Microclimate effects on tick abundances in the Long Island Central Pine Barrens

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Abstract

The need for fire on the pine barren landscape of Long Island, New York, has been an ongoing battle between ecologists and society. Brookhaven National Laboratory (BNL) is situated in this pine barrens ecosystem, which relies on prescribed burns to clear the understory to make way for pitch pine (*Pinus rigida*). A history of fire suppression due to increased human development has led to a process called mesophication. Mesophication is a positive feedback loop in which, once the understory becomes shaded, only shade-tolerant species can thrive, leading to even more shade-tolerant species that outcompete shade-intolerant species. At BNL, pitch pine is the shade-intolerant species, and it is being outcompeted by native species like scarlet oak (*Quercus coccinea*), and black oak (*Quercus velutina*). In this study, we gathered data on vegetation moisture, canopy density, and cloud cover to reveal the relationship between an open canopy and the abundance of tick populations. Ticks are sensitive to drying out so with this hypothesis you would expect to find less ticks in sites that have been burned more often, have a more open canopy, and less cloud cover. Not only could this data be useful in persuading people that prescribed burns are an effective management tool, but it could decrease tick abundance and the transmission of tick-borne illnesses. This would contribute to the efforts of BNL to support environmental stewardship in the community. From this project I have become more confident in vegetation analysis and gained more experience with new sampling and analyzing techniques through tick sampling.

Methods

To collect the environmental data that might influence the abundance of ticks we utilized three different ways of quantifying plot moisture. To quantify cloud cover the observation basics data sheet provided by NOAA in association with the Globe Observer provided multiple points to collect cloud cover and sky data[4]. Lastly, vegetation samples were collected from a 1x1 meter square from a corner of plot 5, 29, 31, 51, 52, 92, 94, 95, 106, and 107, located on BNL property. All live vegetation was cut and collected within this square. The weight was measured before and after being placed in a drying oven set to 70 degrees Celsius for three days. To obtain the Live Fuel Moisture Content percent (LFMC%) the wet weight was subtracted by the dry weight, then divided by the dry weight and multiplied by 100 to obtain a percentage. Most of the datapoints were collected at the same time as the tick sampling which was done within 16 by 25-meter plots established across the pine barrens. 20 sixteen meter transects with a 1x1m white drag. At each end and in the middle (at 8 meters), any ticks that were picked up by the dragger and the blanket would be identified in the field and stored in 100% ethanol. The instar and species would be recorded. If there were larvae, too small to pick up with tweezers, then they were collected using a lint roller and stored to be counted later under a scanning microscope. Before and after dragging, ambient weather conditions would be taken using a Kestrel™ weather meter, these two data points were averaged, and the relative humidity was analyzed for this project. The data analysis was done using R studio using three different statistical test, Shapiro-Wilks to test for normality, Kruskal-Wallis to find differences in the abnormal data, and then the Dunn's test with the Bonferroni method to find where those differences lie.

Using compasses to find previously established plots

Dragging for ticks in the field

Discussion

With the data results we can extrapolate that there were some predictors of tick abundance with relative humidity percentages. Some of the limitations of this study was the timeframe to develop this project, to collect data, and to properly process and analysis data. Specifically with the research that was completed, even more ambient microclimate data could have been collected like soil moisture and light intensity at plots that would have contributed to more variables for further analysis. It is important to note that LFMC% would not be a contributing factor to tick abundance since it varies throughout periods of growth during a given year. It would have been beneficial to not only sample in different fire histories but also making note of shrub density and species and correlate that data with tick abundance and tick species. This would have given more insight to what species of vegetation tick species prefer and allow for a better way for managers to decrease tick-borne illness transmission with the public.

References

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Introduction

We hypothesized that ticks would be found in plots that have more open canopies and receive higher amounts of solar radiation, providing a less suitable habitat for ticks. Our hypothesis is predicated upon the understood pattern of fuel moisture in living vegetation. Live Fuel Moisture (LFM) is the amount of water found in vegetation that could potentially burn in a fire. According to the National Wildfires Coordinating Group, LFM can vary between 30% at dormancy and 250% at peak green up[3]. The moisture of vegetation along with the amount of sun that is reaching a forest floor is important in understanding the behavior of ticks. They must balance the risk of desiccation and the reward of a blood meal. In a study done by Thomas et. al (2010)[1], researchers examined what specific environmental factors influenced questing (the act of climbing up vegetation to find a blood meal) behavior and suggested that questing activity was highly variable across different species. In another study done by Williams and Ward (2020)[2], they looked at plots with varying densities of the exotic shrub Japanese barberry and the relationship with Blacklegged tick (*Ixodes scapularis*) abundance. They found five times the number of ticks in plots with no control of the invasive plant than in controlled plots with no barberry. The authors noted that this may be attributable to the loss of the hospitable microclimate that Blacklegged ticks need to be successful in finding a blood meal and not dry out. In a lab setting, Williams and Ward (2020)[2] manipulated relative humidity (RH) and recorded the percent mortality of *I. scapularis* and various RH percentages. They found "the critical threshold for tick survival is ≈80% RH" but they do address the variability of RH in forested habitats may not always stay above or below this number. Based on multiple lines of evidence exploring the relationship between Japanese Barberry and ticks, it is likely that this plant provides a high RH environment within its dense growth. We can apply this framework to the hypothesis that plots with high tick abundances will likely have a higher RH and vegetation with higher densities.

