Radio Telemetry of Southern Flying Squirrels at Brookhaven National Laboratory

Bradley Buckallew
Office of Science, Science Undergraduate Laboratory Internship (SULI)
Presbyterian College

Jennifer Higbie
Brookhaven National Laboratory
Upton, New York

July 28, 2010

Prepared in partial fulfillment of the requirements of the Office of Science, Department of Energy's Science Undergraduate Laboratory Internship under the direction of Timothy Green in the Natural Resources and Waste Management Division at Brookhaven National Laboratory.

Participant: ______________________________

Research Advisor: ______________________________

Table of Contents

Abstract

Radio Telemetry of Southern Flying Squirrels at Brookhaven National Laboratory
Bradley Buckallew (Presbyterian College, Clinton, SC 29325), Jennifer Higbie
(Brookhaven National Laboratory, Upton NY, 11973).

Southern flying squirrels provide an important food source for organisms on higher trophic levels and help maintain forest health by distributing seeds while foraging. This study estimates the relative home ranges of the southern flying squirrels that inhabit Brookhaven National Laboratory using radio telemetry. The study will serve as a baseline to understand the size and distribution of habitat being used by the squirrels. Sherman traps were mounted to selected trees and baited. The traps were left open overnight and checked the following morning. If a squirrel was captured, it was anesthetized using isoflurane and equipped with an ATS model M1420 miniature mammal collar. The trapping continued until a total of six squirrels were radio collared, two adult females and four juvenile males. All the squirrels were located at least once per day with a receiver. Radio telemetry was used during the nighttime hours to monitor the squirrels' movements. Using triangulation, three locations and headings were taken for an individual squirrel in one twenty minute set. Geographic Information System (GIS) was then used to plot this data to determine the squirrel's location. The movements of each squirrel were tracked for most of the 24 hour period with an average of 1 point per hour. The movements of each squirrel could then be analyzed using GIS. The average roosting range size was 0.374 hectares, while the average foraging range size was 1.980 hectares. The most common vegetation found in the home ranges of the squirrels was scarlet oak-heath forest and red maple/scarlet oak-mesic heath forest. The juvenile males had larger roosting and foraging range sizes than the adult females. If the females were nesting, the small range sizes could be due to their maternal duties. The dispersal of three juvenile male squirrels was also seen over the course of the summer. This is most likely due to them getting weaned out of the nest and then having to slowly move into new areas as food competition became a problem. The vegetative data suggest a preference for scarlet oak which can be explained by the squirrels' penchant for hard mast as a food supply.

Introduction

Southern flying squirrels are a common nocturnal small mammal found throughout the state of New York. Their range extends north to south from Maine to Florida and east to west from the coast to the Mississippi River [6]. Using a skin membrane called a patagium, the southern flying squirrel is able to glide from tree to tree. By changing the tension of the patagium and using its tail, the southern flying squirrel is able to control its direction while gliding. It uses this ability to locate food ranging from carrion to insects, but it mainly feeds on nuts and acorns. It stores nuts and acorns in cavities of trees for a winter supply. It also establishes day hides and nest for reproduction in cavities. It breeds twice a year and the average litter size is three to four pups [1].

The abundance of southern flying squirrels on Brookhaven National Laboratory property was established in a previous study conducted in the summer of 2009. While the squirrels were ear tagged and recaptures made, not enough data was collected to establish an average home range for the squirrels on property. The purpose of this study is to determine the average home range by following the movements of a number of individuals. This will be accomplished through the use of radio telemetry.

Radio telemetry has been used in multiple studies to determine the home ranges of flying squirrels, both northern and southern [3,5,9]. The reported home ranges from these studies vary from 2.45 ha for males and 1.95 ha for females to 16.03 ha for males and 5.88 ha for females [3, 9]. This great disparity could be due to a number of variables including geographic location, habitat, or season. This is supported by Taulman and

Smith, who stated that the home ranges were much smaller in areas of with an abundance of hard mast [9].

