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Authors: FOREYT, WILLIAM, and TRAINER, DANIEL O.

Source: Journal of Wildlife Diseases, 6(1) : 35-42

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-6.1.35

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Experimental Haemonchosis in White-Tailed Deer*

WILLIAM FOREYT, and DANIEL O. TRAINER

Department of Veterinary Science

University of Wisconsin

Madison, Wisconsin

Received August 5, 1969

Abstract

White-tailed deer *(Odocoileus virginianus)* were successfully infected with *Haemonchus contortus* of sheep origin. Individual deer in each of three groups were inoculated with 0, 25,000, and 100,000 larvae respectively. Severity of infection was related to dose and signs of infection were most obvious in the heavily inoculated animals. Infected deer were weak, emaciated, and anemic, similar to the clinical response in sheep. Hemoglobin, packed cell volume, and total serum protein values for both infected groups were significantly lower than for the controls. Inhibition of larval growth was noted in both infected groups, but was most pronounced in the group which received 100,000 larvae. Inhibition of egg production was also noted in this group. The potential importance of *H. contortus* in deer populations was discussed.

Introduction

The numbers and kinds of parasites reported in white-tailed deer are numerous and occur throughout the deer range of North America. At least 69 species of parasites have been reported from deer,[2,15] but the significance and epizootiological importance of parasitisms in deer are virtually unknown.

Haemonchus contortus has been reported in white-tailed deer from widely scattered geographic areas: Florida,[2] Michigan,[28] Texas,[17] Pennsylvania,[15] and Wisconsin.[3] In Wisconsin it has also been recovered from domestic sheep[3] and cattle.[1] Deer and livestock commonly utilize the same habitat and this close association theoretically provides the opportunity for interspecies transmission of parasites such as *Haemonchus*.[22]

Because of the potential importance of *Haemonchus* to deer and the role that deer might play in the epizootiology of the parasite, this study was initiated to (1) determine the susceptibility of deer to *H. contortus*, and (2) establish its pathogenicity for deer.

*This study was supported and conducted in cooperation with the Wisconsin Department of Natural Resources (Wildlife P-R Project No. W-141-R) and published as Veterinary Science Paper No. 611.

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Materials and Methods

Inoculum: Fecal samples from experimental sheep which contained only *H. contortus* eggs (a strain obtained originally from Kentucky sheep) were obtained from Dr. Roger Tetzlaff, Department of Veterinary Science, University of Wisconsin. The infected feces were comminuted, mixed with moist vermiculite, and incubated at room temperature in five gallon plastic containers covered with tin foil. The parasite eggs hatched and developed into infective third-stage larvae within 10 days, at which time they were collected by sedimentation utilizing a Baerman apparatus filled with warm water. Numbers of larvae were determined by counting ten 0.5 ml aliquots of the original larval suspension. Proposed doses of larvae (25,000 and 100,000) were withdrawn from the original suspension, arranged as individual doses, and diluted to reach a final volume of 100 ml. This technique is similar to that described by Benz.[3]

Experimental animals: Nine white-tailed deer fawns, approximately 4 months of age were alloted to three experimental groups, each containing three animals. Each group was placed in an individual 20 x 20 isolation unit and maintained on a diet of hay, corn, and a balanced concentrate. Prior to inoculation, the deer were dewormed with phenothiazine (300 mg/kg body weight) and fecal samples were examined for 10 days after treatment to confirm the deworming.

Pre-exposure: To acclimate deer to the isolation environment, they were allowed a 10 day adjustment period. During the next 4 weeks, blood samples were collected twice a week to establish normal hematological values and fecal samples were collected to further confirm the worm-free status of the deer.

From each fecal sample collected, two 1 gram aliquots were examined for parasite eggs using a direct flotation procedure. A sucrose solution with a specific gravity of 1.270 was used as the flotation solution. An average of the two counts was used as the egg per gram (e.p.g.) value.

At each bleeding, approximately 4 ml of blood were taken from the jugular vein of each animal; half was used for hemoglobin and PCV determinations (anticoagulant, ethylenediaminetetra - acetic acid) and half for total serum protein determinations. Hemoglobin concentration was determined by the cyanmethemoglobin technique adapted for the Bausch and Lomb "Spectronic Twenty" colorimeter; packed cell volume was established with a macrohematocrit (Winthrobe-hematocrit); total serum protein was assayed using the Bausch and Lomb "Protein meter".

Post-exposure: Following the 4 week preconditioning period, animals were inoculated *per os* and examined daily for 77 days. One deer in each group received 25,000 infective larvae; one deer 100,000 larvae; and the third deer 100 ml of water and served as a contact control (Table 1). During the trial, blood and fecal samples were collected at midday every Monday, Wednesday, and Friday. The rooms were cleaned frequently to minimize contamination and transmission of *H. contortus* between experimental animals.

