Integrated Tick Management: Strategies and Barriers to the Prevention of Tick-Borne Disease

 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
 National Environmental Health Association and NEVBD
 Webinar May 28, 2020
"Few agricultural or health problems confronting human societies have proved as intractable as control of ticks and the many diseases they transmit. Tick control [has been and] is heavily dependent upon chemical toxicants…termed acaricides."

Dan Sonenshine
Biology of Ticks, Vol. 2
Total Tickborne Diseases

2004: 22,527
2005: 26,800
2006: 23,770
2007: 31,808
2008: 39,993
2009: 42,649
2010: 34,890
2011: 40,795
2012: 40,119
2013: 46,231
2014: 43,654
2015: 49,825
2016: 48,610
2017: 59,349

Journal of Medical Entomology, Volume 56, Issue 5, September 2019, Pages 1199–1203,
https://doi.org/10.1093/jme/tjz074

The content of this slide may be subject to copyright: please see the slide notes for details.
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

Majority of Reported Vector-Borne Diseases are Spread by Ticks

- Lyme disease (68%)
- 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
Most of these ticks are hard ticks, Family Ixodidae

Blacklegged Tick, *Ixodes scapularis*

Western Blacklegged Tick, *Ixodes pacificus*

Lone Star Tick, *Amblyomma americanum*

Gulf Coast Tick, *Amblyomma maculatum*

Brown Dog Tick, *Rhipicephalus sanguineus*

American Dog Tick, *Dermacentor variabilis*

Rocky Mountain Wood Tick, *Dermacentor andersoni*

Relapsing Fever Tick, *Ornithodoros hermsi*, a soft tick in family Argasidae

Exotic Ticks

Non-native and invasive ticks pose a threat to human and animal health. Ticks come in on people (even baggage), livestock, wildlife, animal products, and through the commercial and illegal pet trade.

Asian longhorned tick

*Haemaphysalis longicornis*
Three Species as Vectors of Majority of Human Diseases

- **Blacklegged Tick**  
  *Ixodes scapularis*
  - Lyme disease
  - Anaplasmosis
  - Babesiosis
  - *Borrelia miyamotoi* disease
  - Powassan disease
  - Ehrlichiosis (*E. muris eauclairensis*)

- **Lone Star Tick**  
  *Amblyomma americanum*
  - Ehrlichiosis
  - Heartland virus disease
  - Tularemia

- **American Dog Tick**  
  *Dermacentor variabilis*
  - Rocky Mountain spotted fever
  - Tularemia

- **Western Blacklegged Tick**  
  *Ixodes pacificus*

- **Gulf Coast Tick**  
  *Amblyomma maculatum*

Maps courtesy CDC
Active Tick Surveillance

Tick surveillance is intended to monitor changes in the distribution and abundance of ticks 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.
Three-host Tick Life-cycle

*IXODES SCAPULARIS*

1. Larvae
2. Nymphs
3. Adults

Engorged female laying eggs

Photos K. Stafford unless otherwise labeled

Kirby Stafford, CT Agricultural Experiment Station

USDA
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 (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 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
Ticks as Vectors

Tick 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.
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.

Climate, Weather, Ticks, and Tick-borne Diseases

- Warmer annual temperatures will result in a generally northward expansion in tick distribution.
- Warmer temperatures increase reproductive capacity of ticks, leading to larger populations of ticks.
- Higher moisture levels allow tick survival in warmer environments.
- With milder winters and earlier springs, tick vectors will likely show earlier seasonal activity.
- Mild and shorter winter is also favoring the northern expansion of the white-footed mouse.
- Larger tick populations, longer seasonal activity and expanding range of ticks will likely increase risk of human exposure to infected ticks.

