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Source: Journal of Wildlife Diseases, 23(1) : 113-120

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-23.1.113

Journal of Wildlife Diseases, 23(1), 1987, pp. 113-120

VISCERAL HELMINTH COMMUNITIES OF SYMPATRIC MULE AND WHITE-TAILED DEER FROM THE DAVIS MOUNTAINS OF TEXAS

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ABSTRACT: Hybridizing populations of mule (*Odocoileus hemionus*) and white-tailed deer (*O. virginianus*) from the Davis Mountains of Texas were examined to determine similarities in species composition of their helminth communities and if abundances of helminth species in those communities varied across host species and seasonal factors. Only three cestode and three nematode species were recovered. There were very low abundances of species and little diversity in the helminth communities of both hosts. Common helminth species were shared by both deer, and the significant variance in abundances of three of the four most common helminth species appeared to result from differences in habitat preferences of the respective hosts. Our results indicated that analyses of helminth communities of deer from this geographical area do not provide a useful quantification technique for determining deer condition, degree of hybridization, or levels of intraspecific competition.

INTRODUCTION

Mule deer (*Odocoileus hemionus*) and white-tailed deer (*O. virginianus*) are sympatric in much of the Trans-Pecos region of western Texas. Wildlife biologists in the area have noted a decline in mule deer densities and an increase in white-tailed deer numbers during the past 20 yr (Texas Parks and Wildlife Department, 1983). Landowners have been increasingly concerned with this trend because they rely heavily on the income from mule deer hunting leases to maintain their cattle and sheep ranching operations. In addition to causing a potential decline in mule deer numbers through competition for available habitat, white-tailed deer encroachment into areas formerly occupied by mule deer (Wiggers and Beasom, 1986) also poses the threat of hybridization. A substantial number of hybrids of these two species have been documented in this region (Stubblefield et al., 1986).

As part of an overall evaluation of the systematics and ecological relationships of these two species of deer in the Davis Mountains of Texas, the present study was initiated to examine their helminth communities. The objectives of the study were to determine (1) whether or not there were important differences in species composition of their helminth communities, and (2) if helminth abundances of the species represented in those communities varied across host species and environmental factors, particularly seasons.

MATERIALS AND METHODS

The study area in the Davis Mountains of the Texas Trans-Pecos is characterized by diverse habitat types, ranging from Sonoran desert to mountainous. Elevation varies from 760–>2,600 m. Average annual precipitation for the area is usually <30 cm, occurring mostly in July and August. The main vegetation types include creosote (*Larrea tridentata*)–tarbush (*Flourensia cernua*) desert shrub, yucca (*Yucca* spp.)–juniper (*Juniperus* spp.) savannahs, and grama (*Bouteloua* spp.) grasslands. Woody vegetation at higher elevations and in arroyos and canyons where most deer were collected consisted of various species of oak (*Quercus* spp.), ponderosa and pinon pine (*Pinus ponderosa* and *P. cimbroides*), and shrubs including Texas mandrona (*Arbutus texana*) and mountain mahogany (*Circocarpus montanus*).

Twelve female mule deer and 14 female

Received for publication 27 March 1986.
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white-tailed deer were collected from five sites in the Davis Mountains (Brewster and Jeff Davis counties) within a 50 km radius of Fort Davis, Texas. We attempted to collect six adult does of each deer species during the fall (November 1984) and spring (March 1985) seasons by a rifle shot to the cervical region. Deer were eviscerated 1–5 hr post mortem and viscera were frozen for later necropsy. Deer were aged according to tooth development as adult and young of the year. At necropsy lungs, trachea, liver, spleen, kidneys, and mesenteries were examined according to the methods of Samuel (1979) and Wobeser and Spraker (1980). The musculature, vascular system, and central nervous system were not examined. The gastrointestinal tract was examined following the methods of Prestwood et al. (1970, 1975, 1976). An attempt was made to recover all visceral helminths. These were recorded as total counts of individuals of each respective species per infected host.

Helminths were collected, fixed, and prepared for examination according to the methods described by Waid et al. (1985). Representative specimens of helminths recovered in this study are deposited in the National Parasite Collection, Beltsville, Maryland 20705, USA (Accession Nos. 79141–79150).

The terms prevalence, intensity, and abundance follow the definitions of Margolis et al. (1982). The terms significant or significantly refer to statistical significance at $P \leq 0.05$.