Deer which succumbed during the study and all surviving animals which were euthanized at the termination of the experiment were eviscerated immediately after death. The abomasum was tied off at both ends and later opened in warm water. Contents were thoroughly washed and concentrated by the process of sedimentation, and preserved in 10% formalin. This suspension was examined under 20X magnification and all worms were sexed and counted. The abomasal wall was digested in a pepsin solution[10] and also examined under 20X magnification.

Data were compared statistically using the F test.[20]

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Results

During the preconditioning period, blood values for all deer were similar (Table 1, Figure 1) and e.p.g. of feces remained negative.

During the experiment, three deer (one from each inoculation level) died of causes other than *Haemonchus* and were not included in the statistical results. A control died of trauma during the preconditioning period. At necropsy, no worms or evidence of *Haemonchus* infection were detected.

One deer which received 25,000 larvae died on day 16 post-inoculation (p.i.). Death was due to traumatic injury of the brain. Six *Odocoileostrongylus tenuis* were detected on the surface of the brain and microscopic examination revealed accumulations of *O. tenuis* eggs in the meninges and adult worms in the parenchyma which may have contributed to the death of the animal. In the abomasum 18,120 *H. contortus* (mostly 4th stage larvae) were recovered.

TABLE 1. *Hemotological results of white-tailed deer experimentally infected with* Haemonchus contortus.

		Hematological Values					
	Inoculum	Pre-exposure*			Post-exposure**		
Deer No.	(No. larvae)	Hb (g/100 ml)	PCV (%)	TSP (g/100 ml)	Hb (g/100 ml)	PCV (%)	TSP (g/100 ml)
9W	0	—	—	—	—	—	—
10W	0	20.7	57	8.0	21.8	54	8.3
12W	0	19.7	51	7.7	22.2	61	8.0
Average	0	20.3	54	7.9	22.0	58	8.1
9B	25,000	19.9	54	7.9	20.5	54	7.5
10B	25,000	20.5	55	7.8	19.6	52	7.6
12B***	25,000	—	—	—	—	—	—
Average	25,000	20.3	55	7.9	20.1	53	7.6
9R***	100,000	—	—	—	—	—	—
10R	100,000	20.4	56	7.5	16.3	42	7.2
12R	100,000	19.8	51	8.0	13.4	34	7.0
Average	100,000	20.1	54	7.8	14.9	38	7.1

* Data are averages based on eight bleedings during 4 weeks pre-inoculation: Hb (hemoglobin), PCV (packed cell volume), TSP (total serum proteins).

** Data are based on three bleedings weekly extending from 4 to 11 weeks p.i.

*** Animal died or was sacrificed during the experiment and was not included in the final results.

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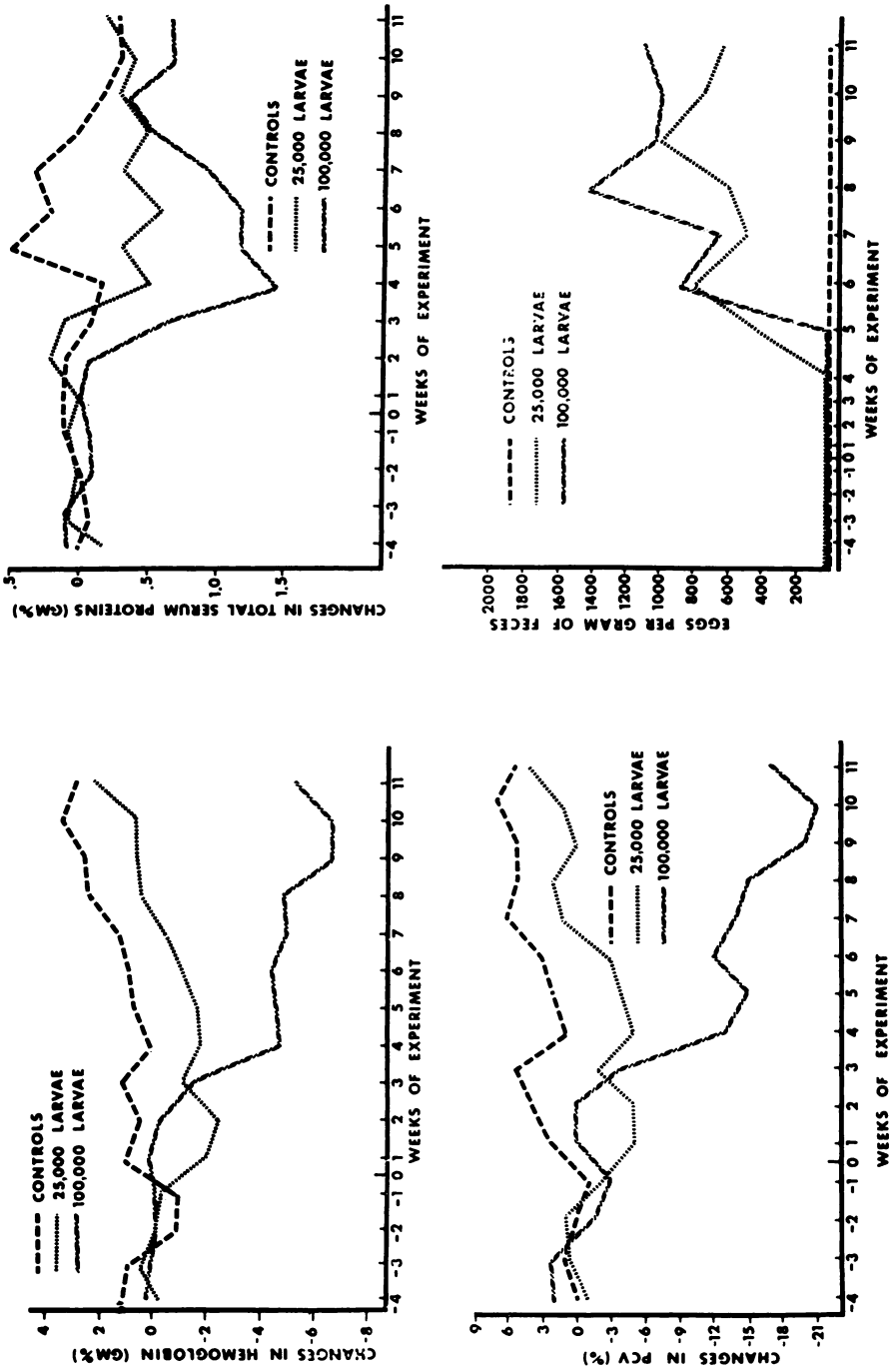