Risk Tick encounters
Passive Tick Surveillance (People submit ticks)
Exposure in Western U.S. is largely recreational
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
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
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
Landscape or Vegetative Management

- Most ticks require high humidity and cover (canopy)
- Most are found in leaf litter, ground cover, and lower vegetation (ecotone)
- Ticks don’t fly, jump, or drop from trees
Reducing risk at Schools

- Most school grounds largely landscaped into a tick safe zone with lawns, mowed fields, playgrounds, and school buildings
- Landscaping the edge
- Edges, paths walking to school are areas of greater risk

[Diagram showing landscaped school grounds with low mowed grass, 10' gravel track, and 4' chain link fence]
Tick safe Walking trail vs woodland trail Tick Bite Prevention & Social distancing!!

Is covid-19 changing how you spend the outdoors?

How crowded are your trails? Trails and parks are busy with those escaping quarantine fatigue. Are you spending increased time outdoors? Does that increase the risk of exposure to ticks?

Cautionary Trails

Tick Safer Trails

Tick alert
Ticks carrying Lyme disease can be found in this area. Examine skin, clothes and pets thoroughly.
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.

---


Connecticut 2016

Control Invasive plants for management of Ticks

- 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</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>25b</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. S3(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*
Tick-Net-CDC study single application bifenthrin houses CT, MD, & NY

- 75.8 and 48.4% reduction ticks treated vs. placebo properties 2011 & 2012, respectively
- No difference in number of ticks encountered by participants and risk of disease
- Questions efficacy just perimeter sprays and how residents use yards and other sources of tick exposure

Tick Control & Pollinators

- Bees, including honey bees, bumble bees and solitary bees, are the prominent and economically most important group of pollinators worldwide; 35% of the world food crop production depends on pollinators.

- Carbaryl (Sevin®) is the carbamate used in the control of ticks. Carbaryl, a common garden insecticide, is extremely toxic to bees and beneficial insects, is moderately toxic to fish, but is relatively nontoxic to birds.

- Most of the current chemicals used for area-wide tick control are pyrethroid insecticides. Synthetic pyrethroids are derivatives of the natural pyrethrins, chemically modified to increase toxicity and stability. These include permethrin, deltamethrin, cypermethrin, flumethrin, cyhalothrin, fenvalerate and cyfluthrin. They are highly toxic to bees exposed directly during application or residues on blooming crops.
Tick Control & Pollinators

- Neonicotinoids are a class of insecticides that are water soluble and systemic in plants and widely used for many agricultural and lawn pests. Imidacloprid and dinotefuran are used in products for flea and tick control on domestic animals. They are not used for area-wide control of ticks. Most are very toxic to honey bees and some states have been restricting their use. For example, neonicotinoids became classified as restricted use pesticides in Connecticut on January 1, 2018 (Public Act 16-17 on pollinator health).

- Some botanical insecticides have been found to have toxic and sublethal effects. “The potential acute toxicity and sublethal effects of botanical insecticides on honey bees and, thereby, provide evidence of the importance of assessing the risks of the side effects of biopesticides, often touted as environmentally friendly, to nontarget organisms such as pollinators”.

Nootkatone

Met52

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/
Host-Targeted Tick Control

**Rodent Reservoir Hosts**
- White-footed Mice
- Eastern Chipmunk

For *I. scapularis*

**Tick Tubes**
- From EcoHealth Inc. & Thermacell

**Fipronil Bait Boxes**
- Entry Points
- Non-Toxic Food blocks
- Wick with 3 mls fipronil

Not applicable for lone star ticks as immature stages don’t readily use rodent hosts
Host-Targeted Tick Control

Exclusion Reduction Treatment

<table>
<thead>
<tr>
<th><strong>Personal protection measures</strong></th>
<th><strong>Treatment/vaccination in humans</strong></th>
<th><strong>Landscape/vegetation management</strong></th>
<th><strong>Killing host-seeking ticks</strong></th>
<th><strong>Rodent-targeted approaches</strong></th>
<th><strong>Deer-targeted approaches</strong></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></td>
<td>Remove leaf litter and brush</td>
<td>Fungal acaricide</td>
<td>Oral antibiotic bait</td>
<td>Deer fencing</td>
</tr>
<tr>
<td>Synthetic chemical repellent</td>
<td></td>
<td>Remove rodent harborage</td>
<td>Acaricide with semiochemicals</td>
<td>Oral tick growth regulator</td>
<td>Oral parasiticide</td>
</tr>
<tr>
<td>Natural product-based repellent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permethrin-treated clothing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural product-based soap/lotion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</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-Vector-Borne Diseases
| Integrated Pest Management in Controlling Ticks and Tick-Associated Diseases |
|-----------------------------|--------------------------------------------------|
| Kirby C. Stafford III,¹,³ Scott C. Williams,¹ and Goudarz Molaei¹,² |