Materials and Methods

Trapping during the 2009 summer had shown the presence of southern flying squirrels and the two most successful areas in 2009 were chosen as the trapping locations in 2010. Twenty Sherman traps were split into two groups of ten and placed throughout the chosen locations. The traps were mounted to the trees at a height of 1.6 meters using modified circular brackets that were secured with a two inch lag screw. The traps were then held in place with zip ties to limit their movement. The traps were bait during the evening with a mixture of peanut butter and oats and checked early the following morning [4, 7]. The traps were left closed if heavy precipitation and cold weather was forecasted to protect the squirrels from hypothermia. Trapping was performed the second and third weeks of June with four trap nights per week.

If a squirrel was captured, it was brought back to the vehicle and the trap was placed in a sealed container along with a cotton ball filled tube laced with the anesthetic isoflurane. After the squirrel had been sufficiently anesthetized, it was removed from the trap and container. One person handled the squirrel and made sure it was kept under anesthesia by holding the isoflurane close to the squirrels mouth and nose. This person was also responsible for checking the respiratory rate of the squirrel to make sure it was not placed too deeply under anesthesia. Another person then ear tagged the squirrel and took measurements of the squirrel's tail length, hindfoot length, and total length while noting any markings or evidence of breeding.

Lastly, while the squirrel was still under anesthesia, it was equipped with an ATS model M1420 radio collar. Prior to attachment, the heat shrink layer of the collar was dipped in plasti dip. The first coat of plasti dip was mixed with cayenne pepper to dissuade the squirrels from chewing through the layer. Then a second coat of pure plasti dip was applied to ensure that the cayenne pepper did not cause skin irritation to the squirrels [2, 8]. The radio collar was attached using fishing line that was cut to the appropriate length. A receiver was then used to check the functionality of the collar and then the squirrels were placed in a small tank for recuperation. A mixture of peanut butter and oats was placed in with the squirrel to help with the recuperation process. The squirrel was released back into the habitat where it was captured only after all the visible effects of the anesthesia had worn off.

Pinpoint tracking was used during the daytime hours because of its accuracy. A Yagi antenna and R-1000 Telemetry receiver (Communication Specialist, Inc) were used to track all the squirrels to their exact location. Each radio collar had a different frequency allowing individuals to be found separately. Each squirrel was found at least once per day.

Triangulation was used during nighttime hours because of safety concerns. The antenna and receiver were used to find the direction of the strongest signal at a given location. A heading of that direction was then taken and a Trimble Geo XT 2008 series with ArcPad 8.0 GPS unit was used to take a point at that location. This was repeated at two more locations, for a total of three. All three locations and headings had to be taken within twenty minutes for the point to be viable. Geographic Information Systems (GIS) software was then used to elongate each heading from its location and using this information the squirrel’s location was determined. The nighttime hours were separated into four hour blocks so that telemetry could be performed. The squirrels were separated into two groups, with one group being tracked one night and the next group being tracked the subsequent night. This ensured that each squirrel was located at least once an hour during the tracking blocks. Overall, the movement of each squirrel was tracked for most of the 24 hour period with an average of 1 point per hour.

The data was then imported into ArcGIS ArcInfo 9.2 and analyzed. The mean center of the points was calculated to estimate the center of the squirrel’s home range. The directional distribution of the points was then calculated at one standard deviation and two standard deviations as estimates of home range. Directional distributions take a weighted average of the telemetry points and produce an elliptical output. There is a 70 % confidence that the squirrel will be found in the 1st standard deviation and a 95 % confidence that the squirrel will be found in the 2nd standard deviation. Using Hawth's tools, a minimum convex polygon was taken as another estimate of home range. A minimum convex polygon is created by simply connecting all the outer telemetry points. Points were then split into roosting and foraging groups based on the time they were taken. Roosting points were taken after 0530 hours but before 2030 hours while foraging points were taken during the remaining hours. The points were then connected and measured to get an idea of total movement and average nightly movement. Vegetative data was analyzed by overlaying the squirrels' minimum convex polygons with vegetative maps to determine the percentage of each vegetative type found within the squirrels' range.

