Vector-borne infections to consider as differential diagnoses for febrile patients from New England

Nonspecific signs and symptoms: Fever, muscle aches, headache, chills, sweats, nausea, weakness/fatigue

- **Ticks:** Lyme disease, babesiosis, human granulocytic ehrlichiosis, Powassan encephalitis, tularemia*, Rocky Mountain spotted fever*, Q fever*
  - *Agents in ticks searching for an emerging infection:* Borrelia miyamotoi, deer tick virus, MO-1 babesia, Anaplasma bovis, Kemerovo group virus
- **Mosquitoes:** West Nile fever, eastern equine encephalitis*, Cache valley fever, Jamestown Canyon fever, Lacrosse encephalitis, zoonotic filariasis
- **Fleas/Lice:** epidemic typhus*, cat scratch disease, trench fever
- **Mites:** rickettsialpox

Distribution of *Ixodes persulcatus* species complex
(deer ticks)

- "Nantucket Fever" (babesiosis) – first case in 1969
- Fever, chills, muscle aches, headache, night sweats, fatigue, brown urine
- Caused by protozoan similar to malaria, long known as parasite of rodents

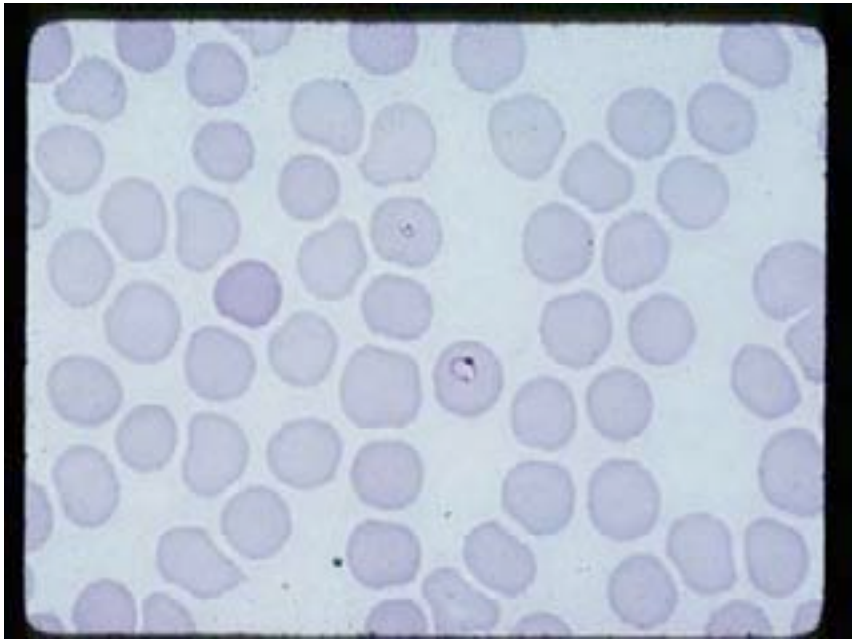
BOARD OF SELECTMEN

NANTUCKET, MASSACHUSETTS

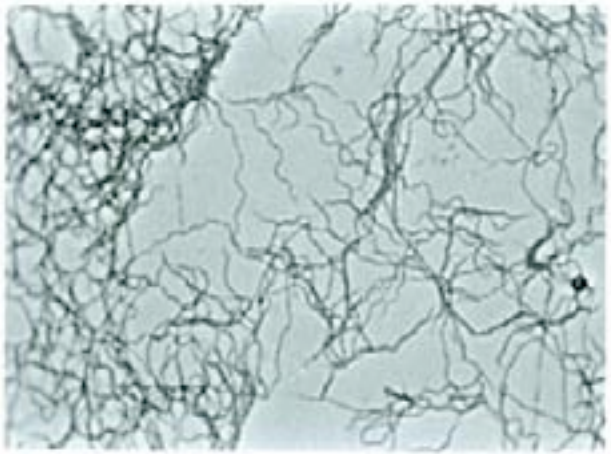
PUBLIC

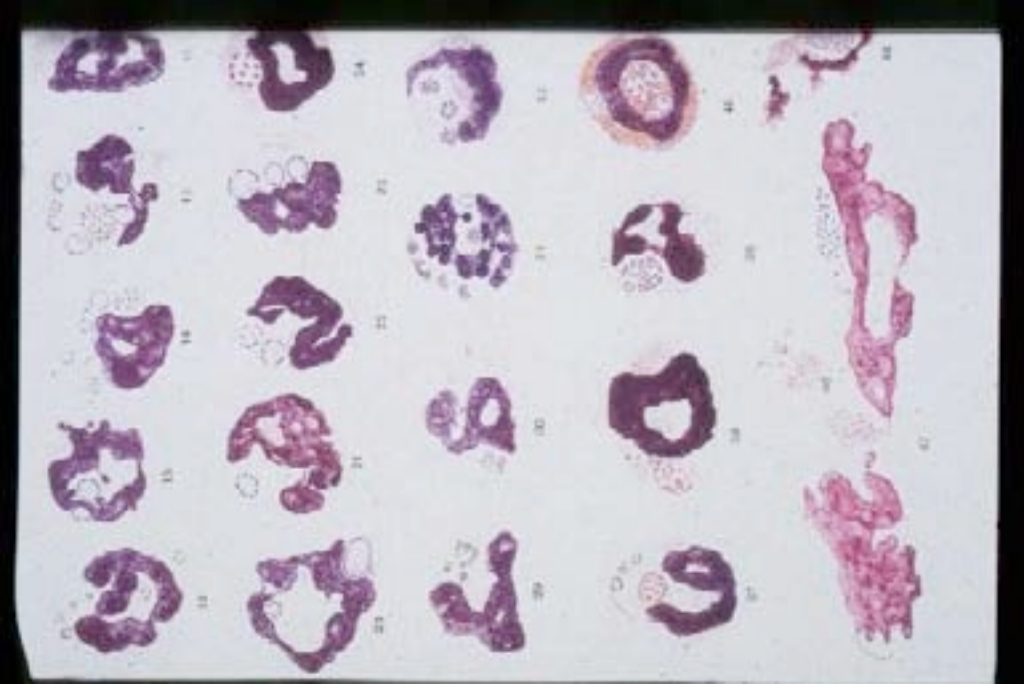
HEALTH NOTICE

NANTUCKET BOARD OF HEALTH



- Outbreak of arthritis in children in Old Lyme; odd rashes precede arthritis, usually after bug bite
- Lyme arthritis and erythema migrans caused by spiral bacteria (spirochetes) transmitted by deer ticks
- Nantucket fever cases often preceded by “spider bite”





Human Granulocytic Ehrlichiosis in the Upper Midwest United States

A New Species Emerging?

Johan S. Bakken, MD; J. Stephen Dumler, MD; Sheng-Mei Chen, MD; Mark R. Eckman, MD; Linda L. Van Etta, MD; David H. Walker, MD

Objective.—To characterize the clinical presentation and course, laboratory findings, and treatment outcome of 12 patients with human granulocytic ehrlichiosis.

Setting.—The 12 patients were male, ranged in age from 29 to 91 years, and contracted their illness in Wisconsin or Minnesota.

Methods.—Cases were recognized by the presence of intracytoplasmic inclusions (morulae) in peripheral neutrophils of patients presenting with temperature of 38.5°C or higher, chills, severe headache, and myalgias. All patients had a complete blood cell count and blood chemistry profile. Blood smears were examined by light microscopy. All available paired serum samples were analyzed for presence of indirect fluorescent antibodies against *Ehrlichia chaffeensis*, *Ehrlichia phagocytophila*, and *Ehrlichia equi*. Blood samples from 12 patients were subjected to polymerase chain reaction analysis using primers specific for the *E phagocytophila-E equi* group, primers that include the agent identified in our patients, as well as *E chaffeensis*.