<table>
<thead>
<tr>
<th>Review: Application of Tick Control Technologies for Blacklegged, Lone Star, and American Dog Ticks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alexis White¹ and Holly Gaff¹,²,³</td>
</tr>
</tbody>
</table>

JIPM Collection on Integrated Tick Management
https://academic.oup.com/jipm/pages/integrated_tick_management
Tick exposure & percent seeking health care by region, 2009

Hook et al. 2015. 6(4): 483-488.
Public perceptions & prevention measures tick-borne diseases
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>
<tr>
<td>East North Central</td>
<td>152 (23.7)</td>
<td>81 (12.1)</td>
<td>219 (29.0)</td>
<td>44 (6.5)</td>
<td>336 (51.9)</td>
<td>60 (7.1)</td>
<td>83 (10.1)</td>
</tr>
<tr>
<td>West North Central</td>
<td>101 (30.3)</td>
<td>65 (20.5)</td>
<td>182 (47.9)</td>
<td>31 (11.1)</td>
<td>118 (32.2)</td>
<td>39 (9.2)</td>
<td>35 (10.8)</td>
</tr>
<tr>
<td>South Atlantic</td>
<td>167 (21.3)</td>
<td>147 (21.4)</td>
<td>287 (38.0)</td>
<td>50 (5.8)</td>
<td>339 (44.8)</td>
<td>136 (13.0)</td>
<td>75 (9.2)</td>
</tr>
<tr>
<td>East S. Central</td>
<td>54 (27.6)</td>
<td>49 (26.6)</td>
<td>86 (43.7)</td>
<td>25 (14.1)</td>
<td>63 (34.2)</td>
<td>50 (15.6)</td>
<td>25 (7.0)</td>
</tr>
<tr>
<td>West S. Central</td>
<td>100 (26.5)</td>
<td>69 (16.9)</td>
<td>112 (26.5)</td>
<td>37 (7.4)</td>
<td>224 (52.6)</td>
<td>113 (22.8)</td>
<td>24 (5.9)</td>
</tr>
<tr>
<td>Mountain</td>
<td>34 (12.2)</td>
<td>18 (6.1)</td>
<td>64 (23.3)</td>
<td>14 (5.0)</td>
<td>216 (64.8)</td>
<td>24 (5.8)</td>
<td>33 (9.8)</td>
</tr>
<tr>
<td>Pacific</td>
<td>38 (5.9)</td>
<td>36 (6.6)</td>
<td>81 (12.0)</td>
<td>37 (5.2)</td>
<td>459 (76.1)</td>
<td>63 (10.3)</td>
<td>74 (14.6)</td>
</tr>
</tbody>
</table>

*2009, respondents in survey could choose more than one response
Hook et al. Ticks & Tick-borne Diseases. 2015. 6(4): 483-488.
Where do we go from here?

- Widespread and difficult to control, diseases from tick bites are major causes of sickness and even death 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, few methods available or utilized by homeowners
- Need safe, cost-effective, socially acceptable, and effective prevention tools
- Multiple challenges or barriers to effective tick management
Barriers to Effective Tick Management and Tick-Bite Prevention in the United States (Acari: Ixodidae)
Lars Eisen and Kirby C. Stafford III

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
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.

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, and The Midwest COE at the University of Wisconsin, Madison.
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.

*mosquitoes

Kirby C. Stafford III, Ph.D.
CT Agricultural Experiment Station
123 Huntington Street-Box 1106, New Haven, CT 06504
Ph: (203) 974-8485
Email: Kirby.Stafford@ct.gov

https://portal.ct.gov/CAES
Publ. 2007