Challenges and Progress in Integrated Tick Management Research and Communication

Rayda K. Krell, Ph.D.
Western Connecticut State University
Tickborne Disease Prevention Laboratory
My Background: Integrated Pest Management
Past Experience
Plant Hosts vs. Human Hosts

- Do not move
- Do not apply management tactics to themselves
- Do not read articles on the internet

- Move (and make decisions about where to move)
- Make their own management decisions
- Read articles on internet
Integrated Pest Management vs. Integrated Tick Management

“A comprehensive pest technology that uses combined means to reduce the status of pests to tolerable levels while maintaining a quality environment.” (Pedigo 2015)

- Pest technologies (tactics) are based on a fundamental understanding of pest ecology, i.e. distribution and abundance of pests in time and space and relationship to environment.

- Certainly applicable to tick management.
Integrated Pest Management vs. Integrated Tick Management

“A comprehensive pest technology that uses combined means to reduce the status of pests to tolerable levels while maintaining a quality environment.” (Pedigo 2015)

• Is there a tolerable level of arthropods when they transmit pathogens?

• The level of control required is much higher with a vector of human pathogens.
…it is increasingly apparent that under most circumstances, no one method is likely to be universally acceptable to homeowners or provide sufficient suppression of tick abundance or the prevalence of the pathogen in the vector or reservoir host in order to prevent human disease.

Integrated Tick Management is likely required for tickborne disease prevention.
Why do we care about ticks?

The pathogens.

- Lyme Disease - bacterium
- Babesiosis – malaria-like protozoan
- Anaplasmosis - bacterium
- Hard Tick Relapsing Fever (Borrelia miyamotoi): <60 cases confirmed in U.S. - bacterium
- Powassan Virus: 7-12 cases in U.S. each year
Reported Cases of Tickborne Disease: U.S. States and Territories, 2004-2016

Google Searches
Relative Interest in Term “tick” (animal)
Reported Mosquitoborne and Tickborne Disease Cases: U.S. States and Territories

Number of Anaplasmosis Cases in U.S.

Source: https://www.cdc.gov/anaplasmosis/stats/index.html
Number of Reported Babesiosis Cases

Number of Reported Powassan Virus Cases in the U.S.

Source: https://www.cdc.gov/powassan/statistics.html
How can we stop this increase and prevent tickborne disease?

- **Reduce Entomologic Risk**
  - Tick abundance
  - Tick infection rates

- **Understand Human Behavior**
  - Prevention practices
  - Outdoor exposures

Prevent Tickborne Disease
Why is this difficult?

Reduce Entomologic Risk
- Tick abundance
  - Sampling
  - Patchy distribution
  - Movement by hosts
- Tick infection rates
  - Lab techniques
  - Multiple pathogens
  - Infection ≠ transmission

Understand Human Behavior
- Prevention practices
  - No method is 100%
  - Communication
  - Trust
- Outdoor exposures
  - Where?
**Ixodes scapularis** Life Cycle

- Entomological approach
  - Understand vector ecology
  - Look for places to break the cycle
Ixodes scapularis Life Cycle

Year One
- Spring: eggs
- Summer: larvae
- Autumn: nymphs
- Winter: adults

Year Two
- Spring: adults mate, produce eggs & die
- Summer: ADULTS
- Autumn: ADULTS
- Winter: ADULTS

Meal 1: Meal 2: Meal 3:
White-footed mice are important reservoir hosts for Lyme bacteria (*B. burgdorferi*)

Other reservoir-competent hosts:
- Chipmunks
- Squirrels
- Meadow Voles
- Short-tailed Shrews
- Virginia Opposum
- Raccoons
- American Robins
- Cardinals
- Catbirds
- Song Sparrows
Deer are Reproductive Hosts

Deer do not infect ticks with *B. burgdorferi*!

Deer contribute to the abundance of ticks in an area
Enzootic Cycle of B. burgdorferi

Year One
Spring    Summer    Autumn    Winter
eggs
larvae

X = infection with B. burgdorferi

Year Two
Spring    Summer    Autumn    Winter
nymphs
adults

Adults mate, produce eggs & die
Eggs
Meal 1
Meal 2
Meal 3
Tickborne Disease Prevention Laboratory
Western Connecticut State University

- Dr. Neeta Connally, MSPH, Ph.D., Associate Professor
- Intersection of tick ecology and human behavior
Research at WCSU
Tickborne Disease Prevention Laboratory

Reduce Entomologic Risk

- Long-term tick phenology surveillance
- Research better tactics to reduce ticks and tickborne diseases on residential properties
- Research on personal protection measures