[From PARASITOLOGY, Vol. XXX, No. 2, 1938.]
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PRINTED IN GREAT BRITAIN

CYTOECTES MICROTI, N.G., N.SP., A PARASITE DEVELOPING IN GRANULOCYTES AND INFECTIVE FOR SMALL RODENTS

By ERNEST E. TYZZER

Medical School of Harvard University, Boston, Mass.

(With Plates X and XI, containing Figs. 1–50)

A MICRO-ORGANISM of unusual type, hereafter designated *Cytoecetes microti*, was discovered by the author in the blood of field voles (*Microtus pennsylvanicus*) which had been inoculated with a suspension in saline of pooled, mortar-ground liver and splenic tissue of a number of voles of the same species and of one white-footed or deer mouse (*Peromyscus leucopus*). This organism occurred

Proc. Natl. Acad. Sci. USA
Vol. 93, pp. 6205–6214, June 1996
Microbiology

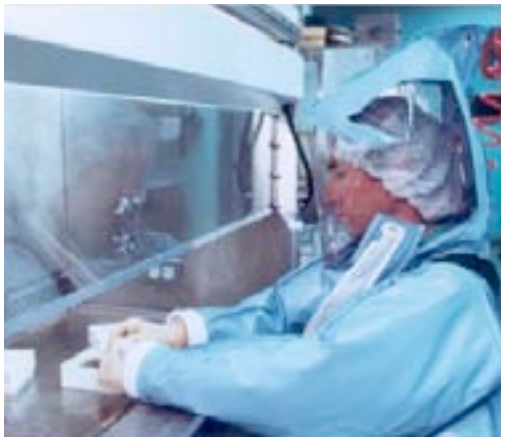
Perpetuation of the agent of human granulocytic ehrlichiosis in a deer tick–rodent cycle

(Ehrlichia/Ixodes dammini/mice/vector/reservoir)

SAM R. TELFORD III*†, JACQUELINE E. DAWSON‡, PAULA KATAVOLOS*, CYNTHIA K. WARNER‡, CHRISTOPHER P. KOLBERT§, AND DAVID H. PERSING§

*Department of Tropical Public Health, Harvard University School of Public Health, Boston, MA 02115; ‡Division of Viral and Rickettsial Diseases, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, Atlanta, GA 30333; and §Mayo Foundation, Rochester, MN 55905

Communicated by William Tavaste, The Rockefeller University, New York, NY, March 5, 1996



Dispatches

A New Tick-borne Encephalitis-like Virus Infecting New England Deer Ticks, *Ixodes dammini*[1]

To determine if eastern North American *Ixodes dammini*, like related ticks in Eurasia, maintain tick-borne encephalitis group viruses, we analyzed ticks collected from sites where the agent of Lyme disease is zoonotic. Two viral isolates were obtained by inoculating mice with homogenates from tick salivary glands. The virus, which was described by reverse transcriptase polymerase chain reaction and direct sequencing of the amplification products, was similar to, but distinct from, Powassan virus and is provisionally named "deer tick virus." Enzootic tick-borne encephalitis group viruses accompany the agents of Lyme disease, babesiosis, and granulocytic ehrlichiosis in a Holarctic assemblage of emergent deer tick pathogens.