FIGURE 1. *Values for hemoglobin, packed cell volume (PCV), total serum proteins, and parasite egg concentration of white-tailed deer which received* Haemonchus contortus *larvae.*

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On day 47 p.i., one deer which had received 100,000 larvae, sustained a compound fracture of the left metatarsal and was euthanized. This deer was severely emaciated and the hemoglobin value at time of death was 7.7g/100 ml, which was 10.3 g/100 ml below its previously established normal. The hematocrit was 22%, compared to its normal of 52%. The total serum protein value was 6.0 g/100 ml, compared to its normal of 7.0g/100 ml. At necropsy, 5,782 adult *H, contortus* and 2,316 4th stage larvae were recovered from the abomasum.

All experimentally exposed deer were successfully infected with *H. contortus* and contained worms at necropsy (Table 2). Although none of the deer died from *Haemonchus,* the three which received 100,000 larvae were extremely weak, emaciated and anemic.

Six deer (two from each inoculation level) survived the duration of the experiment. The two deer which received 25,000 larvae appeared to be in good health, but had significantly lower hemoglobin ($p<.01$), PCV ($p<.01$) and total serum protein ($p<.05$) values than the controls (Table 1). During the experiment, the hematological values were lower than those of the controls, but at the time of necropsy approached normal values (Figure 1). The egg counts averaged 653 e.p.g. during the 4 to 11 week p.i. period (Figure 1), and at necropsy 2,524 and 131 adult *H. contortus* were recovered from the two animals with corresponding egg counts of 1,294 and 227 e.p.g. (Table 2).

The two deer which received 100,000 larvae and survived the duration of the experiment were extremely weak 40 to 60 days post p.i. They were emaciated and debilitated and had difficulty in rising. Later in the study both seemed to regain some of their strength and the blood values tended to increase (Figure 1), suggesting apparent recovery.

During the 4 to 11 weeks p.i. period, hemoglobin and PCV values were significantly lower ($p<.01$) than those of the controls as well as the deer which received 25,000 larvae. Hemoglobin values dropped more than 5 g/100 ml below normal 4 weeks p.i. and remained low for the duration of the experiment. The PCV dropped from 54 to 33% by the 9th week and remained low for a week before slightly increasing. During the last 7 weeks of the experiment, serum protein levels were significantly lower ($p<.01$) than those of the controls and the group which received 25,000 larvae ($p<.05$). Lowest levels of total serum proteins occurred during the 4th week of infection (Figure 1).

The average e.p.g. count for these deer was highest (approximately 1,000 e.p.g.) during the 9th week of infection and was decreasing when the experiment ended (Figure 1). At necropsy, 5,213 and 796 adult *H. contortus* were recovered from the surviving animals. Egg counts were 1,747 and 537 e.p.g. respectively and did not differ significantly from the deer which received 25,000 larvae.

