SHORT COMMUNICATION

An Unexpected Result from Burning Vegetation to Reduce Lyme Disease Transmission Risks

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ABSTRACT The risk for human infection with Lyme disease appears linked to the abundance of infected vector ticks, principally *Ixodes dammini* Spielman, Clifford, Piesman & Corwin, in the eastern United States. Habitat destruction by burning, although not well studied, has long been considered as an effective alternative to synthetic insecticides as a means of reducing tick populations. We evaluated the effect of a single spring burning of the woodland understory on the transmission risk of Lyme disease spirochetes (*Borrelia burgdorferi* Johnson, Schmid, Hyde, Steigerwalt & Brenner) on Shelter Island, Long Island, NY. Following a burn in early April 1991, the abundance of nymphal *I. dammini* was 49% lower in the burned portion of a woodlot compared with the unburned portion. However, risk of encountering nymphs infected with *B. burgdorferi* remained similar in both burned and unburned woods. It is suggested that burning vegetation may disproportionately kill deer-derived rather than rodent-derived nymphs, significantly reducing tick abundance without affecting transmission risk.

KEY WORDS *Ixodes dammini*, Lyme disease, burning

TRANSMISSION RISK of Lyme disease spirochetes (*Borrelia burgdorferi* Johnson, Schmid, Hyde, Steigerwalt & Brenner) depends upon exposure to infected vector-competent ticks, principally those belonging to the *Ixodes ricinus* (L.)-complex. Transmission risk apparently increases with an increased abundance of infected ticks. Thus, tick management, to reduce the abundance of infected ticks, should be an effective means for reducing the intensity of spirochete transmission as well as the incidence of Lyme disease among humans and animals.

Historically, tick management has relied on a variety of chemical and nonchemical methods (Wilkinson 1979, Matthewson 1984, Wilson & Deblinger 1993). Controlled burning of grasslands and forests was once widely used as a means of incinerating grasses, leaf litter, and vegetative undergrowth favored by ticks. However, widespread use of controlled burning for tick management has decreased over the past several decades largely because of wildfire prevention campaigns and the emergence of effective pesticides (Miller 1979).

More recently, risk of infection with Lyme disease spirochetes has rekindled considerable interest in many previously used tick control strategies. To date, proposals to manage the deer tick vector, *I. dammini* Spielman, Clifford, Piesman & Corwin, have largely relied on the use of either host-targeted (Mather et al. 1987, 1988; Deblinger & Rimmer 1991) or broadcast insecticides (Schulze et al. 1987, 1991; Stafford 1991; Solberg et al. 1992). However, habitat destruction by mowing and controlled burning has also been used in an effort to locally reduce the abundance of host-seeking adult *I. dammini*. Using single controlled burns, Wilson (1986) successfully reduced the abundance of adult *I. dammini* by as much as 88% for as long as 6 mo following the burn. Unfortunately, no attempt was made to measure the abundance of nymphal ticks in burned sites or to determine the prevalence of *B. burgdorferi* infection. Nevertheless, it would appear that habitat destruction by burning vegetation might prove useful, in certain circumstances, as a tool for reducing the risk of Lyme disease spirochete transmission. Accordingly, we examined the effect of controlled burning of woodland to reduce Lyme disease transmission risks. Specifically, we simultaneously compared the abundance of spirochete-infected nymphal *I. dammini* in burned and unburned sections of a woodlot on Shelter Island, NY.

Materials and Methods

The study was conducted in a roughly square, generally homogeneous 36-ha woodlot (Sachem's) located in the center of Shelter Island, NY. Shelter Island is located between the north

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Table 1. Relative tick abundance and prevalence of *B. burgdorderi* in populations of nymphal *I. dammini* from a woodlot where vegetation had been burned and from adjacent unburned woods

Date collected	No. 5-min samples	Burned woodlot		Unburned woodlot	
		Mean no. nymphs per sample (±SD)	No. infected/no. tested	Mean no. nymphs per sample (±SD)	No. infected/no. tested
16 June	4	10.8 (±1.0)	6/20	20.0 (±1.6)	2/20
20 June	3	9.3 (±2.1)	7/20	19.7 (±2.1)	4/20
26 June	5	5.2 (±3.2)	8/20	10.8 (±5.1)	5/20
Total	12	8.1 (±3.4)	21/60	16.1 (±5.7)	11/60

and south forks on the eastern end of Long Island. Previous studies on the island have shown that *I. dammini* are abundant and that Lyme disease spirochete transmission is intense (Bosler et al. 1984). The woodlot is primarily an oak and beech-maple forest with a thick herbaceous understory composed principally of sarsaparilla, *Aralia nudicaulis*.