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

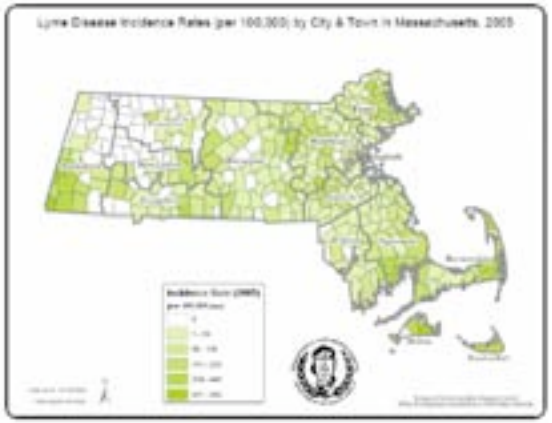
BRIEF REPORT

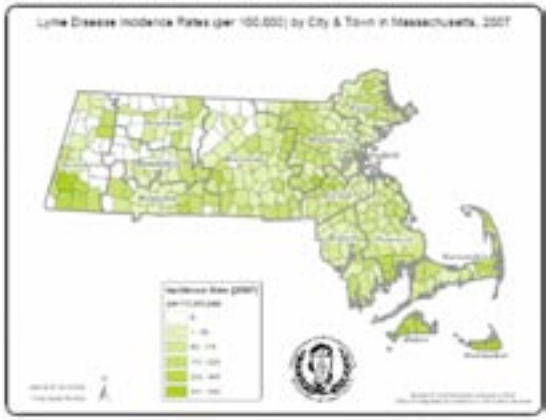
◂ Previous Volume 360:2099-2107 May 14, 2009 Number 20 Next ▸

Fatal Case of Deer Tick Virus Encephalitis

Norma P. Tavakoli, Ph.D., Heng Wang, M.A., Michelle Dupuis, B.Sc., Rene Hull, B.A., Gregory D. Ebel, Sc.D., Emily J. Gilmore, M.D., and Phyllis L. Faust, M.D., Ph.D.

SUMMARY





County*	2005 Confirmed Cases (#)	Incidence Rate (per 100,000)
Barnstable	243	109
Berkshire	73	54
Bristol	159	30
Dukes	89	593
Essex	271	38
Franklin	24	33
Hampden	124	27
Hampshire	69	45
Middlesex	459	31
Nantucket	32	336
Norfolk	264	41
Plymouth	334	71
Suffolk	47	7
Worcester	255	34
State Total	**2460**	**39**

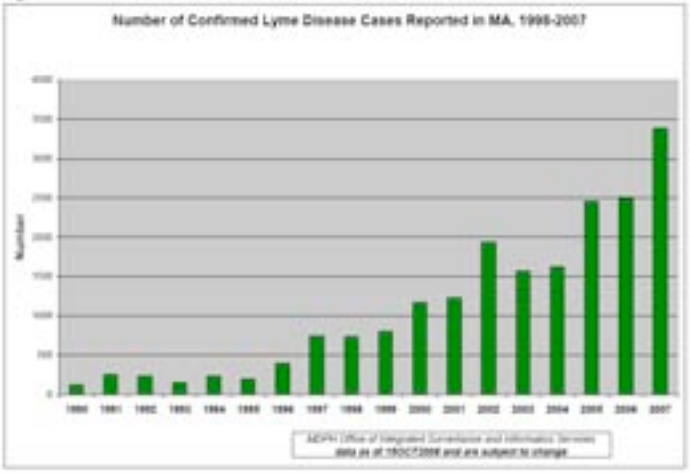
* County was unknown for 17 cases

County*	2006 Confirmed Cases (#)	Incidence Rate (per 100,000)
Barnstable	182	82.0
Berkshire	80	59.3
Bristol	194	36.3
Dukes	44	295.3
Essex	278	38.5
Franklin	15	21.1
Hampden	141	31.1
Hampshire	64	42.1
Middlesex	512	34.9
Nantucket	24	252.6
Norfolk	285	43.8
Plymouth	234	49.8
Suffolk	23	3.3
Worcester	381	50.8
State Total	**2494**	**39.3**

