Tick IPM Series
Part 1: Strategies and Barriers to the Prevention of Tick-Borne Disease

June 10, 2020
Webinar Details

• Welcome

• A recording of this webinar will be available within a week at
  • http://www.neipmc.org/go/ipmtoolbox
We Welcome Your Questions

- Please submit a question **at any time** using the Q&A feature to your right at any time

- If you’d like to ask a question anonymously, please indicate that at the beginning of your query.
Webinar Presenter

Kirby C. Stafford III, Ph.D.
Chief Scientist, State Entomologist
Department of Entomology
Center for Vector Biology & Zoonotic Diseases
CT Agricultural Experiment Station
New Haven, CT
Some Questions for You
“Few agricultural or health problems confronting human societies have proved as intractable as control of ticks and the many diseases they transmit.

Dan Sonenshine
Biology of Ticks, Vol. 2
Outline

• Overview of Tickborne Pathogens
• Tick Surveillance
• Tick Integrated Pest Management (IPM)
• Host Targeted Tick Control
• Challenges to Effective Public Tick Control
• Future Webinars
OVERVIEW OF TICKBORNE PATHOGENS
Discovery of tickborne pathogens as causes of human disease by year, 1909-2020

Note: This timeline shows when tickborne pathogens were recognized as causes of human disease. In some cases, organisms were identified in ticks before they were associated with human disease. In other cases, the disease was recognized before the etiological agent was found to be tickborne.

*Putative vector

Lyme Disease Case Distribution Northeast and Upper Midwest - 22 Year Expansion

1996
16,455 reported cases of Lyme disease

2018
33,666 reported cases of Lyme disease

Majority of Reported Vector-Borne Diseases are Spread by Ticks

- Lyme disease (68%)
  - 42,743 cases
- Other tickborne Diseases (27%)
- Mosquito- or flea-borne diseases (5%)

Diagnosed cases Prob. ~330,000-430,000

Cases of Nationally Notifiable Vector-borne Diseases Reported in the U.S., 2017

N= 62,399 cases
Major Ticks of the Northeast

- Records of 17 species of ticks in northeastern states
  3 species commonly bite humans
- 4, maybe 5, species can transmit disease pathogens
- Occasional exotic tick species from foreign travel and new invasive Asian longhorned tick

Blacklegged Tick
*Ixodes scapularis*

American Dog Tick
*Dermacentor variabilis*

Lone Star Tick
*Amblyomma americanum*

Woodchuck Tick
*Ixodes cookei*

Asian longhorned tick
*Haemaphysalis longicornis*

Others from humans in Connecticut include *Ixodes dentatus*, *Rhipicephalus sanguineus* (brown dog tick)
Three-host Tick Life-cycle

Ixodes scapularis

1. Larvae
2. Nymphs
3. Adults

Engorged female laying eggs

Kirby Stafford, CT Agricultural Experiment Station

Photos: K. Stafford unless otherwise labeled
Lyme disease—Reported confirmed and probable cases by week* of disease onset, United States, 2017 with Seasonal Activity of *Ixodes scapularis* in the Northeast

Case Data from CDC
Tick Surveillance
Passive vs. Active Tick Surveillance

Tick surveillance is intended to monitor changes in the distribution and abundance of ticks, seasonal activity, and the presence and prevalence of tickborne pathogens in order to provide actionable, evidence-based information to clinicians, the public and public health policy makers.
Lone star tick *Amblyomma americanum*

- 90-95% tick bites in southeastern U.S.
  - Bourbon virus infection
  - Ehrlichiosis: *Ehrichia chaffeensis*, *Ehrichia ewingii*
    Panola Mountain ehrlichia
  - Heartland virus infection
  - Southern Rash Illness (STARI)
  - Spotted Fever Group Tick-Associated Rickettsia
  - Tularemia
  - Red Meat Allergy (alpha-gal syndrome)
Expansion of Lone Star Ticks in the Northeastern United States

We have shown adult *A. americanum* can survive in Connecticut and to some extent, coastal Maine. Current environmental and climate conditions, especially moderate maritime climates, favor the establishment and expansion of lone star ticks along the New England coast (and mid-west). Inland areas may be still be to harsh for the immature stages. This tick is aggressive and is associated with several human diseases and will rise in importance for the region.


