Cases of Lyme Disease Appear to Follow Periodic Cycles Linked to Geography

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Abstract

We are studying the spread of Lyme disease through Wisconsin. It is important because the number of people diagnosed with Lyme Disease in the US is around 300,000, annually (CDC 2017). The CDC has collected data of reported Lyme Disease cases since 2001. When looking at the data we noticed that the trends of cases of Lyme disease followed a cyclical pattern. The cycles varied widely. We hypothesized that environmental and geographical factors could affect the main vector of Lyme Disease, *Ixodes scapularis* (the black-legged tick). After analyzing Lyme Disease data from the CDC and using a map making software (Paint Maps 2018), we found that geographical distribution had a marked effect on the rate at which counties cycled between up and down trends in infection rates. These findings are important because they give us more insight into possible control methods to keep the black-legged tick, and therefore Lyme Disease, at a manageable level.

Background

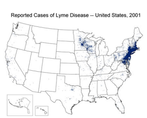
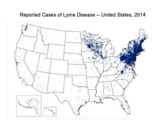
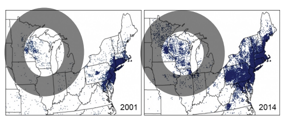


Fig. 1 Case map of Lyme Disease from 2001 to 2014 in the United States (top) and In Wisconsin (bottom)





Preliminary Analysis

In the preliminary analysis we found that the number of cases in each county seemed to be rising and falling in consistent, periodic, cycles. We were curious as to whether these cycles changed according to geographic and environmental factors.

Study System

Ixodes scapularis, or the black-legged tick, and the Western black-legged tick are the only known transmitters of Lyme disease in the US (American Lyme Disease Foundation 2018). *Ixodes scapularis* has a two year life cycle (ALDF 2018). During the first year of life the egg is hatched and turns into a larvae. While it is a larvae the tick feeds on small animals like birds and mice (ALDF 2018). During the second year, the larvae turn into nymphs and start feeding on larger animals like deer and humans (ALDF 2018). After they feed they fall off and molt into adults (ALDF 2018). They soon begin looking for another host so they can feed and then mate (ALDF 2018). If they can not mate they can sometimes live into a third year. (ALDF 2018) The nymph and adult phase are the phases where they pose an infection risk to humans (ALDF 2018).

Methods and Experimental Design

We started the experiment by looking at the CDC webpage over Lyme Disease. The website had surveillance data on a county level for the entire US at this website (https://www.cdc.gov/lyme/stats/survfaq.html).

From there, we pulled all the data for the state of Wisconsin from 2000 to 2015. We put it in Microsoft Excel and started charting the disease rates to see if we could find any patterns. When tracking the rates of disease infection we followed the following rules:

(1) The tracking will start when the difference in number of cases from year to year is greater than two; or if the cases for a beginning year are greater than two.

(2) A change in direction must be greater than 2 cases for a change in direction to be counted.

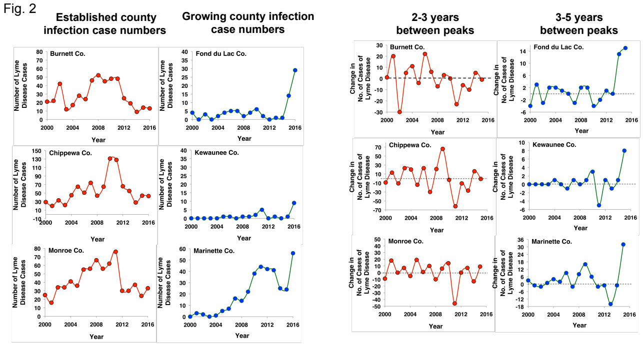
(3) The year where case differences, year to year, are above absolute value two will be the first year that is counted.

We then divided the number of changes, by the number of years we had counted. Once we had a value for every county we entered the data in "Paint Maps dotcom" (https://paintmaps.com/map-charts/277/Wisconsin-map-chart) to get a color coated chart. We then looked for patterns in the values of the chart.

Results

These cycles looked to depend upon geographic distribution for duration of the cycle. In the eastern third of the state, the cycles appeared more drawn out. In the western two thirds of the state the trends in case numbers appeared to change direction more rapidly. This is significant because it gives us insight into how the tick's biology, vector availability (i.e., Deer), and habitat might interact to cause periodic fluctuations in Lyme Disease cases – regardless if the tick population is relatively stable or growing.

Fig. 2



Conclusions

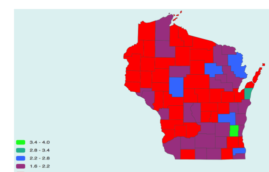
These cycles looked to depend upon geographic distribution for duration of the cycle. In the eastern third of the state the cycles appeared more drawn out. In the western two thirds of the state the trends in case numbers appeared to change direction more rapidly. This is significant because it gives us insight into possible pest management strategies.

Future Directions

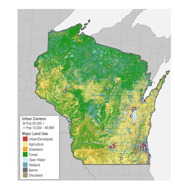
A major future direction we would like to head in is to see how deer populations are affecting the ability of the black-legged tick to establish in different counties. There seems to be a correlation between areas with high deer populations and areas where the ticks are able to establish (Jones 2018). There also seems to be a correlation between forest cover and the ability of the tick to establish. A really interesting follow-up experiment would be to look further into infection rates in areas that are forested and compare them with areas that are non-forested. Another part of that experiment could also include looking at counties with higher deer populations and comparing the cycle length to counties that do not have high deer populations.

Fig. 3

Infection cycle rate



Terrain map of Wisconsin



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