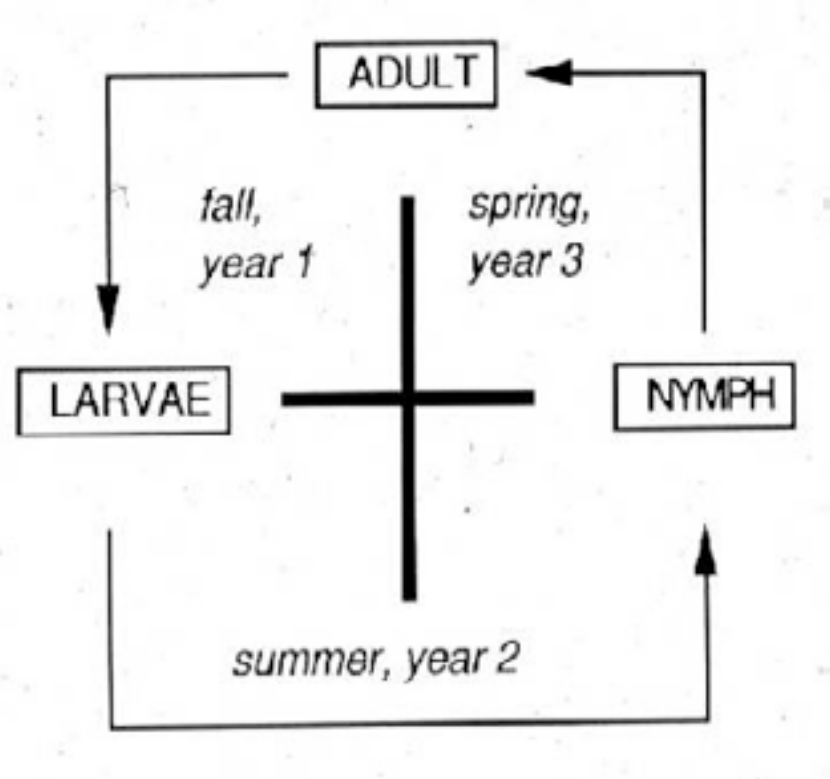
* County was unknown for 37 cases

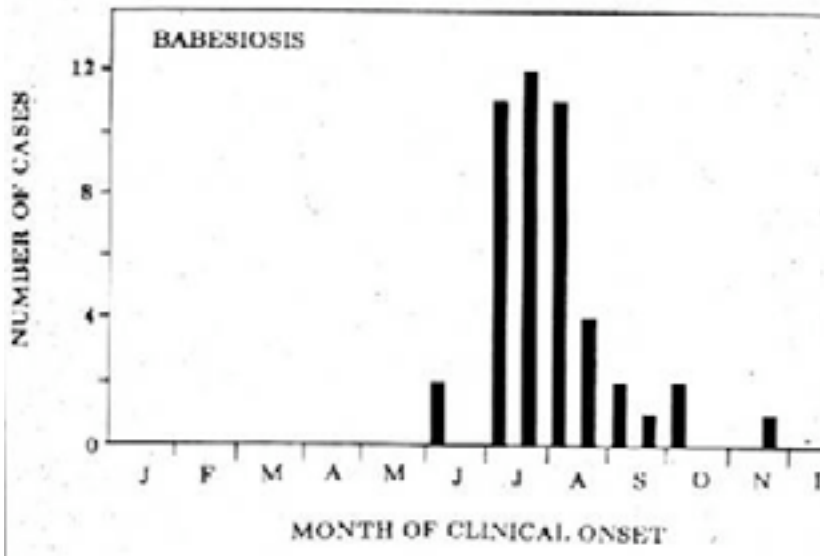
County*	2007 Confirmed Cases (#)	2007 Incidence Rate (per 100,000)
Barnstable	233	105
Berkshire	94	70
Bristol	239	45
Dukes	51	340
Essex	355	49
Franklin	31	43
Hampden	140	31
Hampshire	71	47
Middlesex	665	45
Nantucket	63	662
Norfolk	382	59
Plymouth	366	78
Suffolk	50	7
Worcester	381	51
State Total	3376	53