Asian Longhorned Tick
*Haemaphysalis longicornis*

An East Asian tick, the Asian longhorned tick *Haemaphysalis longicornis*, was discovered on sheep at a farm in Hunterdon County, NJ on 9 Nov 2017. The East Asian tick is considered a serious pest to livestock including cattle, horses, sheep, and goats and will attack pets, wildlife, and occasionally humans. It is a known vector for a number of human and animal pathogens in its native range in parts of China, the Koreas, and Japan.
Counties and county equivalents* where *Haemaphysalis longicornis* has been reported (N = 63) — United States, as of April 15, 2020

- From August 2017 to April 15, 2020, reported from twelve U.S. states (Arkansas, Connecticut, Delaware, Kentucky, Maryland, New Jersey, New York, North Carolina, Pennsylvania, Tennessee, Virginia, and West Virginia)
- Known distribution is expanding as surveillance efforts increase
- Not a vector for *B. burgdorferi*, but in lab for *R. rickettsii*
- Mainly of veterinary concern at this point

Source: National *Haemaphysalis longicornis* Situation Report, US Department of Agriculture, April 15, 2020
“There is increasing evidence from detailed analyses that rapid changes in the incidence of tick-borne diseases are driven as much, if not more, by human behavior that determines exposure to infected ticks than by tick population biology that determines the abundance of infected ticks.”

Randolph, S. E. 2010. To what extent has climate change contributed to the recent epidemiology of tick-borne diseases? Veterinary Parasitology 167: 92-94.

“Habitat diversity, environmental factors influencing survival and tick activity, and geographic distribution of the ticks impacts risk of tick-borne disease.”

Ticks as Vectors

Ticks are found in wooded and successional habitats in relatively high numbers. Infection prevalence and tick-borne disease incidence (TBD) are endemic and non-focal. Ticks don’t fly. People must enter or live in tick habitat to become exposed. Many homes are built in forested [tick & host] habitats.

Infection prevalence may be somewhat predictive of transmission risk for TBDs, but tick abundance and number of tick bites people receive impacts chance of encountering at least one infected tick. Risk is dependent upon human behavior, personal protection measures and tick checks.
Questions
IPM Tick Management
Approaches Integrated Tick Management

- Education and behavior change
- Personal protection measures
- Landscape modifications
- Chemical control
  Synthetic insecticides, botanicals, “natural” compounds
- Biological control
- Host reduction or exclusion
- Host-targeted acaricides
- Host-targeted vaccines
Risk Tick encounters
Passive Tick Surveillance (People submit ticks)
Exposure in Western U.S. is largely recreational
Personal Protection Measures

Tick Bite Prevention

• Clothing – pants tucked in socks
• Skin-based repellents: DEET (25-30%), Picaridin (20%), Oil of Lemon Eucalyptus (30%)
• Permethrin-based clothing tick repellents (0.5%) EFFECTIVE!
• Permethrin-treated clothing Reduced tick bites 58%
• Bathing, TICK CHECKS!
• Promptly remove ticks
Residential Landscape Management

Leaf litter removal 49-70% reduction

Landscape barrier 35-77% reduction
Leaf Litter management

- Leaf litter increases overwinter survival of *I. scapularis* nymphs and *A. americanum* adults
- Leaf blown or raked accumulations of leaves at lawn edge is associated with increased numbers of nymphal *I. scapularis*
- Removal off-site, bagging and possibly composting of leaf litter may help reduce risk.

![Graph showing the effect of leaf removal on nymphal survival.](image-url)
Higher tick counts are associated with exotic invasive forest understory than native forest understory or open understory forests.

Abundance adult blacklegged ticks, *Ixodes scapularis*, infected with *Borrelia burgdorferi*, was greatest in areas dense Japanese barberry.

Greater number lone star ticks, *Amblyomma americanum*, infected with *Ehrlichia sp.* was present in stands of invasive honeysuckle.

Dense stands provide ideal microclimate for ticks and host habitat.

Reduction and long-term management barberry significantly reduced abundance infected ticks.