Prevent Tickborne Disease

Understand Human Behavior

- Record human behaviors associated with tickborne disease
- Increase adoption of tickborne disease practices with better communication
Tick Phenology Surveillance

- Woodland habitats
- 3 sites sampled since 2007
- 1 site added in 2018
- Sampled weekly May-September
- 20-minutes of sampling with drag cloths
- Nymphs not removed
Tick Phenology Surveillance

Average Nymphal Blacklegged Tick Seasonal Activity, 2011-2018

*Estimates based upon forty 30-second sampling drags (20 sampling minutes) at three Fairfield County, CT, locations. Source: NP Connolly, Western CT State University
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We live in tick habitat.
Peridomestic Risk for Exposure to *Ixodes scapularis* ticks

Approx. 90% of backyard ticks are found in the wooded edge and ecotone where lawns meet woods

67%  22%  2%

Backyard Integrated Tick Management Study 2016-2020

STUDY GOALS

1. Evaluate integrated management program with two tick management tick tactics
   • at single vs. contiguously treated backyards

2. Understand how people use outdoor environments
BITM Study Design

• Placebo-controlled

• Properties/households in western CT and southern RI

• Inclusion criteria include no prior tick control for 2 years, property adjacent to forested/brushy habitat

• Outcome measures:
  • **Entomologic**: tick abundance and infection rates
  • **Human**: self reported tick encounters and human disease; daily activity log of outdoor activity
Single, Springtime Application of Acaricide

- Field studies: Reduction of questing nymphal *I. scapularis* 68-100% after a single application of synthetic pyrethroid (multiple studies).

- Best control using high-pressure sprayers.

- Not strong evidence that tick reduction related to decreased human disease, because not evaluated or many other possible factors.
Tick Box™ Tick Control System

Anatomy of a bait box

1. Bait boxes are placed around the perimeter of a home to attract the white-footed mouse that carries the bacteria responsible for Lyme disease and other illnesses. Ticks that feed on the mice become infected with the bacteria and transmit it to humans.

2. The smell of food entices a mouse to enter the bait box.

3. In order to collect its food, the mouse or other small rodent must rub against a wick that applies a low dose of an acaricide known aspermethrin to its fur.

4. The mouse exits the bait box unharmed, as the permethrin quickly works to kill any ticks that the mouse is carrying. The agent continues to kill ticks for many weeks after the initial application.
Tick Box™ Tick Control System

- Fipronil-treated wick (0.7% active ingredient)
- Passive application to mouse and chipmunk reservoir hosts
- Studies
  - Lab evaluation: prevented tick bites for 4-6 weeks after single application to mice in lab (Dolan et al. 2004)
  - Field evaluation (Schulze et al. 2017; Dolan et al. 2004)
    - 62-97% reduction of host seeking *I. scapularis* nymphs,
    - 60% reduction in *B. burgdorferi* infection prevalence in ticks
  - Treated properties were in close proximity to one another
  - Human disease/tick encounter outcomes not measured
## BITM Study Design

**ITM Approach:**

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Active ingredient</th>
<th>Targets:</th>
<th>Time of application</th>
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<tbody>
<tr>
<td>Tick Box™ Tick Control System bait boxes</td>
<td>Fipronil</td>
<td>Larval ticks parasitizing mice and chipmunks</td>
<td>July</td>
</tr>
<tr>
<td>Targeted application of acaricide spray</td>
<td>Beta-cyfluthrin</td>
<td>Questing nymphs</td>
<td>May</td>
</tr>
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</table>
Treatments Include
Two Different Modes of Action
Residential Treatment Groups

SINGLE TREATED YARD
(acaricide spray, active bait boxes)

CLUSTER OF TREATED YARDS
(acaricide spray, active bait boxes)

SINGLE PLACEBO YARD
(water spray, bait boxes without treatment)
Research at WCSU
Tickborne Disease Prevention Laboratory

- Long-term tick phenology surveillance
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- Research on personal protection measures

Prevent Tickborne Disease

• Record human behaviors associated with tickborne disease
• Increase adoption of tickborne disease practices with better communication

Understand Human Behavior

Reduce Entomologic Risk
BITM Study: Understanding How Human Behavior Affects Tickborne Disease Risk

- Monthly surveys administered to measure tick encounters and disease diagnosis
- Ticks detected on humans/pets submitted to URI TickSpotters for confirmatory ID
- Daily activity survey administered for one week in June
BITM Study Design

Time spent in outdoor locations:

In backyard:
• Forest edge
• Lawn adjacent to edge
• Lawn far from edge
• Gardens

Non-backyard locations
BITM Study – Current Status

132 properties enrolled
    single treated (n=28)
    treated clusters (n=29)
    single placebo (n=26)

Ticks sampled twice at all enrolled properties (pre-treatment) in late May-July 2017 (~2000 ticks tested by CDC DVBD)

Ticks sampled twice (post-year 1 treatments) late May-July 2018, ticks sent to CDC for testing.

