P-value*
Location	1	0.005703	0.940025
Time	1	7.807112	0.006755
Interaction	1	0.279436	0.598792

The summary of the results of a two-way ANOVA test, comparing the interaction effect of location and time on frequency of squirrel foraging. Location refers to presence of an artificial light source versus absence of an artificial light source, and time refers to day versus night hours. Interaction refers to the interaction between location and time. A significant effect of time is denoted by *P-value* = 006755

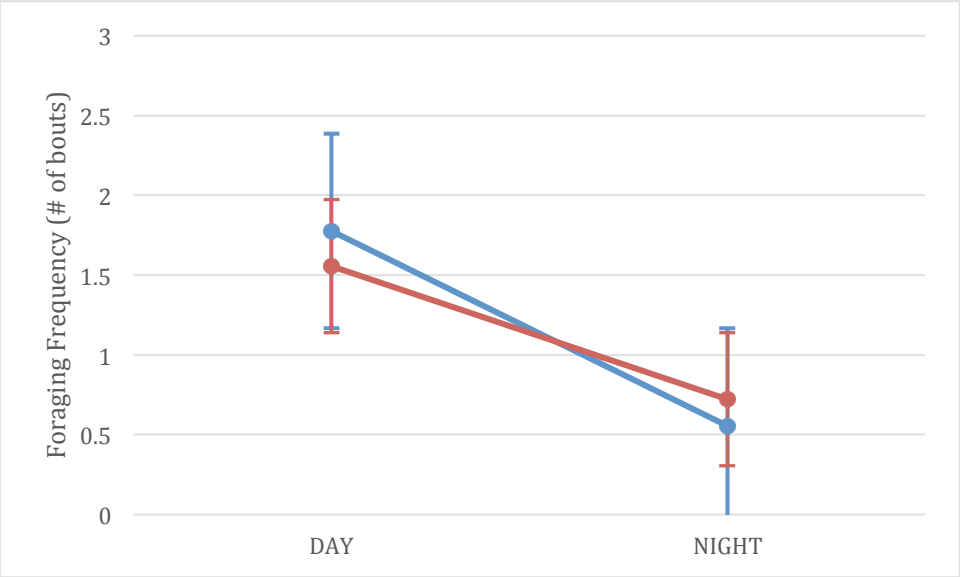

Figure 1—The mean number of foraging bouts at day and night times with the presence of an artificial light source or absence of an artificial light source. The orange line denotes absence of artificial light source and the blue bar denotes presence of an artificial light source. The intersecting lines does not denote a significant interaction effect as a result of *P-value* >.05 indicated by two-way ANOVA.

DISCUSSION

The results of the two-way ANOVA test indicated no significant interaction effect between time and location of *S. carolinensis* foraging frequency which dismisses our hypothesis that foraging frequency would increase in the night hours when location of food is under an artificial light source. Additionally, the two-way ANOVA concluded that time had a significant effect on *S. carolinensis* foraging behavior and location showed no effect. Therefore, time of day is concluded as the limiting factor on *S. carolinensis* foraging frequency. The effect of time of foraging behavior is denoted by a decrease in average foraging bouts between day and night hours in both the presence of artificial light and absence of artificial light (Figure 1).

Because many squirrel species are diurnal (Thorington Jr et al. 2012), foraging behavior of *S. carolinensis* is expected to occur during the day and around dusk. Additionally, we found foraging efforts to not significantly differ between the presence of artificial lighting and lack of artificial lighting (Figure 1). Although no significant interaction between time and location on *S. carolinensis* foraging frequency was displayed, we observed that *S. carolinensis* avoided artificial light sources at night, which is denoted by a decrease in average foraging bout on locations near artificial light sources (Figure 1). Due to safety concerns on campus, students are instructed to walk though well-lit areas during the nighttime hours. Although the eastern grey squirrel has been shown to exhibit antipredator behaviors in the presence of increased human activity (Cooper et al. 2008), we conclude that the close proximity of walkways to artificial light sources as the reasoning behind the observed decline in foraging frequency of *S. carolinensis* at night near artificial light sources. While the squirrels may be more adapted to increased human activity, many of the artificial light sources are located immediately off the walkways, therefore any human traffic is likely to cause the squirrel to retreat.

Although our experiment produced viable data and results, the experiment was far from ideal in terms of setup and funding. On a college campus, it is difficult to avoid human interference with the study plots, so we had to accept the interference as an uncontrolled variable and account for it. On private plots this could be avoided, and possibly provide more conclusive results. We were also restricted to using lampposts around campus as our artificial light sources, which were located in inconvenient locations in terms of proximity to walkways. With complete

control of the lighting situation, it would be possible to test for the effect of light intensity on foraging amongst other variables, as well as develop more conclusive results for our study.

Additionally, we had a limited amount of time to perform our experiment on these squirrels, so we cannot extrapolate if artificial lighting would have a significant effect on foraging behavior over extended periods of time. Further research into the effect of artificial light on foraging behavior is needed to acquire more precise and conclusive results. Future studies could provide better plots to experiment on, more control over light conditions, and trails that stretch over longer periods of time, all allowing for precise experimental parameters.

Our research contributes to the larger picture of mammalian ecology in a changing world. With a continuously increasing prevalence of artificial light in the global setting, it is important to look at how mammals will be affected when they have evolved for million years under the influence of sun and moonlight (Davies et al. 2013). By understanding this mammalian ecology, we can better anticipate further changes in order to protect and sustain our mammalian species.

LITERATURE CITED

COOPER, C.A., NEFF, A.J., POON, D.P., & SMITH, G.R. 2008. Behavioral Responses of Eastern Gray Squirrels in Suburban Habitats Differing in Human Activity Levels. Northeastern Naturalist 15:619-625.

DAVIES, T.W., BENNIE, J., INGER, R., HEMPEL DE IBARRA, N., & GASTON, K.J. 2013. Artificial light pollution: are shifting spectral signatures changing the balance of species interactions? Global Change Biology 19:1417-1423.

DWYER, R.G., BEARHOP, S., CAMPBELL, H.A., & BRYANT, D.M. 2013. Shedding light on light: benefits on anthropogenic illumination to a nocturnally foraging shorebird. Journal of Animal Ecology 82: 478-485.

FELDHAMER, G.A., DRICKAMER, L.C., VESSEY, S.H., MERRITT J.F., & KRAJEWSKI C. 2007. Mammology. Johns Hopkins University Press.

RYDELL, J. 1992. Exploitation of insects around streetlamps by bats in Sweden. Functional Ecology 6:744-750.

SANDRO, B. 2008. Introduction of the American grey squirrel (*Sciurus carolinensis*) in Europe: a case study in biological invasion. Current Science 95:903-906.

THORINGTON, R.W., KOPROWSKI, J.L., STEELE, M.A., WHATTON, J.F. 2012. Squirrels of the World. Johns Hopkins University Press.