Removal honeysuckle decreased deer activity and numbers of *Ehrlichia* infected ticks.
Spraying

- Synthetic Acaricides
  - Carbamate
  - Pyrethroids
  - Neonicotinoids (animals)

- Microbial Biopesticides
  - *Metarhizium anisopliae* (Met52)

- Botanicals & natural occurring substances, including plant extracts (essential oils) (EPA 25b list of minimum risk pesticides)

Photographs: Kirby Stafford
## % Reduction *Ixodes scapularis* Nymphs by Application Acaricides to the Environment

<table>
<thead>
<tr>
<th>Acaricide</th>
<th>Application</th>
<th>reduction nymphs*</th>
<th>Time evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pyrethroids</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bifenthrin</td>
<td>Spray</td>
<td>45-100%</td>
<td>1-6 wks</td>
</tr>
<tr>
<td>Cyfluthrin</td>
<td>Spray</td>
<td>88-100%</td>
<td>2-8 wks</td>
</tr>
<tr>
<td>Cyfluthrin</td>
<td>Granules</td>
<td>87-97%</td>
<td>1-8 wks</td>
</tr>
<tr>
<td>Deltamethrin</td>
<td>Granules</td>
<td>87-100%</td>
<td>1-5 wks</td>
</tr>
<tr>
<td><strong>Carbamate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbaryl</td>
<td>Spray</td>
<td>43-93%</td>
<td>2-13 wks</td>
</tr>
<tr>
<td>Carbaryl</td>
<td>Granules</td>
<td>46-96%</td>
<td>1 wk-3 mo</td>
</tr>
<tr>
<td><strong>Biopesticide 25b</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Metarhizium anisopliae</em></td>
<td>Spray <em>(Met52)</em></td>
<td>36-96%</td>
<td>3-8 wks</td>
</tr>
<tr>
<td><strong>Rosemary, etc.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rosemary, etc.*</td>
<td>Spray (low, 2x) (IC2)</td>
<td>10-95% (high 2nd appl)</td>
<td>1-5 wks</td>
</tr>
<tr>
<td>Rosemary, etc.*</td>
<td>Spray (high) (IC2)</td>
<td>100%</td>
<td>1-2 wks</td>
</tr>
<tr>
<td>Garlic</td>
<td>Mosquito Barrier</td>
<td>37-59% repellency</td>
<td>1-2 wks</td>
</tr>
</tbody>
</table>

Review Eisen, L. and M. C. Dolan. 2016. J. Med. Entomol. 53(3): 1063-1092. *Rosemary, peppermint, wintergreen, original IC2 is no longer available; but there is EcoExempt IC2 and Essentria IC-3 is a different formulation.*
Nootkatone

Metarhizium anisopliae
Future of product?

U.S. EPA Manufacturing Use Registration is Under Review

Evolva has a registration application before the U.S. Environmental Protection Agency (EPA) for the approval of NootkaShield™ for manufacturing use. Any product that will contain NootkaShield™ as an active ingredient must submit a product application to the EPA and be approved prior to initiating sales. Similar governing bodies in other countries must review data demonstrating NootkaShield™ is safe and effective.

https://evolva.com/NootKaShield/
Questions
HOST TARGETED TICK CONTROL
Host-Targeted Tick Control
Rodent Reservoir Hosts
White-footed Mice
Eastern Chipmunk
For *I. scapularis*

Chipmunks do not use the cotton in tick tubes

27.6 & 20.3% control nymphs, Yr 1 & Yr 2

84.0 & 79.1% control nymphs, Yr 1 & Yr 2

Jordan & Schulze 2019 J.Med.Entomol. 56:1095-1101

Non-Toxic Food blocks
Wick with 3 mls fipronil
Entry Points

Not applicable for lone star ticks as immature stages don’t readily use rodent hosts
Exclusion Reduction Treatment