Overdispersion is defined by Bliss and Fisher (1953) and in the present study refers to frequency distributions of helminths where a few host individuals have many helminth individuals and many of the hosts have only a few or no individuals of the respective helminth species. Overdispersion was indicated when the variance was significantly greater than the mean (chi-square analysis) and was measured by the negative binomial parameter k (Bliss and Fisher, 1953).

Since an other than normal distribution was indicated for most helminth species recovered, this precluded the use of normal parametric statistical analyses of the raw data and necessitated either analysis by nonparametric tests or standardization and/or transformation of the data prior to analysis with parametric methods. Rank transformations of Conover and Iman (1981) provided a useful technique for application in a unified manner of the usual parametric statistical methods by replacing abundance values in the contiguously distributed data set with their ranks (RT-2 of Conover and Iman, 1981; PROC RANK of Statistical Analysis Systems, 1985 edition, SAS Institute, Raleigh, North Carolina 27607, USA).

The main and interactive effects (Box et al., 1978) of the two independent variables of host species and season were examined with a factorial ANOVA (PROC GLM; SAS) for the four most common helminth species (>20% prevalence in both host species combined). Three combinations of factors influencing the magnitude of numbers of individuals of these helminth species were possible (deer species, season, and species-season). The importance of specific factors were determined from the relative magnitude of the total variance accounted for in that factor by ranking the values of the F statistic (for significant relationships only) generated across all combinations of the two independent variables (Tabachnick and Fidell, 1983).

RESULTS AND DISCUSSION

Our study supports the previous findings of Gray et al. (1978), Moore and Garner (1980), and Waid et al. (1985) concerning the relative lack of diversity of species in helminth communities from populations of white-tailed deer and mule deer in western Texas. We examined respectable sample sizes of both deer species from their sympatric ranges in the Davis Mountains and recovered only six species of visceral helminths (Table 1). Abundances were very low for all helminth species. A single species of abomasal nematode, *Haemonchus contortus*, was recovered. As previously proposed by Moore and Garner (1980) and Waid et al. (1985), the present study also indicates that abomasal parasites cannot function as a useful index for deer condition in this region, because of the relative absence of nematodes in the helminth community of the upper gastrointestinal tract. This disparity in helminth species has been attributed previously to the very high evapotranspiration rates in the semiarid western Texas environment resulting in very low transmission potentials for direct life cycle species (Gray et al., 1978).

A number of studies have examined the helminth communities of deer and other

TABLE 1. Prevalence, intensity, and abundance of visceral helminths from sympatric mule deer and white-tailed deer from the Davis Mountains of Texas.

Helminth species	White-tailed deer P[a] (%)	I[b] ($\bar{x}$ ± SE)	A[c] ($\bar{x}$ ± SE)	Mule deer P (%)	I ($\bar{x}$ ± SE)	A ($\bar{x}$ ± SE)
Thysanosoma actinioides	36	0.1 ± 0.3	0.5 ± 0.2	4	1.0 ± 0	0.1 ± 0.1
Moniezia benedeni	0	0	0	8	2.0 ± 1.0	0.3 ± 0.3
Taenia omissa	29	3.8 ± 2.1	1.1 ± 0.7	40	3.5 ± 0.6	2.9 ± 0.7
Setaria yehi	57	4.8 ± 3.6	1.1 ± 0.7	40	4.1 ± 0.7	3.4 ± 0.8
Trichuris discolor	0	0	0	4	2.0 ± 0	0.2 ± 0.2
Haemonchus contortus	36	8.4 ± 4.4	3.0 ± 1.9	12	1.3 ± 0.4	0.4 ± 0.2

[a] Prevalence.
[b] Intensity.
[c] Abundance.

large herbivores that occupy sympatric ranges in North America. Prestwood et al. (1975) examined sympatric populations of white-tailed deer, cattle, and feral swine on Ossabaw Island, Georgia. Overlap index values (our calculations of Jaccard's coefficients (JC); see Corn et al., 1985) were low between deer and cattle (29) and between deer and feral swine (40). Likewise, Prestwood et al. (1976) found that only five of 30 species of helminths were shared between white-tailed deer and domestic sheep in West Virginia (JC = 17). It was suggested that the helminth species of these hosts were distinct, with little exchange occurring between them (Prestwood, 1975, 1976). Gray et al. (1978) compared the helminth communities of sympatric mule deer and Barbary sheep (*Ammotragus lervia*) in the Texas Panhandle and found only one of five shared species with an overlap index (JC) of 17. Davidson and Crow (1983) found that none of nine common helminth species of white-tailed deer were shared with sympatric sika deer (*Cervus nippon*) from the Delmarva Peninsula. Davidson et al. (1985) compared helminth faunas of sympatric white-tailed deer and fallow deer (*Dama dama*) from Land Between the Lakes, Kentucky and found only six of 16 shared helminth species with an overlap index of 21 (our calculations).

