

Responses of Intestinal Nematodes in White-footed Mouse (*Peromyscus leucopus*) Populations to Rangeland Modification

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We evaluated the influence of five brush management treatments using the herbicides tebuthiuron and triclopyr, with or without prescribed burning, on the gastrointestinal helminths of white-footed mouse (*Peromyscus leucopus*) populations on the Cross Timbers Experimental Range in Payne County, Oklahoma. We recovered three helminth species (*Syphacia peromysci*, *Nippostrongylus muris*, and one unidentified species of *Trichuris*) in 99 white-footed mice collected in March and June 1986. Overall prevalence of infection for *S. peromysci* (61.6%) and *N. muris* (14.2%) was not significantly influenced by month of collection. Prevalence of *N. muris* infection was significantly greater on untreated control pastures (40.0%) than those subjected to brush removal (7.6%). Prevalence of *N. muris* infections was greater on untreated pastures (40%) than on those treated with herbicide (7.6%). Mean abundances for *S. peromysci* were significantly greater on pastures receiving tebuthiuron than triclopyr treatments. Type of herbicide applied could have influenced *S. peromysci* populations indirectly by altering feeding and habitat use patterns of white-footed mice. Microclimate changes resulting from herbicide applications probably influenced the survival of eggs and infective larvae of *N. muris*.

INTRODUCTION

Composition of helminth communities varies considerably among host populations across geographic regions (1-4). Much of this variation has been attributed to differences in soil moisture and plant communities. Similarly, natural successional and man-induced disturbances of the habitat that alter a variety of abiotic and biotic components can influence the helminth community within a resident host population. Habitat modifications that alter the structure and composition of vegetation can influence both vertebrate and invertebrate populations that serve as either primary or intermediate hosts for a variety of parasite species. For example, several studies have demonstrated that herbicide- and fire-induced alterations of habitats influence the diversity and abundance of small mammals (5, 6) and arthropods (7-10).

Earlier studies by Issac (11) and Bendell (12) reported changes in helminth communities of black-tailed deer (*Odocoileus hemionus columbianus*) and blue grouse (*Dendragapus obscurus*), respectively, following wildfires. Similarly, Seip and Bunnell (13) noted significant reductions in *Protostrongylus* sp. infections among Stone's sheep (*Ovis dalli stonei*) that used annually burned alpine ranges.

Our recent studies have shown that applications of herbicides and burning, which alter structure and composition of vegetation in the habitat, can influence the prevalence of cestodes and abundance and frequency distribution of nematodes in cottontail rabbit (*Sylvilagus floridanus*) populations (14, 15). We present additional evidence in

this paper that man-induced habitat modifications can influence host-parasite relationships on cross timbers rangeland. Specifically, we examined the abundance and prevalence of *Syphacia peromysci* and *Nippostrongylus muris* infections in populations of white-footed mice (*Peromyscus leucopus*) inhabiting rangelands altered by applications of herbicide and prescribed fire.

METHODS

White-footed mice were collected on the Cross Timbers Experimental Range (CTER), located approximately 11 km west of Stillwater, Oklahoma (36°2' to 36°4'N, 97°9' to 97°11'W). The CTER is a 648-ha research area composed of blackjack oak (*Quercus marilandica*)-post oak (*Q. stellata*) and eastern redcedar (*Juniperus virginiana*) upland forest intermixed with tallgrass prairie (16). The CTER includes 20 fenced experimental pastures, each of 32.4 ha, representing four replications each of four commonly used brush management treatments, using combinations of herbicide and annual prescribed burning applications, and an untreated reference area. The five experimental treatments were: 1) tebuthiuron (*N*-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-*N,N'*-dimethylurea), a soil-applied herbicide (Elanco, Products Co., Division of Eli Lilly and Co., Indianapolis, IN 46285, USA) applied aerially at 2.0 kg per ha in March 1983; 2) tebuthiuron applied as in treatment 1 with annual prescribed burning in April, 1985 and 1986; 3) triclopyr ([3,5,6-trichloro-2-pyridinyl]oxy]acetic acid), a foliage-applied herbicide (Dow Chemical Co., Midland, MI 48674, USA) applied aerially at 2.2 kg per ha in June 1983; 4) triclopyr applied as in treatment 3 with annual prescribed burning in April, 1985 and 1986; and 5) untreated reference area. All experimental pastures were moderately grazed by cattle during spring and summer of each year.