Fencing Reduction (> 70 m inside) larvae 100%, nymphs 84%, adults 74%


OPEN ACCESS
## Tick-borne disease toolbox

<table>
<thead>
<tr>
<th>Personal protection measures</th>
<th>Treatment/vaccination in humans</th>
<th>Landscape/vegetation management</th>
<th>Killing host-seeking ticks</th>
<th>Rodent-targeted approaches</th>
<th>Deer-targeted approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoid tick habitat</td>
<td>Antibiotic prophylaxis after tick bite</td>
<td>Xeroscaping/hardscaping</td>
<td>Synthetic chemical acaricide</td>
<td>Topical acaricide bait box</td>
<td>Topical acaricide feeding station</td>
</tr>
<tr>
<td>Protective clothing</td>
<td>Human vaccine</td>
<td>Short grass, remove weeds</td>
<td>Natural product-based acaricide</td>
<td>Oral vaccine</td>
<td>Deer reduction</td>
</tr>
<tr>
<td>Tick checks &amp; prompt removal ticks</td>
<td>Remove leaf litter and brush</td>
<td>Fungal acaricide</td>
<td>Oral antibiotic bait</td>
<td>Deer fencing</td>
<td></td>
</tr>
<tr>
<td>Synthetic chemical repellent</td>
<td>Remove rodent harborage</td>
<td>Acaricide with semiochemicals</td>
<td>Oral tick growth regulator</td>
<td>Oral parasiticide</td>
<td></td>
</tr>
<tr>
<td>Natural product-based repellent</td>
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<td></td>
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<tr>
<td>Permethrin-treated clothing</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Natural product-based soap/lotion</td>
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</tbody>
</table>

- denotes intervention used in combination with another tick control method
- denotes intervention with some supporting data on reduction Lyme disease

Adapted from slide by Ben Beard, CDC-Division Vector-Borne Diseases
Integrated Tick Management (ITM)

Journal of Integrated Pest Management

Integrated Pest Management in Controlling Ticks and Tick-Associated Diseases
Kirby C. Stafford III,1,3 Scott C. Williams,1 and Goudarz Molaei1,2

Review: Application of Tick Control Technologies for Blacklegged, Lone Star, and American Dog Ticks
Alexis White1 and Holly Gaff1,2,3

JIPM Collection on Integrated Tick Management
https://academic.oup.com/jipm/pages/integrated_tick_management

Four 1-mi² neighborhoods

1. Control (n = 12 residences)
2. Deer removal only (n = 8) (dropped after year 2)
3. Met 52 + Bait box (n = 13)
4. Deer removal, Met 52, Bait box (n = 5)

Note: Bait boxes not applicable for lone star ticks as immature stages don’t readily use rodent hosts

Funded by the CDC

Original article
Integrated control of juvenile Ixodes scapularis parasitizing Peromyscus leucopus in residential settings in Connecticut, United States
Scott C. Williams, Eliza A.H. Little, Kirby C. Stafford III, Goudarz Molaei, Megan A. Linske

Ticks and Tick-Borne Diseases 9: 1310-1316.

Vector-Borne and Zoonotic Diseases 18: 55-64

Integrated Control of Nymphal Ixodes scapularis: Effectiveness of White-Tailed Deer Reduction, the Entomopathogenic Fungus Metarhizium anisopliae, and Fipronil-Based Rodent Bait Boxes
Scott C. Williams, Kirby C. Stafford III, Goudarz Molaei, and Megan A. Linske

Photos by Kirby Stafford

Funded by the CDC
Juvenile *I. scapularis* parasitizing captured *P. leucopus*

The combination of fipronil-based bait boxes and broadcast application of *M. anisopliae* had the most impact of any treatment combination; questing nymphs were reduced 78–95% within each year and *Borrelia burgdorferi*-infected questing nympha *I. scapularis* encounter potential was reduced by 66% as compared with no treatment in the third year of the study.
USDA-ARS/CAES ITM Study (MD & CT)
Suppression of Vector Tick Populations in Suburban landscape Through Integrated Use of Host-targeted and Non-host targeted Tick Control Measures

Scott Williams, Megan Linske, Kirby Stafford with Michael Short and Heidi Stuber (with Andrew Li, USDA)

<table>
<thead>
<tr>
<th>Neighborhood</th>
<th>4-poster</th>
<th>Bait Box</th>
<th>Met52</th>
<th>No. 4-poster locations</th>
<th>No. tick sampling properties</th>
<th>No. rodent sampling properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>-</td>
<td>10</td>
<td>9</td>
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<tr>
<td>2</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>3</td>
<td>12</td>
<td>9</td>
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<tr>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>3</td>
<td>12</td>
<td>9</td>
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<tr>
<td>4</td>
<td>Yes</td>
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<td>No</td>
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<td>13</td>
<td>9</td>
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<td>6</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>3</td>
<td>13</td>
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<tr>
<td>7</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>-</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>12</td>
<td>83</td>
<td>63</td>
</tr>
</tbody>
</table>