In contrast to the above studies where there are relatively few shared helminth species (low values for JC) between two or more species of large herbivores occupying sympatric ranges, the present study indicates a high value for the overlap index (67) with four of the six total helminth species shared between mule and white-tailed deer in the Davis Mountains of Texas (Table 1). Of the six helminth species recovered from both deer species, two (*Moniezia benedeni* and *Trichuris discolor*) occurred in only one species of deer (Table 1). However, there were no significant differences in abundances of total helminths between these two host species. Of the total of 191 specimens of helminths recovered from both deer species, 89 individuals were from 12 mule deer ($\bar{x}$ =

TABLE 2. Mean to variance ratios and inverse measure of overdispersion of six species of helminths in sympatric mule deer and white-tailed deer from the Davis Mountains of Texas.

Helminth species	Mean/variance	*k*
Thysanosoma actinioides	1:1.2	1.37
Moniezia benedeni	1:2.5[a]	0.10
Taenia omissa	1:3.6[a]	0.74
Setaria yehi	1:11.7[a]	0.28
Trichuris discolor	1:2.1	0.06
Haemonchus contortus	1:14.8[a]	0.13

[a] Variance significantly larger than the mean by chi-square analysis.

7.4 helminth individuals/deer) and 102 were from 14 white-tailed deer ($\bar{x}$ = 7.3) (Table 1). Only six of the 191 (3%) specimens were represented by the two helminth species that occurred in only one host species. Thus, in terms of total helminth abundances of shared species, there appeared to be little disparity across the helminth communities of these respective sympatric host species. This may be partially attributed to the close phylogenetic relationship of these deer species, with a significant degree of hybridization occurring between them (Stubblefield et al., 1986).

Overdispersion is the commonly observed distribution pattern for individuals comprising the populations of most helminth species across their host populations (Anderson, 1982). There are many possible reasons for these aggregated distributions. Anderson (1982) stated that these principally involve the parasite's response to different host strata across seasons as well as density-dependent constraints on the parasite's ability to establish, survive, and reproduce. Wallace and Pence (1986) argued that, while the parasite's response to different host subpopulations across seasons resulted in changes in magnitude of numbers of individuals of the respective helminth species, the pattern of overdispersion remained relatively stable across these variables.

Despite the small number of individuals recovered, the mean to variance ratios and values of k (Table 2) indicated overdispersion in most (four of six) helminth species from deer in the present study. In contrast to the assumptions in previous studies (Anderson, 1982; Pence and Windberg, 1984; Corn et al., 1985), clumping of helminth individuals in certain host individuals in the present study were not directly attributed to differences in host age strata (all animals collected were adult females) operating over seasons to cause changes in helminth dispersion patterns. As proposed by Wallace and Pence (1986), the present study also indicates that individual host factors (genetic, inherent specific resistance, innate susceptibility, etc.) and/or predisposition of certain host individuals to greater transmission potentials in the environment (an other than random chance of acquiring the infection) seem to be the most important factors in generating overdispersion in the helminth populations of vertebrate hosts. These factors seem to have a sufficiently uniform distribution across the collective host population to account for a homogeneous dispersion pattern across different host age, sex, and condition strata over seasons, although the latter are responsible for relatively dramatic changes in the magnitude of numbers of individuals in the helminth population (Wallace and Pence, 1986).

In contrast to previous studies on helminths of large herbivores in Texas (Corn et al., 1985; Waid et al., 1985) where there was a significant difference in abundances of certain helminth species across seasons (warm and cool or wet and dry), we noted no major disparity in abundances of most helminth species in deer from the Davis Mountains (Table 3). The single exception was *Thysanosoma actinioides* which occurred in significantly greater abundances in white-tailed deer than in mule deer and in fall versus spring for white-tailed deer (Table 4). Possibly, the lack of significant differences in abundances of the remaining helminth species may be the result of our small sample sizes, but also may reflect the more arid environment of the Davis Mountains versus the Edward's Plateau (Waid et al., 1985) and southern Texas brushlands (Corn et al., 1985). In the latter areas, the influence of seasonality on abundances of certain helminth species were attributed to increased prevalences of intermediate hosts and increased transmission potentials of direct life cycle nematodes during or following the warm

TABLE 3. Mean abundances of six species of helminths across two seasons from sympatric mule deer and white-tailed deer from the Davis Mountains of Texas.