On day 77 p.i., when the experiment was terminated, the e.p.g. count for the group which received 100,000 larvae averaged 1,142 e.p.g. and the worm count was 3,005, an average of 1 e.p.g. per 2.6 worms. This is compared to 761 e.p.g. and 1,329 worms detected in the animals that received 25,000 larvae or 1 e.p.g. per 1.8 worms (Table 2).

Two controls survived the experiment. Their hematological values remained similar to the pre-exposure values (Figure 1). At necropsy one was worm-free, and the other contained four adult *H. contortus.*

Discussion

Based on the results of these studies, *H. contortus* from sheep can infect deer. The clinical effects of heavy inocula in deer were similar to those reported for sheep.

The pre-exposure hematological values of deer in this study compared favorably with reported normal hematological values for white-tailed deer.[12,21] At the beginning of the experiment the deer

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were 4 months of age and at the termination 8. During this period, normal hemoglobin and PCV values increase with age,[12] and the controls in this experiment illustrated this increase (Figure 1). The decrease of hemoglobin and PCV values in infected deer of this study are in agreement with experimental results in sheep, goats, and cattle experimentally infected with *H.contortus*.[6,13,16]

Deer that died or were euthanized during the course of the experiment were not used in the statistical analysis of data, but contributed to the results concerning larval development. Inhibition of larval development evidently occurred in deer which received 25,000 larvae. Normally larvae reach the 5th stage of development 9 to 11 days p.i. By the 15th day of development, males should be 9 to 10 mm in length and females 12 to 14 mm in length,[19] Almost all of the larvae recovered from the abomasum 16 days p.i. were still in the 4th stage of development and based on size had retardation of growth. Further illustrating the phenomenon of inhibition of growth, deer 9R at 47 days p.i. contained 2,316 4th stage larvae in addition to the 5,782 adult *H. contortus*. It is highly unlikely that these larvae could have been acquired during the experimental period since the controls remained relatively worm-free throughout the study.

At the end of the experiment, it was noted that egg production per adult worm was less in the group receiving 100,000 larvae than the group receiving

TABLE 2. *Numbers of* Haemonchus contortus *recovered at necropsy from experimentally infected white-tailed deer.*

			Necropsy Results					
Deer No.	Inoculum (no. larvae)	EPG (avg)*	Total worms	Males	Females	EPG	Worm-egg Ratio	Adults %
9W	0	—	—	—	—	—	—	—
10W	0	4	4	1	3	3	1:0.8	—
12W	0	0	0	0	0	0	—	—
Average	0	2	2	0.5	1.5	2	1:0.8	—
9B	25,000	1091	2528	1309	1219	1294	1:0.5	10.1
10B	25,000	195	131	52	79	227	1:1.7	0.5
12B**	25,000	—	—	—	—	—	—	—
Average	25,000	643	1329	681	649	761	1:0.6	5.3
9R**	100,000	—	—	—	—	—	—	—
10R	100,000	735	5213	2630	2583	1741	1:0.3	5.2
12R	100,000	726	796	538	258	537	1:0.7	0.8
Average	100,000	730	3005	1584	1421	1142	1:0.4	3.0

* Data are averages based on three determinations weekly extending from 4 to 11 weeks p.i. (EPG—eggs per gram of feces).

** Animal died or was sacrificed during the experiment and was not included in the final results.

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25,000 larvae (Table 2). These data are in agreement with those of Kates[14] and Poeschel [16] who reported that egg production decreased as the total number of nematodes increased.

A small percentage of infective larvae (0.8 to 10%) reached adulthood in the experimental deer (Table 2). A larger percentage of larvae (5.3%) reached adulthood in the group which received 25,000 larvae than in the group which received 100,000 larvae (3.0%), but there was considerable variation between animals in each group. The deer in this experiment were probably overdosed, which would help explain why larvae were inhibited, egg counts were lower than expected, and a low percentage of adults developed. Similar results have been reported for sheep by Dineen[8] and Donald *et al*,[9] who suggested that the larger dose of larvae provided a greater contribution of antigenic information to the immune threshold and consequently fewer larvae reached the adult stage. Another possible explanation for the small percentage of adults developing from larvae may be the partial host specificity of ovine *H. contortus* in deer, such as exists in sheep and cattle.[11] Similar results were recorded with *Haemonchus* isolated from domestic and wild sheep.[1]

Infections of *H. contortus* exceeding 1,000 worms have been reported in 5-month old free ranging fawns in Texas.[17] This study showed that deer can be adversely affected by *H. contortus* as measured by clinical observations and that parasitisms are potentially important. When considering the possible synergistic effects of parasitisms and other environmental stressors which confront wild deer populations the potential importance is apparent.

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