Impact of Controlled Burns on the Abundance of *Ixodes scapularis* (Acari: Ixodidae)

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ABSTRACT Information on the effect of vegetative destruction by controlled burns in reducing the abundance of the blacklegged tick, *Ixodes scapularis* Say, the vector for the agents of Lyme disease, human babesiosis, and human granulocytic ehrlichiosis, is limited. Therefore, the abundance of nymphal, larval, and adult *I. scapularis* was monitored by dragging the vegetation at 2 separate 4-ha tracts in Cockaponset State Forest in Connecticut following a single controlled burn on 15 April or 21 May 1992. The burn at the April burn site was rated as light to moderate with a flame height of 0.3 m and consumed ≈67% of the surface leaf litter. The burn at the May burn site was rated moderate to severe with a flame height of 0.6–0.9 m., which consumed vegetation <5 cm in diameter and ≈100% of the surface leaf litter. The impact of the burn was strongly influenced by the intensity and timing of the burn. Burning of the vegetation resulted in a reduction of the abundance of nymphal *I. scapularis* by 74% at the moderately burned site and 97% at the severely burned site, compared with adjacent unburned woodland. No larvae were recovered later in the summer from the severely burned tract. However, judging by the comparable abundance of adult *I. scapularis* in the fall at the burned and unburned woodlands, the effect of the burns was temporary. Burning the vegetation for the control of *I. scapularis* appears limited in effect and could be applied only on a large scale in areas with little or no human habitations.

KEY WORDS *Ixodes scapularis*, Lyme disease, ticks, tick control, burning, habitat

THE TICK VECTOR in the northeastern United States for *Borrelia burgdorferi* Johnson, Schmid, Hyde, Steigerwalt & Brenner and *Babesia microti* Franca, the causal agents of Lyme disease and human babesiosis, respectively, is the blacklegged tick, *Ixodes scapularis* Say (Spielman et al. 1979, Steere and Malawista 1979, Burgdorfer et al. 1982, Johnson et al. 1984, Piesman et al. 1986). Since surveillance for Lyme disease was begun by the Centers for Disease Control and Prevention (CDC) in 1982, the number of Lyme disease cases has increased from 491 to 16,461 cases in 1996 (CDC 1997). Much of the research to reduce the incidence of Lyme disease has focused on vector control. Tick control methods for *I. scapularis* have included the application of insecticides to the vegetation (Schulze et al. 1987, 1991; Stafford 1991a; Solberg et al. 1992); a host-targeted insecticide (Daniels et al. 1991; Deblinger and Rimmer 1991; Stafford 1991b, 1992); reduction or exclusion of white-tailed deer, *Odocoileus virginianus* (Zimmerman) (Wilson et al. 1984, Wilson et al. 1988, Daniels et al. 1993, Stafford 1993); and modification of the environment by burning or mowing (Wilson 1986, Mather et al. 1993).

Controlled burning of vegetation has been shown to reduce the abundance of *Dermacentor albipictus* (Packard), *D. variabilis* (Say), and *Amblyomma americanum* (L.) (Smith et al. 1946, Hoch et al. 1972, Drew et al. 1985). Little information is available on the impact of controlled burns on the blacklegged tick. A reduction in the density of adult *I. scapularis* was observed after burning the vegetation in northern Florida and coastal Massachusetts (Rogers 1953, Wilson 1986). Fewer nymphs of *I. scapularis* were recovered from a burned woodlot on Shelter Island compared with an unburned portion (Mather et al. 1993), although the risk of Lyme disease was supposedly unchanged following the burn because of a differential in infection of the nymphs with *B. burgdoferi* between the burned and unburned woods. This study reports the impact of 2 woodland burns, 1 moderate and 1 severe in intensity, on the abundance of *I. scapularis* nymphs, larvae, and adults following the burn.