Helminth species	White-tailed deer Spring (5)[a]	White-tailed deer Fall (9)	Mule deer Spring (6)	Mule deer Fall (6)
Thysanosoma actinioides	1.0 ± 0.3	0.2 ± 0.2	0	0.2 ± 0.2
Moniezia benedeni	0	0	0.2 ± 0.2	0.5 ± 0.5
Taenia omissa	2.2 ± 2.0	0.4 ± 0.3	2.3 ± 1.0	3.4 ± 0.9
Setaria yehi	6.4 ± 5.9	0.7 ± 0.2	3.8 ± 1.3	3.0 ± 0.9
Trichuris discolor	0	0	0.3 ± 0.3	0.3 ± 0.3
Haemonchus contortus	2.0 ± 2.0	3.6 ± 2.7	0.5 ± 0.3	0.3 ± 0.3

[a] Sample size.

or wet seasons. Our observations that *T. actinioides* had significantly greater abundances in white-tailed deer following the warm season, when the majority of annual precipitation occurs in the Davis Mountains, is consistent with results of the above studies. *Thysanosoma actinioides* utilizes a psocopterous insect as an intermediate host (Wardel et al., 1974). These insects are most abundant during the warmer and wetter seasons (Borror and DeLong, 1954).

Although the deer we collected for the above analyses were adult females (>1 yr of age), examination of smaller samples of adult male mule deer ($n = 3$) and white-tailed deer ($n = 1$), juvenile (<1 yr old) male and female mule deer ($n = 1$ and 1, respectively), and juvenile female white-tailed deer ($n = 2$) from the same study area indicated that there was little disparity in prevalence and abundance of helminths across ages and sexes in these respective hosts. This may be partially attributable to the lack of direct life cycle species in the helminth communities of deer from the Davis Mountains. These helminth communities were composed predominantly of species with invertebrate intermediate or vertebrate definitive (in the case of *Taenia omissa*) hosts, and these infections tend to be cumulative with host age.

It has been postulated that white-tailed deer along the southern part of the Atlantic coastal plain and probably the entire Gulf Coast from Florida to Texas should be considered as having the potential for morbidity or mortality due to the *Haemonchus contortus*/malnutrition syndrome and that there is reason to suspect a haemonchosis problem in fawns from regions where *H. contortus* occurs in adult deer (Davidson et al., 1980). The low numbers of *H. contortus* and overall species diversity and very low abundances of all helminths we observed indicated that visceral parasitism is of little consequence to deer populations from the Davis Mountains of Texas.

Stubblefield et al. (1986) found a significant amount (about 25% on some ranches) of hybridization between sympatric mule and white-tailed deer in the

TABLE 4. *F* values from factorial ANOVA showing main and interactive effects of season and host species for abundances of six species of helminths in sympatric mule deer and white-tailed deer from the Davis Mountains of Texas.

Helminth species	Host species	Season	Species × season
Thysanosoma actinioides	7.28[a]	3.19	8.29[a]
Moniezia benedeni	2.27	0	0
Taenia omissa	8.43[a]	0.05	2.23
Setaria yehi	5.38[a]	0.34	0.12
Trichuris discolor	1.14	1.14	1.14
Haemonchus contortus	0.38	0.05	0.76

[a] Significant at $P < 0.05$.

Texas Trans-Pecos. We noted significant differences in abundances of three helminth species between sympatric mule and white-tailed deer from this area (Table 3). However, based on relative abundances of the four most common species in the helminth communities of these deer, it appears that helminth parasitism serves no useful purpose as an indicator of hybridization across these deer populations.

Mule deer and white-tailed deer habitats appear to differ by the amount and structure of the existing vegetation in an area (Anthony and Smith, 1977; Wiggers and Beasom, 1986). On sympatric ranges mule deer occupy areas of greater topographic ruggedness, whereas white-tailed deer seem to prefer areas of less broken topography and more dense woody cover. The abundances of certain helminth species seem to reflect this pattern of habitat segregation.

There was a significantly greater abundance of *T. actinioides* in white-tailed deer (Tables 3, 4), possibly resulting from differences in occurrence and distribution of the bark inhabiting psocopterous insect intermediate hosts (Wardel et al., 1974). While this remains to be confirmed, white-tailed deer may have a greater opportunity for ingestion of the intermediate host as a result of this host's preference for areas of more dense woody cover.

