Weather Conditions on Capture Success of Sciurids in the Upper Peninsula of Michigan

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Abstract

This study examines the effects of average barometric pressure, temperature, and relative humidity on the capture success of sciurids including northern flying squirrels (*Glaucomys sabrinus*), southern flying squirrels (*Glaucomys volans*), red squirrels (*Tamiasciurus hudsonicus*), and eastern chipmunks (*Tamias striatus*) in two trapping grids in the mixed hardwood and coniferous forests of the Upper Peninsula of Michigan. For captures of all sciurid species pooled, there was a significant positive relationship between barometric pressure and catch per unit effort, and a significant negative relationship between temperature and catch per unit effort, which were opposite of our initial hypotheses. For northern and southern flying squirrels only there was a significant positive relationship between relative humidity and catch per unit effort. These relationships are important because they show that weather conditions significantly affect activity levels (as measured by capture success) of sciurids, such as foraging or caching activity. Such alterations in behavior should be taken into account in order to make more accurate small mammal population density estimations when using live-trapping techniques.

Introduction

Mark-recapture is one of the most common methods of small mammal population estimation, but there are several other factors that affect these estimations besides actual animal density. Small mammal activity patterns are affected by foraging behavior, predation avoidance, physiological demands, and social interactions (Vickery and Bider 1981). Weather factors can play a large role in each of these biotic components, possibly changing foraging, nesting, or caching activity patterns and therefore greatly affecting population estimates. It has been hypothesized that animals will be most active when they are subjected to minimal physiological stress and predation risk (Stokes et al. 2001). For many animals including sciurids, however, the effects of weather conditions during trapping on physiological stress and predation risk has gone largely unstudied in the field.

Doucet and Bider (1974) found that increased precipitation also increased nocturnal activity in masked shrews (*Sorex cinereus cinereus*), especially when the rainfall began between 1800 and 2400 hours. One possible explanation for this trend is that rain may reduce predation risk by hindering predators' olfactory and auditory senses (Brown et al. 1988). Due to animal safety concerns, in this study we did not set traps when forecasts predicted a high probability of rain and cannot directly test the effects of rain on trapping success. Therefore, since a drop in barometric pressure is often an indicator of pending rain, we hypothesized that a low mean barometric pressure during a trapping interval will indirectly correspond with an increase in animal activity.

Doucet and Bider (1974) also showed a general positive relationship between masked shrew activity and mean nocturnal temperature trends from the previous night to the night of trapping. Moore and Kennedy (1985) showed that daily variation in trap success of raccoons (*Procyon lotor*) was significantly related to temperature during autumn and winter. During the autumn, midnight temperature was negatively correlated with capture success, while the relationship was reversed during the winter. Vickery and Bider (1981) have shown a positive relationship between nocturnal temperature and activity, and Vernes (2004) showed a positive correlation between northern flying squirrel (*Glaucomys sabrinus*) and red squirrel (*Tamiasciurus hudsonicus*) capture success and maximum daily temperature. Finally, Stokes and colleagues (2001) found a significant positive relationship between winter temperatures and nocturnal activity of prairie voles (*Microtus ochrogaster*) and cotton rats (*Sigmodon hispidus*). Therefore, we hypothesized that we will find a positive correlation between mean trapping interval temperature and capture success of sciurid species.

Red-backed voles (*Clethrionomys gapperi*) tend to increase activity levels with higher humidity (Vickery and Bider 1981). This may be explained by the high surface area to volume ratio of small animals that may cause water loss to be a potential issue, which could lead these animals to be more active on more humid days or in more humid areas. Getz (1961) suggests that there may be less activity from shrews (*Blarina brevicauda*) on sunny days due to a lower relative humidity rather than a direct response to sunshine, but was unable to test this hypothesis. In this study, we also hypothesize that higher relative humidity values will correspond with higher capture success among sciurids.

To explore the effects of temperature and humidity on sciurid trapping success, we will study both ground and arboreal species including red squirrels (*Tamiasciurus hudsonicus*) which are tree squirrels, eastern chipmunks (*Tamias striatus*) which are ground squirrels, and northern (*Glaucomys sabrinus*) and southern (*Glaucomys volans*) flying squirrels. Tree squirrels and ground squirrels are generally diurnal and hibernate during the winter in cool temperate areas, while flying squirrels are nocturnal (Feldhamer et al. 2007). Sciurids, especially flying squirrels, are often studied as significant biogeographic model species for North American coniferous and deciduous hardwood forests, two of North America's most abundant forest types (Arbogast, 2007). Therefore it is important to understand how certain abiotic factors such as weather can affect sciurid trapping in order to improve population estimations. Also, since it is necessary to consider risks to animals in any experiment, knowing which weather conditions affect trapping and how these influence trap success is essential to trapping most efficiently and with minimal risk to the animals. For example, if animal trapping mortality rates rise with increasing summer temperature while trap success coincidentally drops, it would be important to consider the merit of trapping in severe heat.