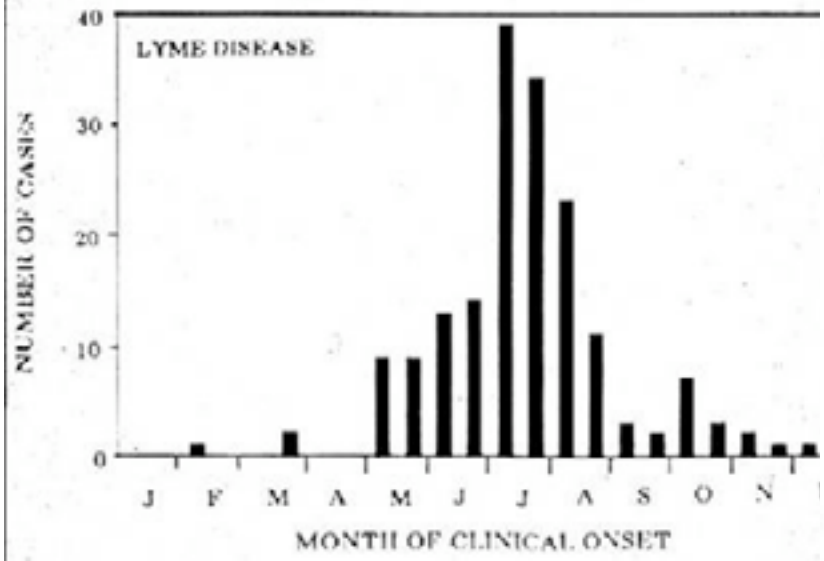
** County was unknown for 255 cases*

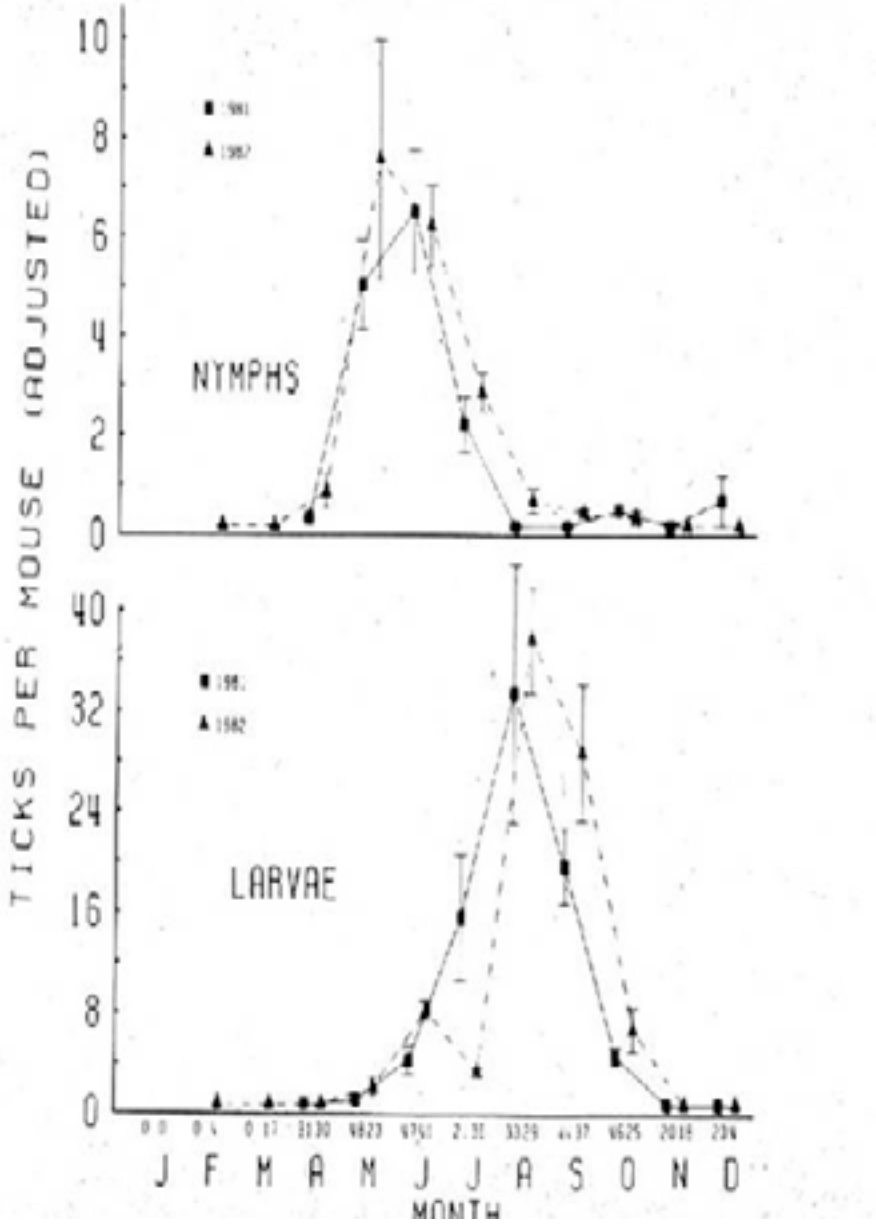


10/15/08 MDPH Office of Integrated Surveillance and Informatics Services


ADULT
fall,
year 1
spring,
year 3
LARVAE
NYMPH
summer, year 2



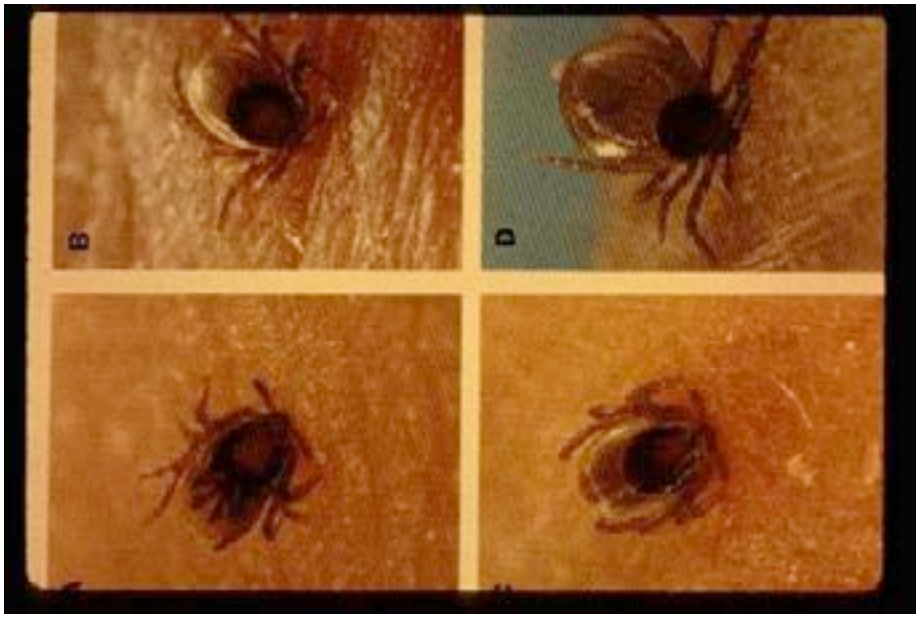




NCH case reports, cumulative, 1981-1986, GJ Dammin

Adaptations to extended durations between feedings

- "Grace periods" for deer tick-transmitted agents
  - *Borrelia burgdorferi*: 24-48 hours (upregulation of OspC, migration from gut to salivary glands)
  - *Babesia microti*: 48-62 hours (sporogony from undifferentiated salivary sporoblast)
  - *Anaplasma phagocytophilum*: 24-36 hours (acquisition of "slime layer"?)
  - Tickborne encephalitis virus: none



Modes of intervention

- At the level of the individual:
  - Repellants and toxicants (permethrin, deet)
  - Appropriate clothing
  - Tick check
  - Education and awareness
  - Habitat avoidance
  - Source reduction around homes

Public Health Interventions

- Define your goals
  - Risk reduction vs. eradication
  - Suppression vs. control
  - Short term vs. long term
  - Different targets have different strategies: individuals, neighborhoods, island-wide
- Consider likely commitment and sustainability (stakeholders, funding) and choose accordingly
- Plan for achievable and measurable milestones
- Educate to facilitate sustainability
- There is no single “magic bullet”; do not hope for development of such a thing in the near future
- Concurrent complementary methods (integrated pest management) are recommended
- Don’t make things worse; consider unintended consequences

Why coastal New England, and why the 1970s?

- Changes in the landscape – forest to farm to forest
- Increased development and recreational use in reforested sites
- Burgeoning deer herds

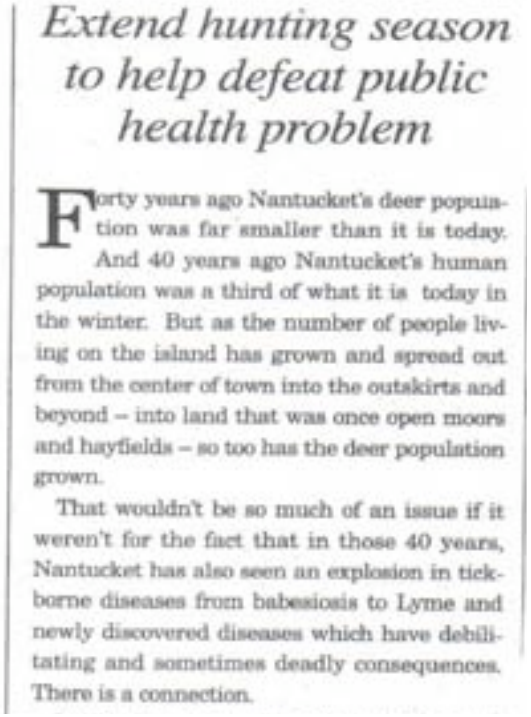
“We know how to kill ticks. We just don’t know how to get people to do it.”