Results

Seven individuals were captured over the course of 160 trap nights yielding a success rate of 4.38% (figure 1). One of the seven died possibly due to the isoflurane. After this incident, the squirrels were more closely monitored while they were under anesthesia. The other six squirrels were successfully collared and released. The individual squirrels are identified by their radio collar frequencies which were 149.281, 149.310, 149.370, 149.400, 149.431 and 149.460.

Squirrel 281 was an adult female who was tracked for only 4 days. This was a result of an improper attachment of the radio collar which left it too loose and allowed squirrel 281 to chew the plastic mounting surrounding the transmitter. The fishing line that was used to attach the collar was secured in the mounting and once compromised, the collar slipped off. Because of this, squirrel 281 was never tracked during nighttime hours and as such not enough data was collected to produce an accurate home range. Over the course of the four days, squirrel 281 moved a total of 379.6 meters with the longest distance moved in a 24 hour period being 156.1 meters over the course of 19 hours and 20 minutes. The area covered by squirrel 281 in the four days she was tracked was 17.2 % pitch pine/mixed oak-heath forest and 82.8 % scarlet oak-heath forest (figure 2).

Squirrel 310 was an adult female who was tracked for 37 days. Its home range was estimated at 0.83 ha using a minimum convex polygon. Using directional distribution, its home range was estimated at 0.97 ha at two standard deviations and 0.24

ha at one standard deviation (figure 3). A directional distribution, at the more conservative one standard deviation, was then performed on the roosting and foraging points to estimate the area squirrel 310 used for nesting versus the area squirrel 310 used for food gathering. The roosting range was shown to be 0.02 ha while the foraging range was shown to be 0.48 ha (figures 8, 9). Squirrel 310 moved a total of 1403.9 meters over the course of the study. The longest distance squirrel 310 moved over both a 24 hour period and a one hour period was 104 meters over the course of 21 minutes. The minimum convex polygon of squirrel 310 was 36.0 % scarlet oak-heath forest, 8.2 % successional, and 55.8 % red maple/scarlet oak-mesic heath forest.

Squirrel 370 was a juvenile male that was tracked for 35 days. A minimum convex polygon had a total area of 5.28 ha while directional distributions at two standard deviations and one standard deviation had areas of 7.49 ha and 1.87 ha, respectively (figure 4). The roosting directional distribution was 0.38 ha while the foraging directional distribution was 2.98 ha, both completed at one standard deviation (figures 8, 9). Squirrel 370 moved a total of 3077.5 meters over the course of the tracking. The longest distance traveled in a 24 hour period was 346.1 meters over the course of 16 hours and 47 minutes. Squirrel 370 moved 182.0 meters in the course of an hour. The territory of squirrel 370 was 3.3 % pitch pine/mixed oak-heath forest, 17.4 % scarlet oak-heath forest, 3.8 % successional, 58.7 % red maple/scarlet oak-mesic heath forest, 2.5 % pitch pine/white oak forest, and 14.2 % red maple-blackgum wet forest.

Squirrel 400 was a juvenile male that was tracked for 36 days. The minimum convex polygon had an area of 4.25 ha and the directional distributions had areas of

11.64 ha and 2.91 ha at two standard deviations and one standard deviation, respectively (figure 5). Squirrel 400's roosting range was shown to be 1.07 ha while its foraging range was 2.96 ha (figures 8, 9). It moved a total of 2473.1 meters during the 36 days. The longest distance it moved in a 24 hour period was 234 meters over the course of 10 hours and 23 minutes and 162.1 meters over the course of 50 minutes was the longest distance it moved in a one hour period. The vegetative percentages were 7.4 % pitch pine/mixed oak-heath forest, 27.1 % scarlet oak-heath forest, 5.7 % successional, 58.3 % red maple/scarlet oak-mesic heath forest, and 1.5% red maple-blackgum wet forest.