Since seasonal and daily weather fluctuations seem to affect capture probabilities by altering small mammal behavior, trap success may be a more accurate indicator of animal activity, as opposed to a direct measure of animal density in an area (Stokes et al. 2001). Therefore, if mark-recapture methods are used to estimate population densities, especially over a brief trapping period, behavioral responses to weather conditions should be established and adjusted for (Doucet and Bider 1974).

Methods

Squirrel Trapping

We performed our study at the University of Notre Dame Environmental Research Center (UNDERC) field station in the Upper Peninsula of Michigan. We had two trapping grid sites, each of which included an upland hardwood and lowland coniferous habitat. The upland areas were predominantly sugar maple (*Acer saccharum*), the lowlands were predominantly balsam fir (*Abies balsamea*) and white spruce (*Picea glauca*), the understory contained bunchberry dogwood (*Cornus canadensis*) and beaked (*Corylus cornuta*) hazelnut, with a ground layer of sphagnum moss (*Sphagnum spp.*) and Canada mayflower (*Maianthemum canadense*).

We trapped on two grids from mid-June to mid-July, leaving the traps open for 24 hours, weather permitting. We did not trap when there was a high probability of rain (over 40%) or when the temperature would drop below approximately 4.5°C. Traps were checked and rebaited at approximately 6am and 6pm. We ear tagged, weighed, and sexed all captured sciurids before releasing them. Although we were unable to get enough data to draw conclusions, our original project focused on northern (*Glaucomys sabrinus*) and southern (*Glaucomys volans*) flying squirrels, which we also radio collared, measured, and took genetic samples from.

Our first grid (South Grid) was 5 x 5, with 40m spacing in between stations, for a total of 25 stations. At each station we had a Sherman live trap on the ground and a Tomahawk 201 trap approximately 1.5m up on a tree, for a total of 50 traps. Our second grid, Kickapoo grid, was located approximately 1000 meters northwest of South grid. It began as a 3 x 3 grid, with 40m spacing in between stations due to space constraints. It was subsequently expanded to a 5 x 5 grid with 20m spacing, after 10 trap sessions, to increase trapping probabilities to match the South grid. These stations also each had a Sherman trap and a Tomahawk trap. For bait we used an apple slice and a mixture of peanut butter, oats, and sunflower seeds in each trap.

Weather Data

Weather data recordings were obtained hourly from a weather station approximately 2000 meters away from both the South and Kickapoo grids. Relative humidity (%), temperature (°C), and barometric pressure (mmHg) readings were all recorded hourly and then averaged over each 12 hour trapping session before analysis.

Data Analysis

We manipulated our data in Microsoft Excel and then used SYSTAT to perform a backwards stepwise multiple linear regression on catch per unit effort against humidity, temperature, barometric pressure for all species overall, and for each species individually. Catch per unit effort was calculated by number of individuals captured divided by number of undisturbed traps on each site for each trap interval.

Results

We hypothesized that there would be a negative relationship between capture success and mean barometric pressure, a positive relationship between capture success and mean temperature, and a positive relationship between relative humidity and capture success. To test these hypotheses we used SYSTAT to perform a backwards multiple stepwise linear regression on all species overall, and one for each species separately.

First we ran the regression for pooled capture data from all species, and found a statistically significant positive relationship between barometric pressure and capture success (F = 6.971, df = 1, p = 0.011; see *Figure 1*), and a statistically significant negative relationship between temperature and capture success (F = 6.352, df = 1, p = 0.015; see *Figure 2*). Both of these results were opposite of our hypotheses. There was no significant relationship between humidity and capture success, and removing humidity from the model lowered the corrected Akaike Information Criterion (AIC) from -137.6 to -140.0.

We then ran a Pearson's correlation analysis between temperature and barometric pressure. We found only a weak positive linear relationship between the two variables (*r* = 0.050), showing that temperature and barometric pressure are relatively independent variables.

Next we ran the same stepwise regression analysis for eastern chipmunks and found similar results. We found a statistically significant positive relationship with barometric pressure (*F* = 5.835, *df* = 1, *p* = 0.020) and a non-significant negative trend with temperature, with humidity again removed from the final model.

We ran a stepwise regression analysis for red squirrels, finding similar results. There was a statistically significant positive relationship with barometric pressure (*F*= 5.305, *df* = 1, *p* = 0.026), and a non-significant negative trend with temperature. We removed humidity from the final model.

Finally, we ran a stepwise regression analysis for combined data from northern and southern flying squirrels. For this analysis we instead found a statistically significant positive relationship between relative humidity and capture success (*F* = 8.191, *df* = 1, *p* = 0.006; see *Figure 3*), which supports our third hypothesis. Both barometric pressure and temperature were removed from the final model, reducing corrected AIC from -245.4 to -248.1.

