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Authors: PRESTWOOD, ANNIE K., SMITH, JAMES F., and BROWN, JOHN

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LUNGWORMS IN WHITE-TAILED DEER OF THE SOUTHEASTERN UNITED STATES*

ANNIE K. PRESTWOOD,[1]

JAMES F. SMITH, [1] and JOHN BROWN[2]

Southeastern Cooperative Wildlife Disease Study, College of Veterinary Medicine, University of Georgia, Athens

Abstract: The lungworm, *Dictyocaulus viviparus,* was found in 240 (29.8%) of 806 white-tailed deer collected in Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, South Carolina, Texas, Virginia, and West Virginia. The infection was not found in deer of Tennessee and St. Croix of the U.S. Virgin Islands. Lungworm infections varied significantly with season of collection, age, and sex of the host.

INTRODUCTION

White-tailed deer *(Odocoileus virginianus)* of North America harbor 4 species of adult lungworms, viz. *Dictyocaulus filaria, D. viviparus, Leptostrongylus alpenae,* and *Protostrongylus coburni.*[1,2] Of these, *D. viviparus* is the most frequently encountered and has been recorded from whitetails in Michigan,[8,14,23] Minnesota,[13] New York,[6] Pennsylvania,[3,19] South Dakota,[4,5] and Wisconsin.[20] Despite such widespread distribution in the northern United States, information is not available on *D. viviparus* infections in white-tailed deer elsewhere in this country. Data are presented herein on the distribution, seasonal abundance, age, and sex variations associated with *D. viviparus* among white-tailed deer of the southeastern United States.

MATERIALS AND METHODS

From 1961 through early 1970 the lungs of 806 white-tailed deer were examined for helminths. Animals were collected from 69 counties in 13 southeastern states (Fig. 1), King County, Texas, and St. Croix of the U.S. Virgin Islands. Deer usually were collected by shooting, although deer dying of accidental and natural causes also were examined. Each season of the year was represented in the samples, and animals collected during a particular season were pooled regardless of the year collected. Ages ranged from 6 months to 9 years with approximately 31 per cent of the deer one year or less in age. Nearly two-thirds of the deer were female since they were more numerous on the study sites.

Carcasses were opened as previously described[17] and the trachea and lungs removed. The entire bronchial tree was opened and the air passages searched for helminths. The lungs were then washed to free worms which may have been missed. Washings were flushed through a 100 mesh screen and the retained material was examined with magnification (3-5X). In the early part of the study (1961-63), parasite burdens were

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[1] Department of Parasitology

[2] Department of Medical Microbiology

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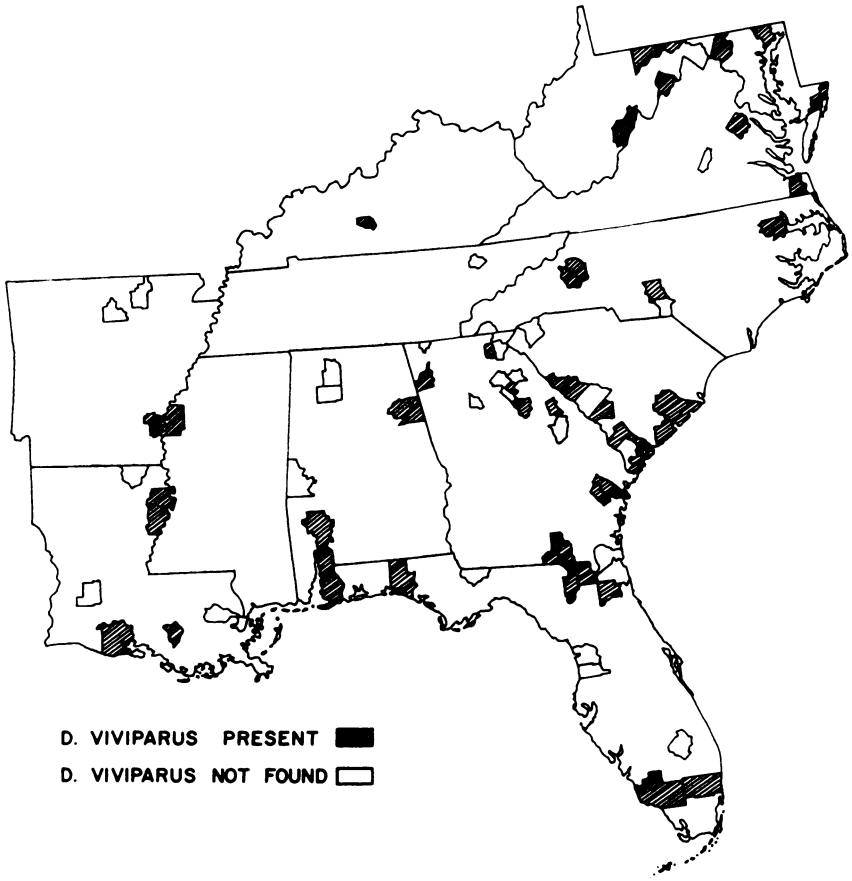