On 8 April 1991, a nearly square, 15-ha portion of the woodlot was burned to reduce tick abundance. The burn was organized and conducted by the Shelter Island Volunteer Fire Company. The fire was contained within an area bounded on three sides by fire lanes and on the remaining side by a macadam road. Burning destroyed most saplings and understory shrubs under 2 cm diameter at breast height (dbh) but had no apparent effect on larger trees or on the herbaceous layer during the subsequent summer. The fire ignited some tree stumps, woody downfall, and surface leaf litter but did not penetrate the soil humus layer. Woodlands located directly adjacent to the burned site remained unburned and were used for later comparison of tick densities and prevalence of spirochetal infection.

Nymphal *I. dammini* were collected in both burned and unburned portions of the woodlot on three separate occasions (16, 20, and 26 June 1991) using a standardized tick flagging technique. Cotton flannel flags (1 m^2) were dragged behind collectors walking generally straight lines (150 m) in both burned and unburned woods in such a fashion that the cloth remained in constant contact with the forest floor. No attempt was made to keep the flag extended to its full breadth and length as it was pulled through the vegetation. Samples were collected in strings of 10 30-s samples (hereinafter, 5-min samples), alternating between burned and unburned sites for each sample. Sampling avoided woodland edges and covered nearly the whole area. All ticks collected were stored in plastic vials with moistened plaster bases. In total, 12 5-min samples were collected in each of the burned and unburned sites. A similar number of samples was collected from each of the sites on a particular sampling day.

We examined 60 nymphal ticks from each site for the presence of Lyme disease spirochetes by sampling 20 from each collecting day. To detect the presence of spirochetes, tick midgut tissues were dissected into a drop of phosphate-buffered saline (pH 7.3) on a glass microscope slide; this tissue was smeared onto the slide with a glass coverslip, then air-dried and fixed in an acetone bath before storage at −20°C. Later, slides were treated with a 1:100 dilution of a fluorescein isothiocyanate–conjugated polyclonal antibody prepared from two New Zealand white rabbits inoculated with the Guilford strain of *B. burgdorferi* (Steere et al. 1983) and then were examined at 400X magnification by fluorescent microscopy.

Results

We compared the number of nymphal *I. dammini* collected in the burned site with that collected in adjacent unburned woods. In unburned woods, 193 nymphs were collected in a total of 12 5-min samples (16.1 ± 5.7 [mean ± SD] / 5 min), whereas in the burned portion of the woodlot, only 97 nymphs were collected (8.1 ± 3.4 / 5 min) in an equal number of samples (Table 1). To test for differences between the number of nymphs collected in the two areas of the woodlot, totals from each of the 24 5-min samples were compared using the Mann-Whitney U test. Significantly fewer nymphs were collected along transects in the burned area compared with collections along transects in the unburned woodlot ($U = 19.5$; $P = 0.0024$).

We also compared the prevalence of spirochetal infection in nymphs collected in the burned area with that of nymphs from the adjacent unburned woods. Lyme disease spirochetes were detected in 21 of 60 nymphs (35%) collected in the burned area but only in 11 of 60 nymphs (18%) collected in the unburned site (Table 1). These differences were compared by χ^2 analysis and found to be nearly significant ($P = 0.063$).

To compare the relative risk for exposure to infected ticks in the burned and unburned sites, we calculated an "entomologic" risk index (ERI) for each site. The ERI is calculated as the product of the prevalence of infection ("tick infection rate") and the estimate of nymphal abundance. Overall, we calculated an ERI of 34.0 infected

nymphs per h of exposure in the burned woods and 34.7 in the unburned woods.

While dissecting the tick midguts for spirochetal detection, we observed large nematodes in 9 of the 60 nymphal ticks (15%) examined from the unburned woodlot. None were observed in similar preparations of nymphs from the burned site. Most of the parasitized ticks contained just one nematode, although one tick contained two of the worms. None of the nymphs containing nematodes were concomitantly infected with *B. burgdorferi*. Geimsa-stained preparations of two nematodes were examined, each from a different tick, and were compared with the published description (Beaver & Burgdorfer 1984) of an extrordinarily large nematode from Shelter Island *I. dammini*.