Discussion

Contrary to our initial hypotheses, our data showed that there was an inverse relationship between capture success and both average barometric pressure and average temperature throughout the trapping session. Stokes and colleagues (2001) also found that a rising barometric pressure was positively correlated with capture success in prairie voles, and especially cotton rats. One possible explanation for this positive relationship with barometric pressure is that during and immediately following rainfall, barometric pressure will rise sharply. Therefore, high barometric pressure could reflect precipitation events which probably caused increased small mammal activity.

Our results also showed the opposite trend than we hypothesized for the relationship between temperature and capture success. However, because we did not trap on nights that got below approximately 4.5°C, our average temperature range went from 9.9 to 30.0°C. This means that we may not have captured the behavioral pattern trend showing that animals do not move on severely cold nights, and instead avoided excessive activity during extremely warm summer temperatures. Woodland jumping mice (*Napaeozapus insignus*) tended to be most active on colder nights in a study by Brower and Cade (1966). This may be because predators also tend to be more active during warm temperatures, so small mammals reduce activity under these conditions to avoid predation (Vickery and Bider 1981).

Finally, our prediction that increased humidity would correspond with increased capture success was supported by our flying squirrel trapping success (see *Figure 3*). Since a major factor in water loss for small mammals is the large surface area to volume ratio (Vickery and Bider 1981), it follows that flying squirrels will be most affected by humidity due to their extreme surface area to volume ratio. A distinguishing characteristic of flying squirrels is the patagium, a flap of furred skin connecting their front and hind limbs, which increases surface area to extend gliding and improve maneuverability (Feldhamer et al. 2007). The patagium likely increases flying squirrels' susceptibility to water loss, making them more sensitive to changes in humidity so they are able to take advantage of optimal weather conditions.

We found that weather conditions have a statistically significant effect on capture success of sciurids. This finding shows the importance of studying these relationships and taking them into account when using live trapping methods as a means of small mammal population estimation. Further experiments could test possible effects of other weather factors on sciurids, including cloud cover or moon phases, which may play a large role in predation avoidance for small mammals, especially nocturnal species. These studies should also include longer trapping periods encompassing more seasons, temperatures, and weather factors, and should not exclude all extreme weather occurrences as in the present study.

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Figures

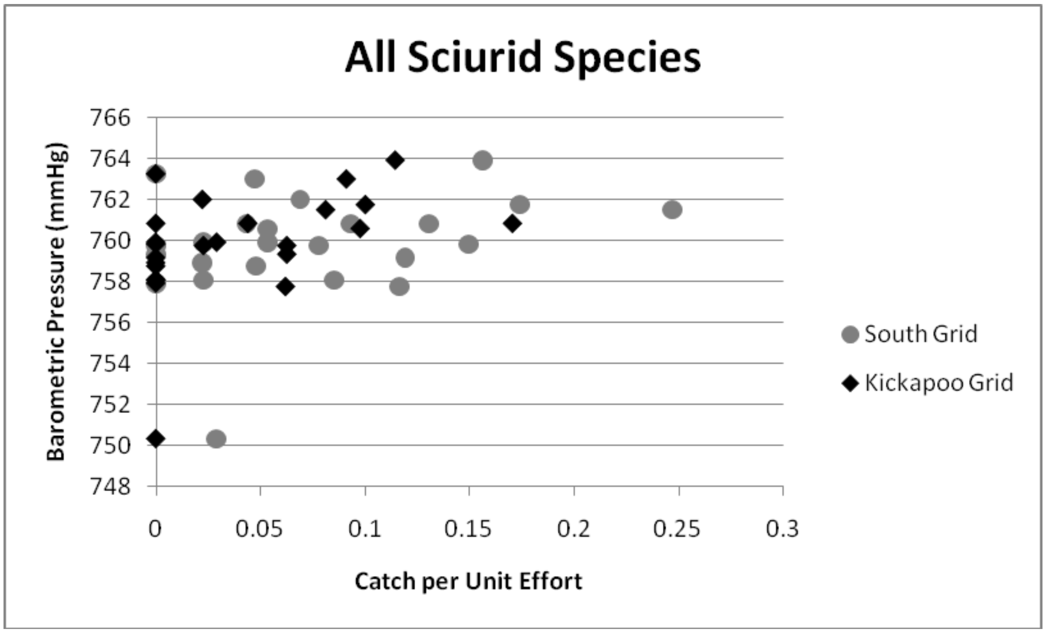

Figure 1. There is a statistically significant positive relationship (R^2 = 0.221) between average barometric pressure for each trapping session and catch per unit effort for all sciurid species combined (F = 6.971, df = 1, p = 0.011).