Figure 1. Map of the southeastern United States showing counties from which white-tailed deer were examined for lungworms.

recorded as light, medium, or heavy. Since that time attempts were made to count all adult lungworms. Parasites were preserved in formalin or glycerine-alcohol and cleared in phenol-alcohol for identification.

Two methods of statistical analysis were employed. Incidence was analyzed by the method of chi-square,[10] though we are advised that strict application of this test to sets of data of heterogenous origin may not be valid. An analysis of variance by the method of least squares* was made for data from all 668 deer collected in 1963 and thereafter when actual helminth counts were made. In this design each deer was considered a block or replicate and 3 factors (season, age, sex) were tested for significance and interaction. Season was considered

*Computer Center, University of Georgia. University of Georgia Least Squares Analysis of Variance, Version of July 12, 1966.

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at 4 levels (summer, fall, winter, spring); and age at 2 levels, young (1 year and younger) and adult (greater than 1 year). Sex was considered at 2 levels. Since data on counts of animals tend to be distributed in a manner which is not "normal" in the specialized statistical sense, a square root transformation was used in the form $\sqrt{X + 0.5}$.[21] Comparisons among means were made with transformed values using Duncan's new multiple range test.[21]

RESULTS

Dictyocaulus viviparus was the only mature lungworm found in southeastern whitetails and occurred in Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, South Carolina, Texas, Virginia, and West Virginia (Fig. 1). Adult lungworms were not found in limited numbers of deer from Tennessee and St. Croix.

Nearly 30 per cent of all deer harbored *D. viviparus,* with lungworm burdens ranging from 1 to 175. Seasonal variations in incidence and numbers of lungworms in young and adult white-tailed deer are presented in Tables 1 and 2. A chi-square test revealed that the prevalence was significantly higher in young animals (35.2 per cent) as compared to adults (27.2 per cent; $P < 0.05$), and in males (40.6 per cent) as compared to females (24.4 per cent; $P < 0.01$). Differences in helminth burdens associated with season, age, and sex were established by the analysis of variance (Table 3). A comparison of mean *D. viviparus* burdens by Duncan's multiple range test revealed that there was no significant difference in numbers of worms in spring, summer, or fall, but that burdens were significantly lower ($P < 0.05$) in winter, in adult deer, and in females. The absence of statistical interaction suggests that the factors of season, age, and sex may operate independently.

Localized mild bronchitis and peribronchitis occasionally were associated with the lower numbers of *D. viviparus* encountered in deer virtually free of other pulmonary nematodes. Verminous pneu-

Table 1. Seasonal incidence of **D. viviparus** in young and adult white-tailed deer (1961-1970).

	Winter (Dec 22 - Mar 21)	Spring (Mar 22 - June 21)	Summer (June 22 - Sept 21)	Fall (Sept 22 - Dec 21)	Total
Young Males	11/35 (31.4)*	12/32 (37.5)	21/37 (56.7)	9/22 (40.9)	53/126 (42.1)
Young Females	10/39 (25.6)	8/32 (25.0)	11/39 (28.2)	8/19 (42.1)	37/129 (28.7)
Adult Males	9/29 (31.0)	1/13 (7.7)	15/39 (38.5)	29/56 (51.8)	54/137 (39.4)
Adult Females	25/133 (18.8)	13/71 (18.3)	37/122 (30.3)	21/88 (23.9)	96/414 (23.2)
Seasonal Total	55/236 (23.3)	34/148 (22.9)	84/237 (31.2)	67/185 (36.2)	240/806 (29.8)

* no. infected/no. examined (per cent)

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Table 2. Average **D. viviparus** worm burdens in deer by season.