Populations of white-footed mice were sampled in upland post oak-blackjack oak savannas by removal snap-trapping using a randomly placed 8 × 8 grid (15-m spacing between stations) on each pasture. Two replications of each of the five experimental treatments were sampled in March and June 1986 and adequate numbers of adult mice were collected from all treatments. Trapping grids were relocated to unsampled areas prior to sampling in June. Mice were returned to the laboratory and total recovery of gastrointestinal helminths was undertaken using irrigation and lavage. The specifics of these techniques have been described (14). Representative samples of helminths recovered from this study have been deposited in the U. S. National Parasite Collection (Beltsville, Maryland 20705, USA, Accession Nos. 80492-80493).

Abundances for *S. peromysci* were independently rank transformed (17) prior to data analysis. Differences among experimental treatments were examined by using a two-way analysis of variance for the ranked abundances of *S. peromysci* with treatment and month as main effects [general linear model procedure, PROC GLM (18)]. *A priori* specific contrasts were used to compare variation in abundance among brush treatment components (burned herbicide-treated versus unburned herbicide-treated, tebuthiuron-treated versus triclopyr-treated, untreated versus treated). Prevalence of *S. peromysci* and *N. muris* was subjected to chi-square analysis for determination of heterogeneity among experimental brush treatments. *A priori* specific contrasts (2 × 2 contingency tables corrected for continuity with Haber's (19) correction) were used to compare variation in prevalence among brush treatment components as described above. Data were pooled across seasons or treatment categories only if statistical interactions were not indicated.

RESULTS

Three nematode species (*S. peromysci*, *N. muris*, *Trichuris* sp.) were recovered from a total of 99 white-footed mice on the CTER. Only one female *Trichuris* of unknown species was recovered (Table 1). Both *S. peromysci* and *N. muris* were represented on all five experimental brush treatments. Overall prevalence of infection for *S. peromysci* (62.6%) and *N. muris* (14.2%) were not significantly influenced ($X^2 = 1.068$, $df = 1$, $P > 0.100$; $X^2 = 2.078$, $df = 1$, $P > 0.100$, respectively) by month of collection (Table 1). Since no statistical interactions between months were indicated we pooled data from the two collections for analysis of treatment effects.

Prevalence of *S. peromysci* infections in white-footed mouse populations from

burned herbicide treatments (73.0%) tended to be greater ($X^2 = 3.453$, $df = 1$, $P < 0.100$) than on unburned herbicide treatments (52.4%). Prevalence also tended to be greater ($X^2 = 3.439$, $df = 1$, $P < 0.100$) on all tebuthiuron (72.5%) than all triclopyr (51.3%) treatments, but differences were not significant.

In contrast, prevalence of infection for *N. muris* was significantly ($X^2 = 14.285$, $df = 4$, $P < 0.01$) influenced by experimental brush treatments. Prevalence was significantly greater ($X^2 = 12.902$, $df = 1$, $P < 0.001$) on untreated controls (40.0%) than on herbicide-treated pastures (7.6%). Prescribed burning and type of herbicides applied had no significant influence on prevalence for *N. muris*.

Although prevalence of *S. peromysci* showed no significant difference between collection dates, abundance and intensity of infections were greater in March than June (Table 2). Overall, intensity of infection for *S. peromysci* ranged from 1 to 2789 worms/host. Mean ranked abundances for *S. peromysci* were significantly influenced by experimental brush treatments ($P < 0.041$) and season ($P < 0.020$). Specific contrasts indicated that abundances were significantly greater ($P < 0.034$) on tebuthiuron (177.2 worms/host) than triclopyr (125.1 worms/host) treatments; no other specific contrasts were significant.

Abundance and intensity of infection for *N. muris* was highest in animals from untreated control pastures. Intensity of infections ranged from 1 to 3 worms/infected host (Table 2). Of the white-footed mice infected with *N. muris*, only 28.6% (4 of 14) had more than one worm, and 75% of these animals were from untreated control pastures.

DISCUSSION

Although white-footed mice are widely distributed throughout the United States, relatively little is known of their nematode parasite fauna as related to habitat. Harkema (20) and Leiby (21) noted that species diversity of helminth infections in *Peromyscus* species tends to be low in comparison to that in larger rodent species. We have made similar observations in small mammal communities from central Oklahoma; two prominent gastrointestinal parasite species were documented in the white-footed mouse

TABLE 1. Prevalence (number infected/number examined) by intestinal helminths recovered from white-footed mice (*Peromyscus leucopus*) collected from five experimental brush-treatment areas on the Cross Timbers Experimental Range, Payne County, Oklahoma in March and June 1986.