Dr. Joe Piesman
Chief, Lyme Disease Vector Studies
Centers for Disease Control and Prevention
11th International Conference on Lyme Borreliosis and Other Tickborne Diseases, Irvine, CA, October 2008

Modes of intervention

- At the level of communities
  - Habitat management (brush clearing, fire, dessicants)
  - Education and awareness
  - Spraying
  - Host-targeted acaricides (Damminix, 4-poster)
  - **Deer reduction**

K. Stafford



Extend hunting season to help defeat public health problem

Forty years ago Nantucket's deer population was far smaller than it is today. And 40 years ago Nantucket's human population was a third of what it is today in the winter. But as the number of people living on the island has grown and spread out from the center of town into the outskirts and beyond – into land that was once open moors and hayfields – so too has the deer population grown.

That wouldn't be so much of an issue if it weren't for the fact that in those 40 years, Nantucket has also seen an explosion in tick-borne diseases from babesiosis to Lyme and newly discovered diseases which have debilitating and sometimes deadly consequences. There is a connection.

American Lyme Disease Foundation

Tick Management Handbook

An integrated guide for homeowners, pest control operators, and public health officials for the prevention of tick-associated disease

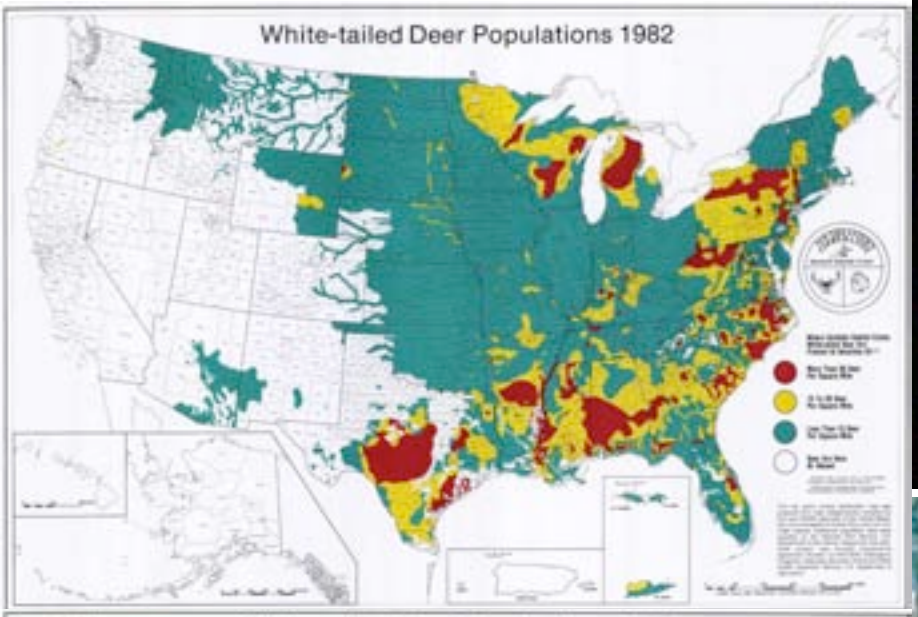
Revised Edition

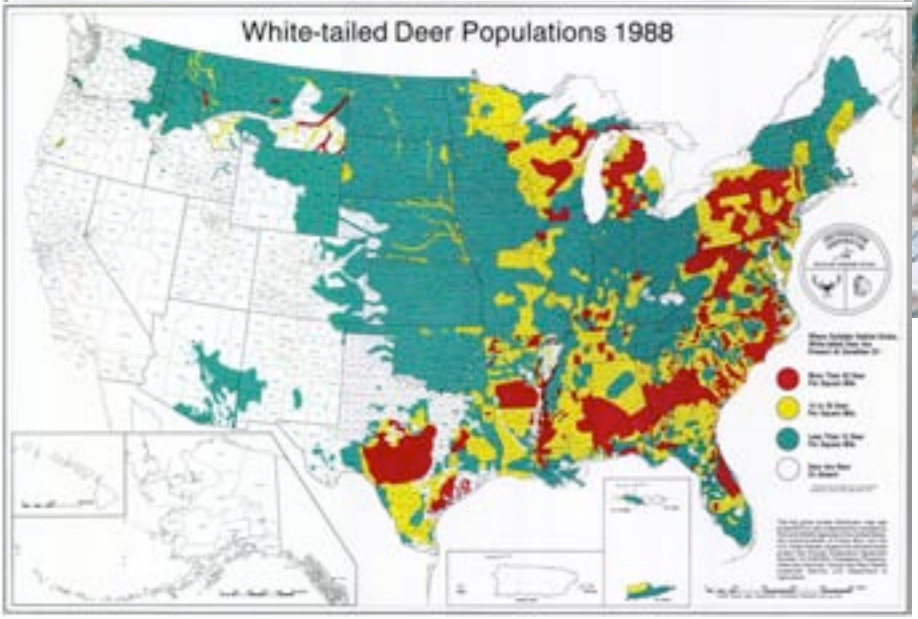
Prepared by:

Kirby C. Stafford III, Ph.D.
Vice Director, Chief Entomologist
Connecticut Agricultural
Experiment Station, New Haven

Perpetuation of Lyme disease spirochetes depends on two largely INDEPENDENT factors

- **Tick production**: Reproduction of the tick.
  - Adult female tick acquires a bloodmeal; blood becomes eggs; eggs hatch and become larvae; such larvae are NOT infected
  - The source of the reproductive bloodmeal is a larger animal (deer, dog, coyote, bear, moose, human, cat)
  - Adult ticks do not feed on mice, shrews, squirrels, rabbits, birds
- **Infection of the tick**: uninfected larvae need to get infected
  - White footed mice, shrews, rabbits, squirrels and certain birds (yellowthroats, wrens, robins, pheasant) are known to infect ticks
  - Larvae also feed on deer, cats, many ground-foraging birds but do not become infected as a result


White-tailed Deer Populations 1982


White-tailed Deer Populations 1988


Bambi's
REVENGE


SUICIDAL
DEER
CROSSING
NEXT
5 MILES

Deer feed most adult deer ticks

Wilson ML et al. 1990. Host dependent differences in feeding and reproduction of Ixodes dammini (Acari:Ixodidae). Journal of Medical Entomology 27:945-954

Deer tick egg mass = 2000 larvae

Host	No. present on site	No.ticks per host	% of all ticks
deer	24	38.3	94
Raccoon	51	0.7	3.7
possum	8	1.2	1.0
cat	11	0.1	0.1

Reduced Abundance of Immature *Ixodes dammini* (Acari: Ixodidae) Following Elimination of Deer

MARK L. WILSON,[1,2] SAM R. TELFORD III,[1]
JOSEPH PIESMAN,[1,3] AND ANDREW SPIELMAN[1]

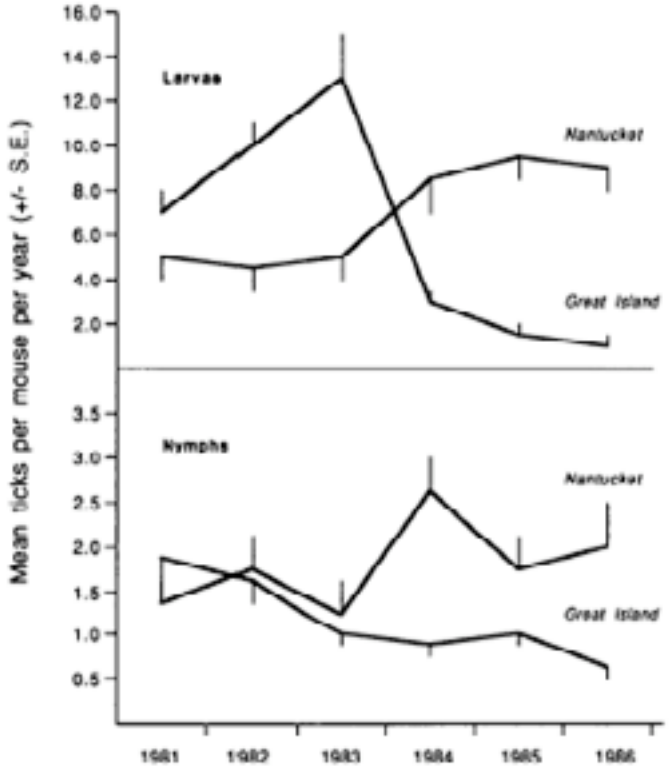


Fig. 2. Abundance of larval and nymphal *I. dammini* on Great Island and on Nantucket Island.

Reduction of risk on Great Island

- *Principle of overflow*: more reproductive units generated than can be "used" by the natural hosts
  - Pre-intervention 17 mice/ha x 132 larvae/mouse = production of 2244 nymphs/ha
    - But only 17 mice/ha x 26 nymphs/mouse = 442 nymphs "removed" per ha, therefore "overflow" is 2244 – 442 or 1802 "extra" nymphs/ha
  - Post-intervention 17 mice/ha x 25 larvae/mouse = production of 425 nymphs/ha
    - But only 17 mice/ha x 8 nymphs/mouse = 136 nymphs "removed" by feeding on mice on each ha, therefore "overflow" is 425-136 or 289 extra nymphs/ha
    - Risk of seeing an "extra" nymph is 289/1802 or nearly 80% less than pre-intervention

Deer serve as bloodmeal sources for many other pests, including mosquitoes and deerflies