Materials and Methods

The study was conducted in Cockaponset State Forest in the town of Chester, CT. The burns were conducted at 2 locations of 4 ha each by personnel from the Connecticut Department of Environmental Protection. Both sites were mesic with slopes of <5%. The woodland at the 1st burn site (Truck Road) was composed of mixed oak, *Quercus* spp., and hickory, *Carya* spp., overstory with a subcanopy of maple, *Acer* spp., birch, *Betula* spp., and American beech, *Fagus grandifolia* Ehrh. Sweet pepperbush, *Clethra alnifolia* L., blueberries, *Vaccinium* spp., and beaked hazelnut, *Corylus cornuta* Marsh, dominated the shrub layer. There was a stand of eastern hemlock, *Tsuga canadensis* (L.), in 1 portion of the burn site. The 2nd burn site

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(Spruce Ledge) was dominated by oaks and *Liriodendron tulipifera* L., with a subcanopy of maple, birch, beech, and sassafras, *Sassafras albidum* (Nutt.). The shrub layer was composed primarily of pepperbush, blueberries, and hophornbeam, *Ostrya virginiana* (Mil.). Unburned woodlands adjacent to the 1st burn site and separated from that site by a fire lane was used as the 1st control site. Woodlands in East Haddam, CT, were used for a 2nd control site. This privately owned 44-ha tract is a mixture of woodlands and open pasture. The woods were dominated by oaks and maples with a shrub layer dominated by barberry, *Berberis* spp. The Truck Road site was burned on 15 April 1992 with a light to moderate intensity with flame height of ≈0.3 m and a rate of spread of 0.3–0.6 m/min. The fire produced an vegetative diameter LD_{50} of 1.3 cm and cleared ≈67% of the surface litter. The Spruce Ledge site was burned on 21 May 1992 with a flame height of 0.6–0.9 m and moderate to severe intensity. The rate of spread is unknown, but the resulting fire consumed ≈100% of the surface leaf litter, and the vegetation diameter LD_{50} was 5.1 cm.

The abundance of host-seeking *I. scapularis* was determined by dragging a 1.0-m^2 piece of white flannel cloth over the vegetation at plots (10 by 10 m) established at 6 locations in each of the burn and control sites in Cockaponset State Forest. Two plots (10 by 25 m) were sampled in the woodlands in East Haddam. Host-seeking *I. scapularis* were sampled twice each month from May through October. Any ticks found on the drag cloth were removed, placed in vials with a blade of grass, and returned to the laboratory for identification and testing for *B. burgdorferi*. The presence of *B. burgdorferi* in host-seeking nymphs was determined by indirect fluorescent antibody (IFA) staining of tick midgut tissues with murine monoclonal antibody (H5332) directed to outer surface protein A (Osp A) and fluorescein-conjugated antibodies as previously described (Magnarelli et al. 1987).

Tick abundance was tabulated for the period of activity for each stage (i.e., August for larvae, May–August for nymphs, and October and November for adults). The number of ticks per 100 m^2 for the 2 burned and 2 unburned areas was compared by the nonparametric Kruskal–Wallis 1-way analysis of variance (ANOVA) on ranks using SigmaStat 2.0 (Jandel 1995) (Fox et al. 1995). Dunn's method using SigmaStat was used for pairwise multiple comparisons of the 4 treatment groups.

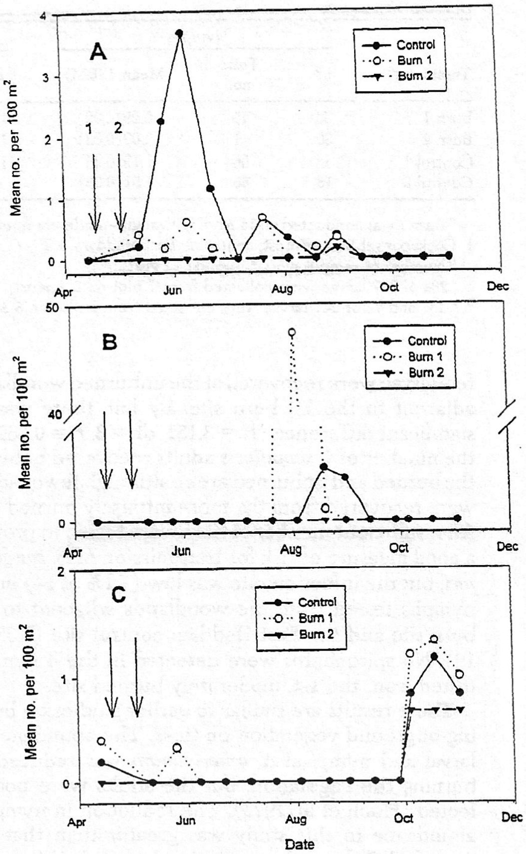

Fig. 1. Mean number of *I. scapularis* collected per 100 m^2 from April through November 1992 at the control and burn sites in Cockaponset State Forest. (A) Nymphs. (B) Larvae. (C) Adults. Arrow 1 indicates burn 1 (15 April, Truck Road site); and arrow 2 indicates burn 2 (21 May, Spruce Ledge site). Data for the East Haddam control site is not shown.