Summer 2017 Baseline Year Sampling
Spring 2018 began deployment 4-posters for fall and spring each year.
Summer 2018, 2019, 2020 full implementation of treatments with spraying Met52 (*M. anisopliae*) and deployment of fipronil bait boxes.
A total of 10 bait boxes were distributed at each of the 9 properties within the 6 treatment neighborhoods (n= 540 boxes).

A 100 gallon spray rig was purchased and the Met52 was applied by CAES staff in mid-June. Nine properties in each of four neighborhoods (n= 36) received Met52 application. Twelve 4-posters placed on land trust, town, and private property.

Public perceptions & prevention measures tick-borne diseases

Hook et al. 2015. 6(4): 483-488.

### Use of prevention measures (2011), n (% within region)

<table>
<thead>
<tr>
<th>Region</th>
<th>Use repellent</th>
<th>Shower</th>
<th>Do tick checks</th>
<th>Other steps</th>
<th>Do nothing</th>
<th>Currently Use yard pesticides*</th>
<th>Would not use yard pesticides*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>826 (21.1)</td>
<td>589 (15.7)</td>
<td>1316 (30.6)</td>
<td>312 (7.6)</td>
<td>2066 (51.2)</td>
<td>558 (10.7)</td>
<td>4476 (10.2)</td>
</tr>
<tr>
<td>New England</td>
<td>53 (25.6)</td>
<td>32 (15.1)</td>
<td>103 (43.2)</td>
<td>25 (13.1)</td>
<td>64 (35.9)</td>
<td>15 (7.2)</td>
<td>21 (14.1)</td>
</tr>
<tr>
<td>Mid-Atlantic</td>
<td>127 (26.1)</td>
<td>92 (19.2)</td>
<td>182 (30.7)</td>
<td>49 (9.5)</td>
<td>247 (45.4)</td>
<td>58 (6.8)</td>
<td>76 (10.5)</td>
</tr>
</tbody>
</table>

*2009

% reporting tick exposure family member past year
% consulting health professional
Questions
CHALLENGES TO EFFECTIVE PUBLIC TICK CONTROL
Challenges to effective public tick control

1. Differing tick species, ecologies & where ticks are located (much northeast forested with likely tick habitat)

2. Who is responsible for tick control on private properties versus community/public lands, including neighborhood greenbelts, school grounds, and city, county and state parks?

3. How can we deal with low acceptability of many current tick control methods and limited willingness to pay?

4. What methods are novel, ecological or biorational in nature and for what specific ticks and localities? How sustainable are they?

5. Variable, uncertain, unknown efficacy for tick control methods or even whether any can prevent disease!
Challenges to effective public tick control

6. Lack of municipal/local vector-control efforts specifically aimed at ticks

7. Little recent research on control of some species of increasing concern (focus on *I. scapularis* due to Lyme disease).

8. How can we get industry to invest in developing new products for an unclear public health tick control market?

9. How effective are broadcast acaricides when applied by homeowners or Pest Management Professionals? i.e., Efficacy

10. Homeowner problem; largely rely on licensed commercial pesticide. PMP model doesn’t allow time for consideration individual habitat conditions and tick density
Barriers to Effective Tick Management and Tick-Bite Prevention in the United States (Acari: Ixodidae)

Lars Eisen\textsuperscript{1,3} and Kirby C. Stafford III\textsuperscript{2}

With credit to the HHS Tick-Borne Disease Working Group and Subcommittee reports

- Skepticism and public distrust of chemical pesticides and repellents.
- Social acceptability of deer management.
- Willingness to pay for effective tick-control measures.
- Lack of funding for large-scale neighborhood/community/area-wide studies.
- Increased pesticide resistance concerns, pollinator health concerns.
- Declining public health entomology workforce and lack of funding to support employment to sustain continued tick-borne disease prevention research.
- Effectiveness, scale, cost, and implementation are key components for tick management strategies
Where do we go from here?