Monthly tick encounter surveys conducted May 2017 – July 2018

Daily activity survey conducted in June 2017 and 2018

Bait boxes installed in late July 2017 and 2018
    - weighed 4 weeks post-installment

Acaricide applied mid-May 2018
BITM Study – Next Steps

- Weigh Bait Boxes, August 2018
  - Bait box visitor monitoring
- 2\textsuperscript{nd} Acaricide-spray May 2019
- Continue surveys, TickSpotters, residential tick sampling
- 2020: no treatments, tick sampling continued
Research at WCSU  
Tickborne Disease Prevention Laboratory

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Permethrin-treated Clothing and Repellents
Research at WCSU
Tickborne Disease Prevention Laboratory

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Human Exposure Study
Research at WCSU
Tickborne Disease Prevention Laboratory

Reduce Entomologic Risk

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Understand Human Behavior

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Prevent Tickborne Disease
Partnership with Communities
Uncertainty about Pesticide Use

Use of Pesticides on Properties

- **Agree/Strongly Agree**
- **Disagree/Strongly Disagree**
- **Not Sure**

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Agree/Strongly Agree</th>
<th>Disagree/Strongly Disagree</th>
<th>Not Sure</th>
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<tbody>
<tr>
<td>Effective</td>
<td>33%</td>
<td>24%</td>
<td>43%</td>
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<tr>
<td>Safe for Adults</td>
<td>25%</td>
<td>30%</td>
<td>45%</td>
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<tr>
<td>Safe for Children</td>
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<td>Safe for Pets</td>
<td>13%</td>
<td>44%</td>
<td>42%</td>
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<tr>
<td>Safe for Environment</td>
<td>12%</td>
<td>44%</td>
<td>45%</td>
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<tr>
<td>Expensive</td>
<td>30%</td>
<td>17%</td>
<td>53%</td>
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WCSU & Ridgefield Health Dept receive EPA grant for tick management

Published on Wednesday, 04 October 2017 12:38
Written by Sheri Hill

WCSU and Ridgefield Health Department receive EPA grant to educate communities about tick management

Western Connecticut State University and the town of Ridgefield's Health Department are building upon a long-standing community partnership to reduce the incidence of Lyme and other tick-borne diseases with a new $25,000 grant from the Environmental Protection Agency. The EPA Healthy Communities Grant Program funds projects that “…reduce environmental risks, protect and improve human health and improve the quality of life,” The WCSU-Ridgefield Health Department collaboration was one of 11 projects selected from 70 submissions.
Social Media

- 9 in 10 adults uses the Internet
- 70% use social media platforms (e.g., Facebook, Twitter, Instagram, LinkedIn)
- 75% of Facebook users visit the site multiple times per day
Social Media has Farther Reach than Traditional Scientific Communication

Source: Bic and Goldstein PLOS Biology 2013
The warm weather this week meant that blacklegged ticks were out looking for a meal. Here’s some of the 120+ adult ticks picked up by our student intern, Sandra, on Wednesday afternoon in Danbury, CT!
Lyme Prevention Social Media Survey

OBJECTIVE:

• Understand how social media users interact with Lyme prevention information

Source: Bic and Goldstein PLOS Biology 2013
Initial Response Results

Survey posted for 12 days:
• 456 responses
• 92% from high-incidence states in the Northeast/Mid-Atlantic
• 80% ages 30-60, predominantly female
• 70% visit social media sites several times per day

• Survey was shared directly from source page 84 times
• Post “organically” reached ~12,000 users (showed up on newsfeed)
• 1560 direct interactions with the post
Likelihood of Trusting Various Sources

- "Lyme-literate" physician
- CDC/Gov't Public Health
- Personal physician
- WebMD or Internet
- Friend or family
- Online forum
- Pest control company

Percentage of Respondents

- Very likely
- Somewhat likely
What is next for effective ITM?

- Results from current ITM projects…what really works?

- Understanding entomological factors alone may not be adequate to prevent disease

- Understanding human behavior to ensure recommendations can prevent disease in the scope of activity that puts humans at risk

- Improving communication: evidence-based prevention tactics are only as good as our ability to communicate and encourage adoption

- Build trust with the general public about the scientific basis for recommendations
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