Results

There was no significant relationship between the relative humidity ranges and the abundance of species with life stages.

LSL by RH
chi-squared = 8.3429, df = 4, p-value = 0.07979
LSA by RH
chi-squared = 2.6642, df = 4, p-value = 0.6155
LSN by RH
chi-squared = 1.0016, df = 4, p-value = 0.9096
DN by RH
chi-squared = 4.3655, df = 4, p-value = 0.3588

The Kruskal-Wallis's rank sum test found there was a slight significance between two RH ranges in Lone Star (*A. americana*) larvae abundance values. Between the RH percentages of 60-65 and 65-70, Dunn's test calculated an adjusted p-value of 0.11. The second RH range 65-70 and 75-80 had an adjusted p-value of 0.15. The scatterplot in Figure 1 shows the trend of LFMC% percent and the date the vegetation was collected. Figures 2-5 show the Kruskal-Wallis and Dunn tests results.

Figure 1: *Live Fuel Moisture Content over a span of two months in 2023 from vegetation collected in the central pine barrens of Long Island.*

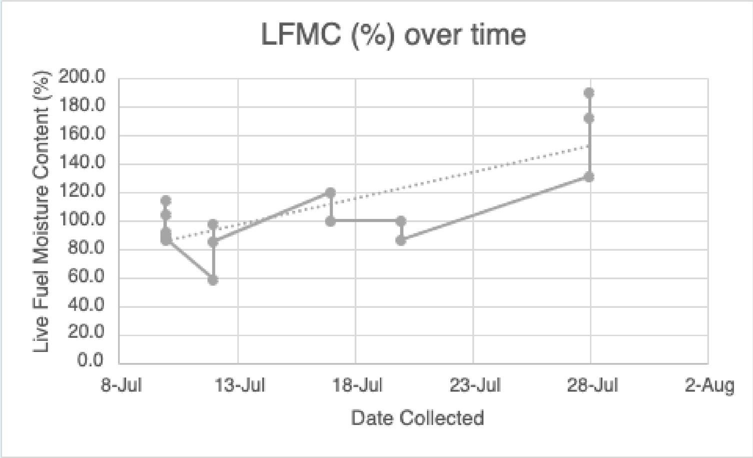

Figure 2: *Dunn's statistical test results for* A. americana *nymph abundance against relative humidity percent.*

Comparison	Z	P. adj
50-55 - 55-60	0.7228974	1
50-55 - 60-65	0.3934955	1
55-60 - 60-65	-0.5622535	1
50-55 - 65-70	0.2811268	1
55-60 - 65-70	-0.6985007	1
60-65 - 65-70	-0.1740309	1
50-55 - 75-80	0.6558258	1
55-60 - 75-80	-0.1338699	1
60-65 - 75-80	0.4543695	1
65-70 - 75-80	0.6024145	1

Figure 3: *Dunn's statistical test results for* A. americana *larvae abundance against relative humidity percent.*

Comparison	Z	P. adj
50-55 - 55-60	--0.5463444	1
50-55 - 60-65	0.0000000	1
55-60 - 60-65	0.9105740	1
50-55 - 65-70	-1.5240134	1
55-60 - 65-70	-1.5458303	1
60-65 - 65-70	-2.5400223	0.1108454
50-55 - 75-80	0.0000000	1
55-60 - 75-80	0.8638464	1
60-65 - 75-80	0.0000000	1
65-70 - 75-80	2.4096767	0.1596666

Figure 4: *Dunn's statistical test results for* A. americana *adults against relative humidity percent.*

Comparison	Z	P. adj
50-55 - 55-60	-0.36965497	1
50-55 - 60-65	0.03353578	1
55-60 - 60-65	0.67085532	1
50-55 - 65-70	-0.51340968	1
55-60 - 65-70	-0.22729616	1
60-65 - 65-70	-0.91044651	1
50-55 - 75-80	0.36889358	1
55-60 - 75-80	1.21849232	1
60-65 - 75-80	0.58085675	1
65-70 - 75-80	1.45808350	1

Figure 5: *Dunn's statistical test results for* I. scapularis *nymph abundance against relative humidity percent.*

Comparison	Z	P. adj
50-55 - 55-60	-1.6000370	1
50-55 - 60-65	-0.7110920	1
55-60 - 60-65	1.5055201	1
50-55 - 65-70	-1.1544571	1
55-60 - 65-70	0.7045237	1
60-65 - 65-70	-0.7628869	1
50-55 - 75-80	-1.4387209	1
55-60 - 75-80	0.3173069	1
60-65 - 75-80	-1.2602904	1
65-70 - 75-80	-0.4253263	1

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"The research described herein is Fundamental Research as defined in the ITAR (22 CFR 120.34(a)(8)), EAR (15 CFR 734.8), or Part 810 (10 CFR 810.3), as applicable, and as described in the USD (AT&L) memoranda on Fundamental Research, dated May 24, 2010, and on Contracted Fundamental Research, dated June 26, 2008."

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