Brush treatment	<i>Syphacia peromysci</i>		<i>N. muris</i> ^a		<i>Trichuris</i> sp.	
	Mar	Jun	Mar	Jun	Mar	Jun
Tebuthiuron	8/11	6/10	1/11	1/10	0/11	0/10
Tebuthiuron & burning	7/9	8/10	0/9	1/10	0/9	0/10
Triclopyr	5/10	3/11	0/10	1/11	0/10	0/11
Triclopyr & burning	5/9	7/9	2/9	0/9	0/9	1/9
Untreated	8/10	4/10	1/10	7/10	0/10	0/10
Overall (%)	61.6		14.2		1.0	

^a *Nippostrongylus muris*

TABLE 2. Abundance and intensity of infection for intestinal helminths recovered from white-footed mice (*Peromyscus leucopus*) collected from five experimental brush-treatment areas on the Cross Timbers Experimental Range, Payne County, Oklahoma in March and June 1986.

Brush treatment	Line Code ^a	<i>Syphacia peromysci</i>				<i>Nippostrongylus muris</i>			
		March		June		March		June	
		X	SE	X	SE	X	SE	X	SE
Tebuthiuron	A	174	60	130	113	0.09	0.09	0.10	0.10
no burning	I	240	69	218	186	1		1	
Tebuthiuron & burning	A	330	270	88	47	0		0.10	0.10
	I	425	344	110	57			1	
Triclopyr	A	289	277	12	10	0		0.19	0.19
no burning	I	579	522	44	37			2	
Triclopyr & burning	A	147	82	58	39	0.22	0.15	0	
	I	265	130	75	49	1			
Untreated	A	709	270	92	47	0.10	0.10	1.10	0.31
control	I	886	308	231	81	1		1.57	0.30

^a A denotes line describing "Abundance"; I denotes line describing "Intensity".

compared to five species in *Sigmodon hispidus*, three in *Neotoma floridana*, and seven in *Sylvilagus floridanus* (22).

Syphacia peromysci were recovered primarily from the cecum and have been reported in surveys of white-footed mice in North Carolina (20), Maryland (23), and Kentucky (23). This oxyurid pinworm has been widely reported in other species of *Peromyscus* as well (21,24). In contrast to *S. peromysci*, infections of *N. muris* and *Trichuris* sp. in *Peromyscus* have not been widely reported. Unlike infections in the genus *Peromyscus* (21,24), abundance of infection for *N. muris* in a common host, *Rattus norvegicus*, often exceeds 100 worms/host (20,25).

Brush removal with herbicides appeared to influence the abundance and prevalence of *S. peromysci* and *N. muris* in white-footed mouse populations on the CTER. Triclopyr and tebuthiuron applied on the CTER significantly altered the vegetation community by decreasing woody overstory and increasing herbaceous understory production. Detailed descriptions of how herbicides and prescribed burning influenced vegetation on the CTER are available (26,27).

The greater abundances of *S. peromysci* infections, and tendency for greater prevalence, in white-footed mouse populations on tebuthiuron than triclopyr treatments may be attributed more to a clumped distribution of preferred habitats than differences in microclimatic factors. The universal distribution of *S. peromysci* among *Peromyscus* spp., including harsh and environments in Utah (24), suggest that this pinworm has eggs resistant to extremes in temperature and moisture. Vegetation structural characteristics were dissimilar between tebuthiuron and triclopyr treatments, with a greater abundance and distribution of preferred woody cover on triclopyr-treated pastures (26,27). Tebuthiuron was more efficient at preventing resprouting of woody vegetation after canopy removal and also was effective against a greater number of woody species compared to triclopyr. As a result, feeding and other habitat-use behaviors of white-footed mice may have been more concentrated on tebuthiuron treatments with a limited distribution of preferred habitat types. Observed differences did not appear to be related to host density, as relative population densities (catch per unit effort) of white-footed mice were found to be significantly greater on triclopyr than tebuthiuron treatments on the CTER (28).

Differences in the prevalence of *N. muris* infections between untreated pastures and those subjected to brush removal could be a reflection of more suitable microclimatic conditions for survival of eggs and larvae. Infective larvae of *N. muris* primarily enter the host by boring through the skin, although some infections may be acquired orally (25). Moisture is required for the development of eggs and larvae of *N. muris*, and conditions similar to those found in fresh feces are ideal (25). Eggs and larvae apparently are susceptible to damage by direct sunlight and high temperature (20,25). The greater amount of forest floor material (14) and shade provided by the woody overstory on untreated control pastures compared to herbicide-treated pastures probably protected eggs and larvae of *N. muris* from desiccation.

Our study indicates that habitat alterations which modify the structure or composition of rangeland vegetation can potentially alter host-parasite community relationships in small mammals. The impact of habitat modifications on any particular species of helminth is undoubtedly correlated with life cycle, mode of transmission, resistance to microclimatic changes, and effects on host behavior and habitat use. It is possible that similar alterations in host-parasite communities could occur in livestock and other wildlife species grazing brush-treated rangeland.

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