Discussion

Destruction of vegetation by burning appears to be an effective means for reducing the overall abundance of nymphal *I. dammini*. Compared with adjacent unburned forest, we observed 49% fewer nymphs in a woodlot 2 mo after it had been burned.

Unfortunately, we were unable to evaluate the densities of ticks and prevalence of Lyme disease spirochete infection in nymphal tick populations from Sachem's Woods before the 1991 burn. Nevertheless, similarities in tick densities across other Shelter Island woodlots sampled in 1991 (unpublished data) suggest that differences in tick densities seen between the burned and unburned portions of Sachem's most likely resulted from the effect of the fire. Burning vegetation may result directly in mortality of ticks living in the leaf litter or indirectly by removing vegetative cover required by the tick for body water homeostasis.

Despite significantly fewer ($P = 0.0024$) nymphal ticks in the burned portion, the entomologic risk (i.e., the likelihood for encountering infected nymphal ticks, all other factors being equal) was nearly the same in both burned and unburned woods. The prevalence of Lyme disease spirochete infection in those nymphs sampled appeared to be greater in the burned area (35%) than in the unburned woodlot (18%). When both nymphal abundance and infection prevalence are considered, we found the same density of spirochete-infected ticks (compare 34.0 infected nymphs per h in burned woods versus 34.7 in unburned woods). Although it is not possible to compute a meaningful statistic from these values, our findings suggest that this burn had no effect on reducing entomologic risk for *B. burgdorferi* transmission.

One possible explanation for these results is that burning vegetation may have increased mortality just among selected subpopulations of *I. dammini*. Microfilarial nematodes, similar to descriptions of an exceptionally large microfilaria found parasitizing adult *I. dammini* on Shelter Island (Beaver & Burgdorfer 1984, 1987) were found parasitizing nymphs collected from the unburned (but not the burned) portion of the woodlot. Interestingly, it was the presence of this nematode in *I. dammini* from Shelter Island that led to the original discovery of the Lyme disease spirochete (Burgdorfer 1986). In this study, if these worms were derived from one particular tick host, then they may have served as a unique biological marker. In Europe, another large nematode, *Dipetalonema rugosicauda*, parasitizes cervids, especially deer, and can be found in *I. ricinus* derived from deer (Aeschlimann et al. 1979, Jaenson & Tälleklint 1992). If the nematodes found parasitizing Shelter Island *I. dammini* are also deer parasites, their accidental ingestion by bloodfeeding *I. dammini* would "label" parasitized ticks as deer-derived. In such a scenario, the absence of nematodes from the burned portion of the woodlot would suggest that deer-derived ticks were affected by the burn. Furthermore, disproportionate mortality among deer-derived ticks as opposed to those that were mouse-derived would cause an increase in the prevalence of spirochete infection among the remaining ticks. Rodent-derived nymphs (not those from white-tailed deer) are most likely to be infected with Lyme disease spirochetes, (Telford et al 1988, Mather et al 1989). It is interesting to speculate that at least a portion of the nymphal tick population derived from rodents might have been protected from the effect of burning vegetation because they resided in burrows. Although the vertebrate host of these Shelter Island nematodes remains to be identified, the fact that none of the parasitized nymphs examined were simultaneously infected with Lyme disease spirochetes is compatible with our suggestion that the nematode we observed was deer-derived. Deer appear incapable of infecting ticks with Lyme disease spirochetes (Telford et al. 1988, Jaenson & Tälleklint 1992) but could infect feeding ticks with the nematode.

Although a single spring burn appeared to reduce the abundance of nymphal ticks by half, it apparently failed to reduce the risk of encountering *B. burgdorferi*-infected nymphs. In fact, by removing understory vegetation, human use of the woodlot and thus, human exposure to infected nymphal ticks, may be enhanced whenever vegetation destruction is used as a sole tick reduction strategy. Burning over several years, a hotter fire, or burning later in the spring may prove more effective in killing rodent-derived *I. dammini* in addition to those derived from deer and other nonburrow-dwelling animals. An integrated tick reduction program, including late summer application of permethrin-treated rodent nesting material (Mather et al. 1987) or broadcast pesticides (Schulze et al. 1991) to kill

mouse-derived larvae followed by a spring burn to kill all other ticks, might effectively reduce both tick abundance and the entomologic risk for Lyme disease spirochete infection.

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