Squirrel 431 was a juvenile male that had a minimum convex polygon with an area of 2.41 ha. Directional distributions were taken at one and two standard deviations with areas of 1.26 ha and 5.02 ha, respectively (figure 6). Its roosting range was 0.26 ha and its foraging range was 1.94 ha (figures 8, 9). Squirrel 431 moved a total of 1713 meters over the course of 18 days. After 18 days, the signal was lost and never recovered even though the search area was expanded to include the surrounding habitat. It is possible that squirrel 431 moved off site, was taken by a predator, or that the collar failed. The longest distance moved in both a 24 hour period and a one hour period was 209.3 meters over the course of 56 minutes. The vegetative data was 2.7 % pitch pine/mixed oak-heath forest, 41.5 % scarlet oak-heath forest, 4.1 % successional, 46.0 % red maple/scarlet oak-mesic heath forest, 4.2 % red maple-blackgum wet forest, and 1.6 % road.

Lastly, squirrel 460 was a juvenile male that was tracked for 35 days. A minimum convex polygon estimated its home range at 3.94 ha while directional distributions at one and two standard deviations estimated the home range at 0.92 ha and 3.70 ha respectively (figure 7). Its roosting range was 0.15 ha while its foraging range was 1.55 ha (figures 8, 9). It moved a total of 2208.2 meters over the course of the 35 days. Its maximum movement both over 24 hours and one hour was 226.1 meters over the course of 42 minutes. The territory of squirrel 460 was 23.5% pitch pine/mixed oak-heath forest, 52.1 % scarlet oak-heath forest, 3.6 % successional, 20.4 % red maple/scarlet oak-mesic heath forest, and .5 % red maple-blackgum wet forest.

Squirrels 310, 370, 400, 431, and 460 had average directional distributions of 5.76 ha and 1.44 ha, with the first being at two standard deviations and the second being at one. The average of the minimum convex polygons was 3.34 ha. The average roosting range was 0.37 ha while the average foraging range was 1.55 ha. Squirrel 281 was not included because of the short time span for which it was tracked.

By plotting the locations and home ranges on a map, the territories of the squirrels can be observed. Squirrel 281 had the western most territory and moved slightly south during the four days it was tracked. The territory of squirrel 310 changed little over the course of the study, in both location and size. The territories of squirrels 370, 400, and 431 heavily overlapped for most of the study, even down to the exact trees they were using for day hides (figure 9). Squirrel 460 had a more western territory that was similar in size to the other juvenile males.

Since squirrel 400 showed the most movement over the course of the study, his foraging and roosting data was separated into weekly categories. The mean center of each week was calculated and the distance between the mean centers week to week was measured along with the area of directional distributions taken at one standard deviation. The roosting areas were 0.07 ha, 0.31 ha, 0.001 ha, 0.0002 ha, and 0.02 ha for weeks one through five, respectively. The foraging areas were 0.46 ha, 1.33 ha, 0.12 ha, and 0.34 ha for weeks two through five, respectively. There were no foraging points for the first week because nighttime triangulation was not started until the second week. The distances between the roosting mean centers were 34.57 m between weeks one and two, 43.44 m between weeks two and three, 260.9 m between weeks three and four, 7.8 m between weeks four and five, and 7.7 m between weeks five and six. The distances between the foraging mean centers were 74.6 m between weeks two and three, 208.9 between weeks three and four, and 57.0 m between weeks four and five (figure 10).

Discussion

Home range sizes varied greatly between the individual squirrels, with the adult female having a far smaller home range than the juvenile males. This could be explained by a number of different possibilities. Since the adult female stayed in the same day hide for most of the study, it is possibly that she slipped the collar and that the foraging range taken from the points at night was a result of error in the triangulation. Another likely possibility is that she had a nest of young in the tree. When she was captured it was noted that she appeared to be lactating, indicating that she had young she was caring for. Her home range could be smaller due to her having to care and protect her young, making her less inclined to venture farther away from the nest.