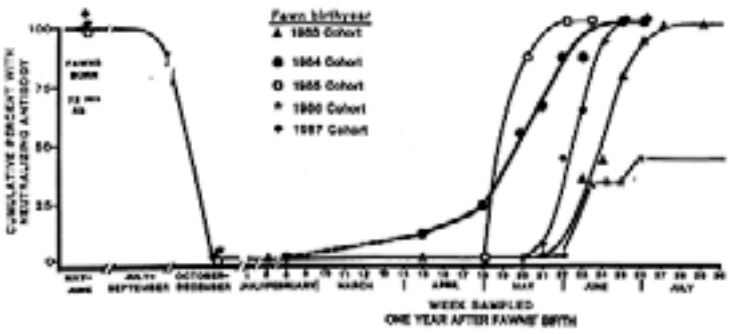
www.agnews.tamu.edu

www.insects.tamu.edu

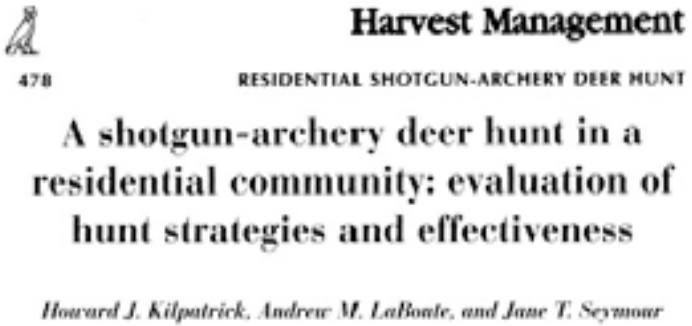
- Robertson et al. Bionomics of Anopheles quadrimaculatus and Culex erraticus (Diptera: Culicidae) in the Falls Lake basin, North Carolina: seasonal changes in abundance and gonotrophic status, and host-feeding patterns. J Med Entomol. 1993 Jul;30(4):689-98.
- Burkot & Defoliart. Bloodmeal sources of Aedes triseriatus and Aedes vexans in a southern Wisconsin forest endemic for La Crosse encephalitis virusAm J Trop Med Hyg. 1982 Mar;31(2):376-81.
- Apperson et al. Host Feeding Patterns of Established and Potential Mosquito Vectors of West Nile Virus in the Eastern United States. Vector Borne and Zoonotic Diseases, Mar 2004, Vol. 4, No. 1: 71-82

Jamestown Canyon and Cache Valley viruses

- California group encephalitis (bunyavirus)
- Usually cause mild febrile illness; most cases asymptomatic, but severe disease has been reported; CVV is a teratogen
- 10% seroprevalence for JCV among febrile Nantucket patients
- Transmitted by Aedes vexans and other woodland mosquitoes.
- Deer are reservoir hosts



How to safely hunt deer around homes



478 Harvest Management

RESIDENTIAL SHOTGUN-ARCHERY DEER HUNT

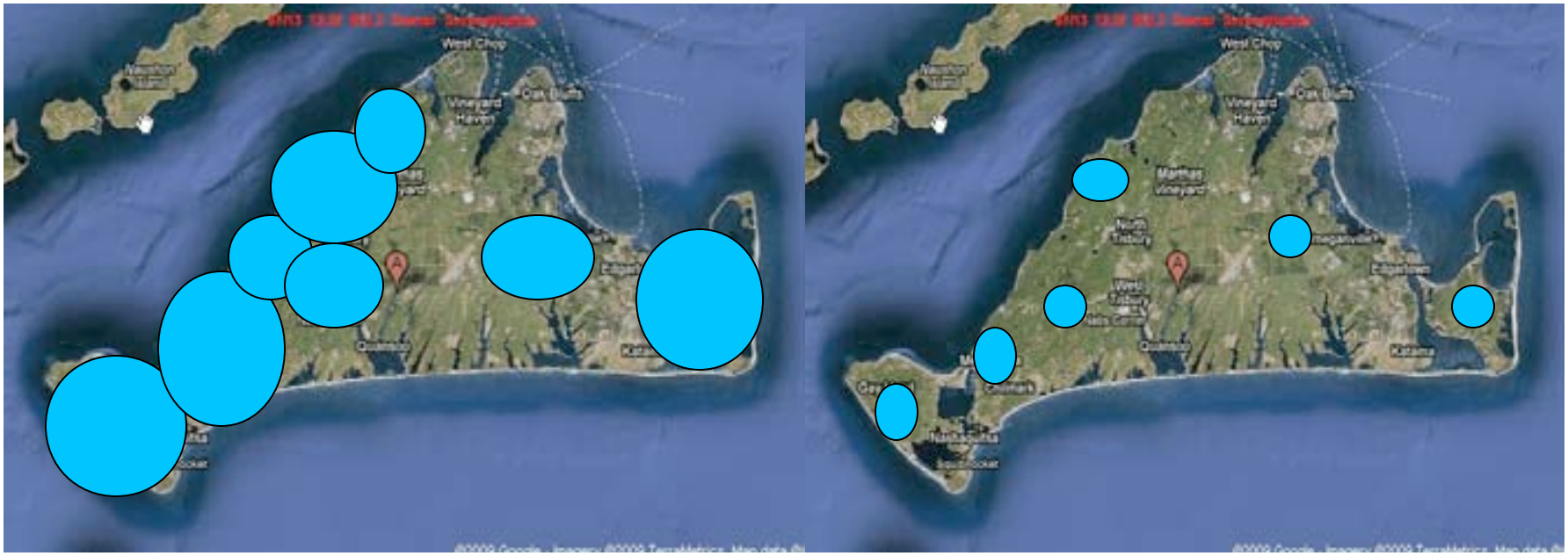
A shotgun-archery deer hunt in a residential community: evaluation of hunt strategies and effectiveness

Howard J. Kilpatrick, Andrew M. LaBonte, and Jane T. Seymour

Shotgun-archery deer hunt • Kilpatrick et al. 479

Firearms hunting occurred close to houses in Mumford Cove, Connecticut, 2001.

1. Application process, vetting of applicants (including interviews)
2. Firearms proficiency test, hunter safety course
3. Tree stand only; all fixed and approved by hunt manager
4. Written permission from abutters
5. Archery option for firearms-unsafe site
6. Notification of hunt dates and property closures if applicable
7. Hunting during work week
8. Hunters restricted to assigned tree stand with specified break periods
9. Hunt manager staff helps find and transport shot deer by ATV



Before intervention

After intervention

With thanks

- National Institutes of Health
- The late Burt Engley
- The late Roger Engley
- Bill Wilcox
- John Varkonda (Mass Dept of Conservation and Recreation)
- Jay Walsh
- Cathy and Willy Glover
- Walter and Connie Ashley
- Vineyard Open Land Foundation
- Chris Kennedy/TTOR
- Gus Ben David (then at Mass Audobon/Felix Neck
- LuAnne Johnson