Results and Discussion

Burning of the vegetation resulted in a reduction in the abundance of nymphal *I. scapularis* of 74 and 97% at the April moderate burn and May severe burn sites, respectively. However, judging by the presence of adult *I. scapularis* at all 4 sites in the fall, the impact was temporary (Fig. 1). A summary of the abundance of *I. scapularis* larvae, nymphs, and adults for each of the burn and unburned sites from May through October is shown in Table 1. The abundance of nymphal *I. scapularis* at the burned properties during the summer following the burn was significantly lower than that in unburned woodland (H = 35.088, df = 3, $P < 0.001$). There was no significant difference in nymphal abundance between the 2 control sites (Q = 1.923, $P >$ 0.05) or between the 2 burn sites (Q = 1.387, $P > 0.05$) by the pairwise multiple comparison procedure (Dunn method). There was a significant difference in larval abundance between the East Haddam control site and the other 3 treatment sites (H = 20.154, df = 3, $P < 0.001$), but there was no significant difference in larval abundance between the unburned and burned tracts within Cockaponset State Forest (Q = 1.626, $P > 0.05$). The majority of the larvae (98.6% of 248) at the 1st burn site were recovered from a single plot located near the hemlocks, and a stream, where the impact of the burn was slight, and ≈10 m from a rabbit warren. The failure to recover any larvae at the moderate to severely burned site and more heavily burned portions of the 1st burn site suggests that many engorged females may not have survived. However,

Table 1. Mean number (SEM) per 100 m^2 of host-seeking *I. scapularis* larvae, nymphs, and adults recovered at 2 burn sites and an unburned site in Cockaponset State Forest, Deep River, Connecticut, and at an unburned site in East Haddam, CT, May–October 1992

Treatment[a]	Nymphs			Larvae			Adults		
	n^b	Total no.	Mean (SEM)	n	Total no.	Mean (SEM)	n	Total no.	Mean (SEM)
Burn 1	53	15	0.29(0.09)	18	287[c]	15.94(15.77)	18	21	1.17(0.26)
Burn 2	30	1	0.03(0.03)	18	0	0.00(0.00)	18	12	0.67(0.18)
Control 1	53	56	1.12(0.25	18	25	1.34(0.75)	18	20	1.11(0.27)
Control 2	18	68	1.51(0.38)	6	247[d]	16.13(8.86)	6	13	2.17(0.98)

[a] Burn 1 was conducted on 15 April with slight–moderate intensity; burn 2 was conducted on 21 May with moderate–severe intensity; control 1, Cockaponset State Forest; control 2, East Haddam, CT.
[b] Number of sample plots * number of visits.
[c] 284 of 287 larvae were collected from 1 plot on 3 August.
[d] 137 and 73 of 247 larvae were collected from 1 plot on 5 August and 20 August, respectively.

few larvae were recovered at the unburned woodlands adjacent to the 1st burn site. By fall, there was no significant difference ($H = 3.151$, df $= 3$, $P = 0.369$) in the number of *I. scapularis* adults recovered between the burned and unburned areas, although fewer adults were recovered from the more intensely burned site. An insufficient number of ticks were tested to provide a good measure of risk for transmission of *B. burgdorferi*, but the infection rate was low (7.1% of 14) in the nymphs tested from the woodlands adjacent to the burn site and the East Haddam control site (5.3% of 19). No spirochetes were detected in the 4 nymphs tested from the 1st, moderately burned site.

These results are similar to earlier studies on burning of ground vegetation on ticks. The abundance of larval and nymphal *A. americanum* was reduced by burning the vegetation, but the adults were not affected (Hoch et al. 1972). The reduction in nymphal abundance in this study was greater than that observed (49% fewer *I. scapularis* nymphs) by Mather et al. (1993), but the single spring burn on Shelter Island, although igniting surface leaf litter, did not penetrate the soil humus layer. No information on larval and adult *I. scapularis* later in the season was provided. Vegetative burns on Great Island, MA, reduced adult *I. scapularis* by 70 and 80% following the burns, but the effect of the burn on adult tick abundance could no longer be detected 1.5 yr later (Wilson 1986). Reductions in tick abundance in this study appears to be affected primarily by the intensity of the burn and degree to which the litter was consumed. The hotter fire performed later in the spring (burn 2, May 21) resulted in 97% fewer nymphs. Only 1 nymph was recovered at the severely burned site and few ticks were recovered from any of the plots located in areas where the fire was more intense. Many of the ticks recovered within the 1st (Truck Road) burn site were from the plots located near wetland and more dense vegetation where the burn intensity was less.