	Winter	Spring	Summer	Fall
Young Males	3.9 (12.9)*	7.9 (19.9)	10.1 (17.1)	17.4 (23.2)
Young Females	2.4 (9.1)	10.8 (39.2)	5.9 (18.4)	8.4 (12.9)
Adult Males	1.2 (4.1)	0.1 (1.0)	6.6 (15.5)	4.3 (8.7)
Adult Females	0.8 (3.8)	0.7 (3.4)	3.2 (8.9)	1.3 (5.4)
Overall Average	1.5 (6.5)	4.3 (10.1)	5.4 (13.5)	4.8 (13.6)

* numerical average (average per infected deer)

Table 3. Comparison[1] of burdens of **D. viviparus** in 668 deer, the values of parasite numbers transformed by the formula $\sqrt{X + 0.5}$

Source of Variation	Degrees Freedom	Mean Square
A = Season	3	11.00*
B = Age	1	58.99**
C = Sex	1	10.54*
AB	3	3.14
AC	3	3.36
BC	1	2.42
ABC	3	0.41
Error	652	2.34

[1] Analysis of variance — least-square method
* significant at 5 per cent level of probability
** significant at 1 per cent level of probability

monia of varying intensity was not uncommon, however, where heavy infections with unidentified, first-stage, protostrongylid larvae (similar to *Pneumostrongylus tenuis* larvae) were revealed. Verminous pneumonia, unaccompanied by protostrongylid larvae, rarely was observed. Lesions of uncomplicated *D. viviparus* pneumonia therefore were difficult to define. In a limited number of deer having mild protostrongylid infections and relatively large numbers of *D. viviparus,* fibrinous pleuritis with adhesions to the thoracic wall, bronchitis and peribronchitis, with accompanying excessive exudate in the air passages nevertheless were observed. Histologic lesions were similar to those associated with lungworm infections in Michigan deer.[8]

DISCUSSION

In many counties recorded as negative, only a few deer were available for study, whereas if more deer had been examined, additional infections probably would have been disclosed. With the techniques used, light lungworm infections also could have been missed, and the counts presented must be considered minimal. This study nevertheless shows that *D. viviparus* is widespread in white-tailed deer throughout the Southeast, where its occurrence is scattered throughout the coastal plain, piedmont, and mountain physiographic provinces.

Environmental factors favoring lungworm development were reviewed by Poynter and Selway[16] and Gupta and

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Gibbs.[9] The high incidence of infection therefore was not surprising when considering the abundant rainfall and mild temperatures which prevail throughout the southeastern region. While studying variations in lungworm infections among Quebec cattle, Gupta and Gibbs[9] found a similar low incidence of *D. viviparus* in cattle which were examined during the winter. The prevalence of infection in cattle was highest in the fall. Although not statistically significant, *D. viviparus* infections in southeastern deer also seemed to be more prevalent and present in higher numbers in the fall. Gupta and Gibbs[9] attributed seasonal variations in incidence of *D. viviparus* to climate and husbandry. The present study suggests that climate probably is the predominant factor in producing seasonal variations in prevalence and burdens of *D. viviparus*.

Young deer, particularly males, were more frequently infected and harbored higher numbers of lungworms than did adults. The relatively high percentage (27.2 per cent) of adult deer which harbored *D. viviparus* was somewhat surprising; however, periodic reinfection may be necessary to stimulate an immune response.

Differential susceptibility to *D. viviparus* infections associated with sex of the host has not been reported, but this phenomenon has been recorded for a variety of other nematodes.[7,11,12] For example, failure to establish high numbers of *Aspiculuris tetraptera* in mice has been attributed to male sex hormones.[11,12] Gonadotropic hormones similarly may influence susceptibility of deer to *D. viviparus* infections.

Low numbers of *D. viviparus* apparently are well tolerated by deer, but the pathologic capabilities of this nematode cannot be discounted as a substantial mortality factor. The authors therefore feel justified in reiterating that this regional study indicates adult lungworm infections to be seasonal, with the lowest prevalence and intensity of infection occurring in the winter, followed by a build-up of infection extending through the fall. Young male deer concomitantly show the greatest susceptibility to lungworm infection, which suggests an additional explanation for the imbalanced sex ratios reported in mule deer *(Odocoileus hemionus)*[18,22] and observed in some deer herds of the Southeast.[15] Future research may show that hunting regulations must take into consideration this intrinsic host/parasite relationship.

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