- Widespread and difficult to control, diseases from tick bites are a major problem worldwide. The growing number and spread of tick-borne diseases pose an increasing risk in the U.S.
- There are many tools available for killing ticks, but impact on disease unclear or unproven and few methods available or utilized by homeowners
- Need safe, cost-effective, socially acceptable, and effective prevention tools
- Multiple challenges or barriers to effective tick bite prevention
One Health Approach

TBDs can be difficult to control due to their complex epidemiology and ecologies that may involve different tick vectors and animal hosts.

Animal Branch
- Veterinarians
- Veterinary Entomologists
- Wildlife Biologists
- Animal Scientists
- Animal Health Officials

Unify Communicate

Environmental Health

Human Branch
- Physicians
- Medical Entomologists
- Vector Biologists
- Public Health Officials
- Epidemiologists
- Pest Management Professionals

Five universities with partners were established as Regional Centers for Excellence in Vector-Borne Diseases (COEs) to help prevent and rapidly respond to emerging vector-borne diseases across the United States.

The Northeast Regional COE at Cornell University
The Pacific Southwest COE at the University of California, Davis and Riverside
The Southeastern Regional COE at the University of Florida
The Western Gulf COE at the University of Texas Medical Branch in Galveston
The Midwest COE at the University of Wisconsin, Madison
The charter for the Tick-Borne Disease Working Group was approved by the Secretary of Health and Human Services on August 10, 2017, marking the official establishment of the Working Group within HHS. The Working Group was authorized by Congress for a total of six years from the date that the Act became law.

The charter defines how the Working Group is structured and functions in response to the charge provided by the 21st Century Cures Act, and is renewed every two years in accordance with Federal advisory committee guidelines. The current charter expires August 10, 2021.
An old prayer, circa 1856

From red-bugs and bed-bugs, 
from sand-flies and land-flies, 
Mosquitoes, gallinippers*, and fleas, 
From hog-ticks and dog-ticks, 
from hen-lice and men-lice, 
We pray thee, good Lord, give us ease.

Kirby C. Stafford III, Ph.D.  
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Ph: (203) 974-8485  
Email: Kirby.Stafford@ct.gov

https://portal.ct.gov/CAES  
Publ. 2007
Questions
Some Questions for You
Find a Colleague

• To post a profile about yourself and your work:
  • http://neipmc.org/go/APra
  • “Find a Colleague” site
  • http://neipmc.org/go/colleagues
Upcoming Webinars

• **Tick IPM #2: What Happens When/If Reducing Source or Preventing Tick Bites Has Failed**
  Dr. Stephen Rich, University of Massachusetts, Amherst, June 22, 2020. 11:00 a.m.

• **Tick IPM #3: Asian Long-Horned Tick IPM**
  Dr. Dina Fonseca and Dr. Matt Bickerton, Rutgers University, July 13, 2020. 11:00 a.m.

• **Tick IPM #4: Habitat Management for Vector-borne Diseases**
  Allison Gardner, University of Maine, August 10, 2020. 11:00 a.m.

• **Tick IPM #5: Pathogens Found in Ticks Collected on School Grounds and Public Parks**
  Drs. Jody Gangloff-Kaufmann, Joellen Lampman, Matt Frye, NYS IPM Program. Dr. Laura Goodman, College of Veterinary Medicine, Cornell University. Date TBD

• **Tick IPM #6: Host-Targeted Tick Control – What Works, What Doesn’t, and What’s New**
  Dr. Andrew Li, Research Entomologist, USDA-ARS Invasive Insects Biocontrol and Behavior Laboratory, Beltsville, MD. September 30, 2020, 11:00 am

For Updates: https://www.northeastipm.org/ipm-in-action/the-ipm-toolbox/
Recording of Tick IPM Webinar Series

- Past recordings and today’s Webinar will be available to view on demand in a few business days.

- [http://www.neipmc.org/go/ipmtoolbox](http://www.neipmc.org/go/ipmtoolbox)

- You can watch as often as you like.
Acknowledgements

This presentation was funded in part by the Northeastern IPM Center through Grant #2018-70006-28882 from the National Institute of Food and Agriculture, Crop Protection and Pest Management, Regional Coordination Program.