Recent efforts to control *I. scapularis* have focused upon methods that could reduce the local abundance of the tick at individual homes. Environmental modification or vegetative management as a method to reduce the abundance of *I. scapularis*, including controlled burns, has received little attention, although a number of studies have examined the impact of destroying the vegetation on other tick species (Wilson and Deblinger 1993). Area-applied acaricides have been found to be effective in controlling *I. scapularis* (Schulze et al. 1987, Schulze et al. 1991, Stafford 1991a, Solberg et al. 1992, Curran et al. 1993). The use of a wood chip border at the lawn edge and removal of leaf litter has been found to reduce tick populations around the home (K.C.S., unpublished data), and the removal of leaf litter in wooded residential plots was shown to reduce significantly the abundance of *I. scapularis* nymphs (Schulze et al. 1995). Mowing the vegetation reduced adult *I. scapularis* by as much as 70% (Wilson 1986).

However, controlled burns are limited to a large scale, and burning may ultimately increase tick abundance. As reviewed by Wilson and Deblinger (1993), several studies have shown that burning woodlands can improve deer browse and the density of *Peromyscus* spp., a major host for immature *I. scapularis*. This may increase tick densities. Indeed, researchers conducting vegetative studies at the 2 burn sites in this study in the years following the burn noted that blacklegged ticks appeared to be more abundant than previously, but these tick densities were not quantified. The destruction of vegetation by controlled burns, unless done annually, does not appear to be effective in reducing the abundance of *I. scapularis*. Alternative technologies aimed at reducing adult tick populations on their primary host, the white-tailed deer, may have more potential for the control of *I. scapularis* over large areas and could be applied in residential settings where burns cannot be performed.

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References Cited

Burgdorfer, W., A. G. Barbour, S. F. Hayes, J. L. Benach, E. Grunwaldt, and J. P. Davis. 1982. Lyme disease—a tickborne spirochetosis? Science (Wash. D.C.) 216: 1317–1319.

Centers for Disease Control and Prevention. 1997. Lyme disease—United States, 1996. MMWR (Morb. Mortal. Wkly. Rep.) 46: 531–535.

Curran, K. L., D. Fish, and J. Piesman. 1993. Reduction of nymphal *Ixodes dammini* (Acari: Ixodidae) in a residential suburban landscape by area application of insecticides. J. Med. Entomol. 30: 107–113.

Daniels, T. J., D. Fish, and R. C. Falco. 1991. Evaluation of host-targeted acaricide for reducing risk of Lyme disease in southern New York state. J. Med. Entomol. 28: 537–543.

Daniels, T. J., D. Fish, and I. Schwartz. 1993. Reduced abundance of *Ixodes scapularis* (Acari: Ixodidae) and Lyme disease risk by deer exclusion. J. Med. Entomol. 30: 1043–1049.

Deblinger, R. D., and D. W. Rimmer. 1991. Efficacy of permethrin-based acaricide to reduce the abundance of *Ixodes dammini* (Acari: Ixodidae). J. Med. Entomol. 28: 708–711.

Drew, M. L., W. M. Lutiwski, and J. N. Willman. 1985. An evaluation of burning for control of winter ticks, *Dermacentor albipictus*, in central Alberta. J. Wildl. Dis. 21: 313–315.

Fox, E., K. Shotton, and C. Ulrich. 1995. SigmaStat statistical software user's manual. Jandel, San Rafael, CA.

Hoch, A. L., P. J. Semtner, R. W. Baker, and J. A. Hair. 1972. Preliminary observation on controlled burning for lone star tick (Acarina: Ixodidae) control in woodlots. J. Med. Entomol. 9: 446–451.

Jandel. 1995. Sigmastat 2.01. SPSS, Chicago, IL.

Johnson, R. C., G. P. Schmid, F. W. Hyde, A. G. Steigerwalt, and D. J. Brenner. 1984. *Borrelia burgdorferi* sp.nov.: etiologic agent of Lyme disease. Int. J. Syst. Bacteriol. 34: 496–497.