Mule deer had significantly greater abundances of *T. omissa* and *Setaria yehi* (Tables 3, 4). The definitive host for *T. omissa* is the mountain lion (*Felis concolor*) (Rausch, 1981). In our study area mule deer were the predominant species, principally occurring in sites with more rugged and broken topography. White-tailed deer occurred in lower densities, were more dispersed, and mostly occurred at lower elevations in more open country or in wooded arroyos and canyons. Mountain lions are expected to frequent areas of greatest prey base density (Waid, pers. comm.). Therefore, mule deer may have a greater chance of ingesting infective eggs passed by the definitive host.

Mosquitoes appear to be the primary vector of various species of *Setaria* (Soulsby, 1965). The vector species for *S. yehi* in the Davis Mountains is unknown. However, considering the arid environment of the area and the absence of major and defined drainage systems, it is tempting to postulate that the majority of mosquitoes that could serve as intermediate hosts are temporary pool breeders. There is a greater density of these temporary pools of standing water in the more rugged mountainous areas preferred by mule deer than in the lower wooded elevations preferred by white-tailed deer.

In summary, there was a basic disparity in terms of diversity and abundances of species in the helminth communities of sympatric mule deer and white-tailed deer in the Davis Mountains of Texas. The most common visceral helminth species of both deer species were shared, and the significant variance in abundances of three of the four most common helminth species appeared to be related to differences in habitat preferences of the respective host species. Our results show that analyses of helminth communities cannot be used as a quantitative technique for determining host condition, degree of hybridization, or levels of interspecific competition for mule and white-tailed deer populations from this semiarid region in the southwestern United States.

ACKNOWLEDGMENTS

We thank the following landowners and managers of ranches for permission and assistance in collecting the deer examined in this study: B. Meriwether, A. Prude, M. Ross, D. Smith, Sr. and Jr., and Mr. and Mrs. C. Stringfellow. We also appreciate the technical assistance of Texas Parks and Wildlife Department Game Wardens: J. Hearn, R. Wells, and D. Cook. The following individuals assisted in the field and laboratory: S. Demarais, R. Heinen, B. Murphy, B. Pence, R. Stubblefield, B. Wallace, O. Wallace, and R. Wallace. This study was supported in part by the Caesar Kleberg Foundation for Wildlife Conservation; The Department of Pathology, Texas Tech University Health Sciences Center; and the Institute for Museum Research, The Museum of Texas Tech University.

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BOOK REVIEW . . .

World Animal Science, Parasites, Pests and Predators, S. M. Gaafar, W. E. Howard, and R. E. Marsh (eds.). Elsevier Science Publishers, Amsterdam. 1985. 575 pp. $139.00 U.S.

This is but one volume in an extraordinary feat in modern reference book publishing. The publisher has begun production of a series of volumes on animal science which when completed will contain 33 volumes. Eight have been published.

This volume contains 19 chapters on protozoan, helminth and arthropod parasites of relevance to animal production and another 11 chapters on vertebrate pests, predators and competitors and their influence on animal husbandry. All chapters are written by recognized authorities on their topics.

The invertebrate section begins with several general chapters dealing with general concepts as the effects of parasites on their hosts, means of parasite transmission and dissemination, parasite control by chemical, genetic and biological means, and public health concerns. These are followed by individual chapters on intestinal protozoans, blood protozoans, flukes, tapeworms, ruminant trichostrongyles, ascarids, equine strongyles, lungworms, flies, mites and ticks. The final chapter in this section is a general chapter on immunology emphasizing basic immune responses, vaccine potentials, and immunodiagnostic tests. Each chapter reflects the apparent style of the individual author instead of a strictly regimental format.

The vertebrate portion of the book begins with an overview of undesirable effects of vertebrates on animal production. The ensuing chapters deal with predators from Africa, Australia, Asia and North America. The role of wild ungulates, lagomorphs, and rodents as competitors of livestock is examined. The final two chapters cover contributions of wild mammals to livestock diseases and the impact of vampire bats. This section includes a good deal of vertebrate ecology and behavior. Most chapters discuss means of control of the species under consideration.

This book is written at a level that should allow non-specialists to comprehend and apply the information included. Due to the vastness of some chapters, the topics are not covered in the detail found in more specific references. There is a wealth of current literature citations, but there are too few illustrations included for this expensive book. There is a complete subject index. It is a worthwhile reference for those wishing an overview on the subjects included. The literature citations provided will assist in delving into particular subjects in greater detail. This book contains a great deal of information and should be a useful reference to a variety of professions.

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