Toward the beginning of the study, squirrels 370, 431, and 460 were often found sharing the exact same day hides. As the summer progressed, they moved to a location further south but still remained together. Only toward the end of the study did they separate and establish their own day hides in different territories. An explanation for this is that they were siblings from the previous breeding season. They were most likely newly weaned from the nest early in the summer and as the summer progressed they spread out due to the developing food competition. This is clearly illustrated by figures 8 and 9. As shown, squirrel 370 foraged in the southeastern portion of the study area while squirrel 400 foraged in the northern portion. Squirrel 431 seems to have been foraging and moving southwest before his signal was lost.

The greater home ranges and movement rates of the four juvenile squirrels are consistent with the theory that they were exploring and establishing their own territories as the summer progressed. The roosting range and directional distributions for squirrel 400 in particular are very large. This is because squirrel 400 showed the most movement throughout the study, moving first from the eastern portion of the study area to the southeastern portion of the study area, and finally to the northern portion of the study area. He moved a significant distance between weeks three and four, in terms of both roosting and foraging (figure 10). This move supports the theory that the juveniles were competing for food resources because the foraging range of squirrel 400 was much lower in the weeks after his move north than it was in previous weeks.

The vegetative data shows a trend that the squirrels prefer scarlet oak-heath forest and red maple/scarlet oak-mesic heath forest to other vegetative types. One of these two types was by far the majority percentage in all of the squirrels and in many they were the top two. While the majority of the study area consisted of these two forest types, there were large stands of other forest types present in the area and these areas were underused by the squirrels. This indicates that the squirrels preferred the scarlet oak-heath forest and red maple/scarlet oak-mesic heath forest to the other vegetative types and were not simply in these areas because of the scarlet oak-heath and red maple/scarlet oak-mesic heath forest abundance. The common link between these forest types is the scarlet oak, which could explain the preference since scarlet oak produces nuts that the squirrels consume. The abundance of hard mast in these forest types would provide a much larger food source for a foraging squirrel than other forest types dominated by other tree species.

Acknowledgements

I would like to thank the Department of Energy, Brookhaven National Laboratory, Science Undergraduate Laboratory Internship and the Office of Educational Programs. I would like to extend a special thanks to Jennifer Higbie for all her work teaching and helping me throughout this project. I would also like to thank Tim Green, Alex Mancuso, Brittany Hernon, Maria Brown, Rich Lagattolla and all the guys at building 528 for all their help.

References

[1] A. Godin, *Wild Mammals of New England*. Baltimore, MD: The Johns Hopkins University Press, 1977.

[2] Adams, Ian, Campbell, G. Douglas, Improved Radio-Collaring for Southern Flying Squirrels, *Wildlife Soc. B.*, 24:4-7, 1996.

[3] Bendel, Peter, Gates, J. Edward, Home Range and Microhabitat Partitioning of the Southern Flying Squirrel (Glaucomys volans), *J. Mammal.*, 68:243-255, 1987.

[4] Bowman, Jeff, Holloway, Gillian, Malcolm, Jay, Middel, Kevin, Wilson, Paul, Northern Range Boundary Dynamics of Southern Flying Squirrels: Evidence of an Energetic Bottleneck, *Can. J. Zool*., 83:1486-1494, 2005.

[5] Holloway, Gillian, Malcolm, Jay, Northern and Southern Flying Squirrel Use of Space Within Home Ranges in Central Ontario, *Forest Ecol. Manag.*, 242:747-755, 2007.

[6] J. Whitaker Jr. and W. Hamilton, *Mammals of the Eastern United States*, 3rd ed. Ithaca, NY: Cornell University Press, 1998, pp. 249-254.

[7] Loeb, Susan, Chapman, Gregg, Ridley, Theodore, Sampling Small Mammals in Southeastern Forests: The Importance of Trapping in Trees, *Proc. Annu. Conf. Southeast. Assoc. Fish and Widl. Agencies*, 53:415-424, 1999.

[8] Madden, Robert, Giacalone-Madden, Jacalyn, A Method for Radio-Tagging Flying Squirrels, *J. Wildlife Manage*., 46:525-527, 1982.

[9] Taulman, J. F., Smith, K. G., Home Range and Habitat Selection of Southern Flying Squirrels in Fragmented Forests, *Mamm. Biol.*, 69:11-27, 2004