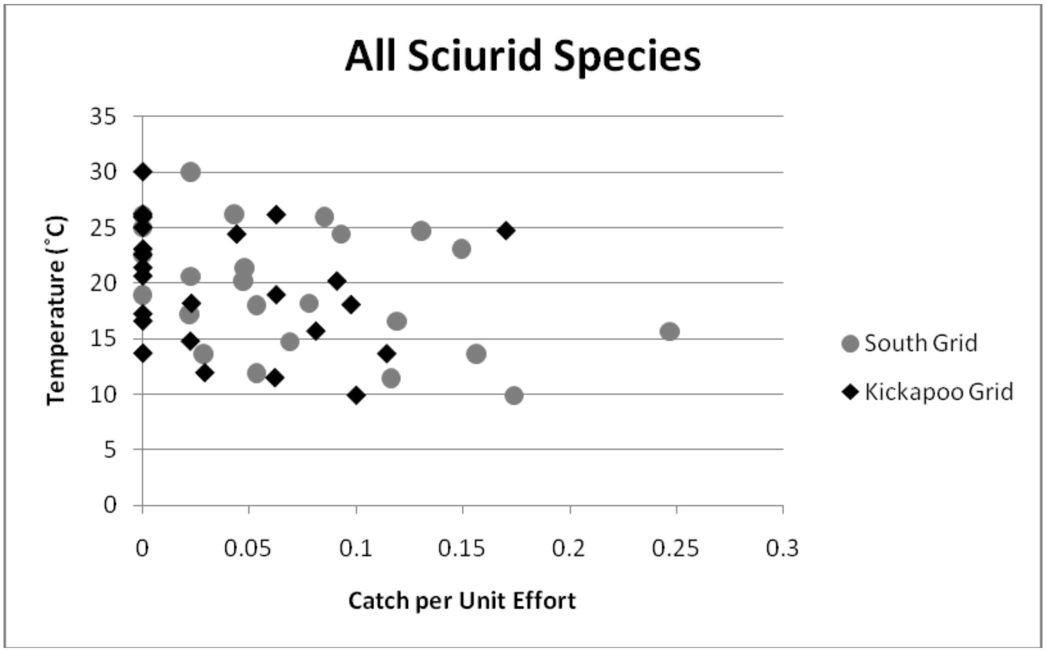

Figure 2. There is a statistically significant negative relationship (R^2 = 0.221) between average temperature for each trapping session and catch per unit effort for all sciurid species combined (F = 6.352, df = 1, p = 0.015).

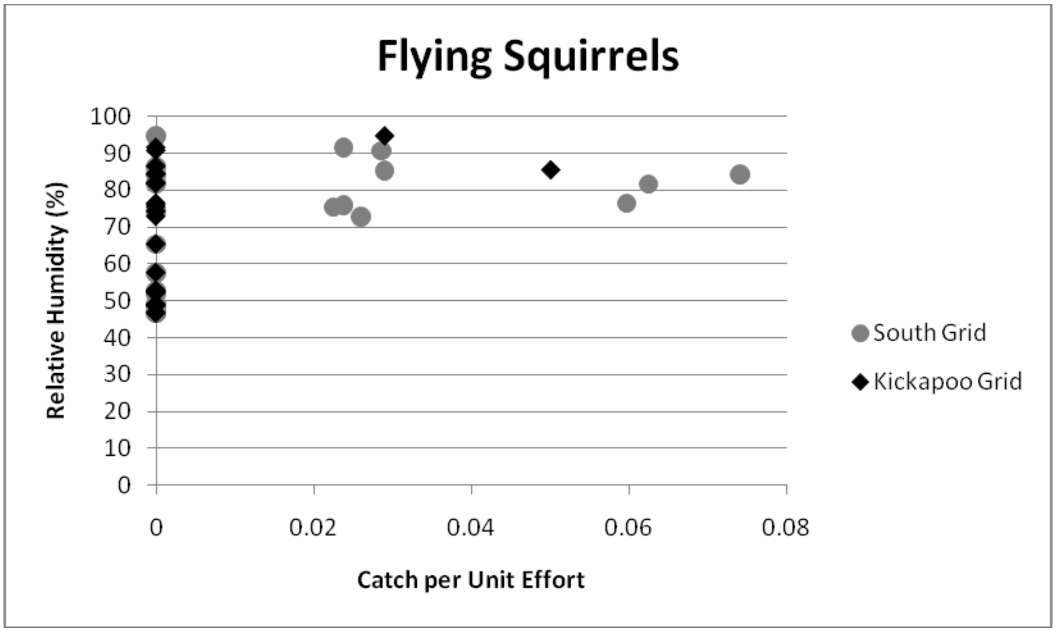

Figure 3. There is a statistically significant positive relationship (R^2 = 0.189) between average relative humidity for each trapping session and catch per unit effort for northern and southern flying squirrels (F = 8.191, df = 1, p = 0.006).