Magnarelli, L. A., J. F. Anderson, and D. Fish. 1987. Transovarial transmission of *Borrelia burgdorferi* in *Ixodes dammini* (Acari: Ixodidae). J. Infect. Dis. 156: 234–236.

Mather, T. N., D. C. Duffy, and S. R. Campbell. 1993. An unexpected result from burning vegetation to reduce Lyme disease transmission risks. J. Med. Entomol. 30: 642–645.

Piesman, J., T. N. Mather, J. G. Donahue, J. Levine, J. D. Campbell, S. J. Karakashian, and A. Spielman. 1986. Comparative prevalence of *Babesia microti* and *Borrelia burgdorferi* in four populations of *Ixodes dammini* in eastern Massachusetts. Acta Trop. 43: 263–270.

Rogers, A. J. 1953. A study of the ixodid ticks of northern Florida, including the biology and life history of *Ixodes scapularis*. Ph.D. dissertation, University of Maryland, College Park.

Schulze, T. L., W. M. McDevitt, W. E. Parkin, and J. K. Shisler. 1987. Effectiveness of two insecticides in controlling *Ixodes dammini* (Acari: Ixodidae) following and outbreak of Lyme disease in New Jersey. J. Med. Entomol. 24: 420–424.

Schulze, T. L., G. C. Taylor, R. A. Jordan, E. M. Bosler, and J. K. Shisler. 1991. Effectiveness of selected granular acaricide formulations in suppressing populations of *Ixodes dammini* (Acari: Ixodidae): short-term control of nymphs and larvae. J. Med. Entomol. 28: 624–629.

Schulze, T. L., R. A. Jordan, and R. W. Hung. 1995. Suppression of subadult *Ixodes scapularis* (Acari: Ixodidae) following removal of leaf litter. J. Med. Entomol. 32: 730–733.

Smith, C. N., M. M. Cole, and H. K. Gouck. 1946. Biology and control of the American dog tick. USDA Tech. Bull. No. 905.

Solberg, V. B., K. Neidhardt, M. R. Sardelis, F. J. Hoffman, R. Stevenson, L. R. Boobar, and H. J. Harlan. 1992. Field evaluation of two formulations of cyfluthrin for control of *Ixodes dammini* and *Amblyomma americanum* (Acari: Ixodidae). J. Med. Entomol. 29: 634–638.

Spielman, A., C. M. Clifford, J. Piesman, and M. D. Corwin. 1979. Human babesiosis on Nantucket Island, USA: description of the vector, *Ixodes (Ixodes) dammini*, n. sp. (Acarina:Ixodidae). J. Med. Entomol. 15: 218–234.

Stafford, K. C., III. 1991a. Effectiveness of carbaryl applications for the control of *Ixodes dammini* (Acari: Ixodidae) nymphs in an endemic residential area. J. Med. Entomol. 28: 32–36.

1991b. Effectiveness of host-targeted permethrin in the control of *Ixodes dammini* (Acari: Ixodidae). J. Med. Entomol. 28: 611–617.

1992. Third-year evaluation of host-targeted permethrin for the control of *Ixodes dammini* (Acari: Ixodidae) in southeastern Connecticut. J. Med. Entomol. 29: 717–720.

1993. Reduced abundance of *Ixodes scapularis* (Acari: Ixodidae) with exclusion of deer by electric fencing. J. Med. Entomol. 30: 986–996.

Steere, A. C., and S. E. Malawista. 1979. Cases of Lyme disease in the United States: locations correlated with distribution of *Ixodes dammini*. Ann. Intern. Med. 91: 730–733.

Wilson, M. L. 1986. Reduced abundance of adult *Ixodes dammini* (Acari: Ixodidae) following destruction of vegetation. J. Econ. Entomol. 79: 693–696.

Wilson, M. L., and R. D. Deblinger. 1993. Vector management to reduce the risk of Lyme disease, pp. 126–156. *In* H. S. Ginsberg [ed.], Ecology and environmental management of Lyme disease. Rutgers University Press, New Brunswick, N.J.

Wilson, M. L., J. F. Levine, and A. Spielman. 1984. Effect of deer reduction on abundance of the deer tick *(Ixodes dammini)*. Yale J. Biol. Med. 57: 697–705.

Wilson, M. L., S. R. Telford III, J. Piesman, and A. Spielman. 1988. Reduced abundance of immature *Ixodes dammini* (Acari: Ixodidae) following elimination of deer. J. Med. Entomol. 25: 224–228.

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