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EFFECTS OF SEASON AND PHYSICAL CONDITION ON THE GASTROINTESTINAL HELMINTH COMMUNITY OF WHITE-TAILED DEER FROM THE TEXAS EDWARDS PLATEAU

Douglas D. Waid,[1] Danny B. Pence,[2] and Robert J. Warren[1,3]

ABSTRACT: Eighty-six adult female white-tailed deer, *Odocoileus virginianus* (Zimmermann), collected over a 12-mo period in the Texas Edwards Plateau, harbored six species of nematodes (*Haemonchus contortus, Gongylonema pulchrum, Oesophagostomum venulosum, Ostertagia ostertagi, Cooperia* sp., and *Apteragia odocoilei*), and two cestodes (*Moniezia* sp. and *Taenia hydatigena*). The patterns of distribution of the three common species of gastrointestinal helminths (*H. contortus, O. venulosum*, and *G. pulchrum*) were overdispersed. When analyzed for the main and interactive effects of the extrinsic and intrinsic variables of season and physical condition, respectively, aggregated abundances in *H. contortus* and *O. venulosum* appeared to result from the main effect of seasonal changes operating over the collective populations of these two species rather than from the intrinsic factor of physical condition operating within selected subpopulations. Abomasal parasite counts do not appear to be a useful index for monitoring herd condition of white-tailed deer from this geographic region.

INTRODUCTION

White-tailed deer and domestic livestock are important economic resources in the Texas Edwards Plateau (Ramsey, 1965) where they often share common range and the possibility for cross transmission of helminths exists, as indicated from other regions (Beaudoin et al., 1970; Foreyt and Todd, 1972; Prestwood et al., 1975, 1976; Pursglove et al., 1976). Although the helminths of deer are of potential importance to the resource manager, there is little information presently available on helminth faunal composition and respective species abundances from deer in this region. Consequently, the present study was undertaken to (1) identify and quantify the gastrointestinal helminth fauna of white-tailed deer from the Edwards Plateau and (2) observe variations in helminth abundances across host and season variables, especially in relation to the use of abomasal parasite counts in monitoring deer herd condition.

MATERIALS AND METHODS

Study area

Deer were collected on the 22,400-ha YO Ranch in Kerr County, Texas. Low rolling hills typify the topography of this region. Soils are predominantly shallow stony clays of limestone origin. Climate type is Caf (Threwartha, 1954), characterized by hot summers and mild winters. Average annual precipitation is 63.5 cm, with peaks occurring in May and September. Water resources for game and livestock on the ranch are limited to tanks supplied by wells, and ephemeral pools. Vegetation is dominated by mixed stands of oaks (*Quercus* spp.) and Ashe juniper (*Juniperus asheii*), with a grass-forb understory of relatively low diversity (Rollins, 1983).

The ranch has free-ranging herds of five exotic ungulate species including sika deer (*Cervus nippon* (Temminck)), axis deer (*Axis axis* (Erxleben)), fallow deer (*Dama dama* L.), Barbary sheep (*Ammotragus lervia* (Pallas)), and blackbuck (*Antilope cervicapra* L.). There also are herds of Angora and Spanish goats, sheep, and longhorn cattle. Domestic livestock were removed from study areas approximately 6 mo prior to initiation of this project to allow pasture regeneration in conjunction with concurrent studies on dietary habits.

Data collection

Eighty-six adult female white-tailed deer were collected over a 12-mo period, as part of

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a study on helminth parasitism, physiological indices, and dietary habits (Waid, 1983). Approximately 15 does were obtained every 2–3 mo in six collection periods, beginning in August of 1981.

Does were killed by a rifle shot to the cervical vertebrae and eviscerated 1–5 hr post-mortem. The abomasum was ligated (Samuel, 1979) and the entire viscera frozen for later recovery of parasites. Deer ages were determined by tooth eruption and wear (Severinghaus, 1949). A physical condition class (excellent, good, fair, or poor) was assigned to each animal based on the kidney fat index (Riney, 1955) and percent femur marrow fat (Warren and Kirkpatrick, 1982).

Necropsy procedures in general followed the methods of Prestwood et al. (1970, 1975, 1976). Rumen contents were brought to a 10,000-ml volume, mixed, and a 200-ml aliquot removed for helminth examination. The entire contents from the remainder of the gastrointestinal tract were examined. All helminths recovered were recorded as total counts of individuals. The remainder of the viscera was examined following the methods of Samuel (1979) and Wobeser and Spraker (1980).

Nematodes were fixed in glacial acetic acid, stored in a mixture of 70% ethanol and 5% glycerine, and examined in glycerine wet mounts. Cestodes were fixed in acetic acid–formalin–ethyl alcohol, stained in celestin blue B and mounted in Canada balsam. Representative specimens of helminths recovered in this study have been deposited in the U.S. National Parasite Collection, Beltsville, Maryland 20705, USA (Accession Nos. 77717–77722).

Analytical methods

The terms prevalence, intensity, mean intensity, and abundance follow the definitions of Margolis et al. (1982). Habitat is defined by Whittaker et al. (1973) and in the present study refers to the habitat for the helminth infracommunity (Hobbs, 1976). The relationship between helminth species abundances and the independent variable of host age was examined with Spearman rank correlation coefficients (SAS CORR; Statistical Analysis Systems, 1982, SAS Institute, Raleigh, North Carolina). In this and the following analyses the 86-sample data set was reduced to 84 samples because condition class was not determined for two deer.

Overdispersion is defined by Bliss and Fisher (1953) and in this study refers to frequency distributions of common (>25% prevalence) species of helminths where a few host individuals harbor many helminth individuals and many of the hosts have only a few or no individuals of a particular helminth. Overdispersion was indicated when the mean abundance of helminths was significantly less than the variance based on their frequency distribution (χ^2-analysis) and measured by the negative binomial parameter k (Bliss and Fisher, 1953) which is an inverse measure of the degree of overdispersion. The rank transformation procedure 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 contagiously distributed data set with their ranks (RT-2 of Conover and Iman, 1981; SAS PROC RANK).

Prior to subsequent analysis the six collection periods were combined to winter (January and March 1982), spring (June 1982), summer (August 1981, August 1982) and fall (October 1981) season classes. Also, the four physical condition classes were combined to (1) optimal (excellent to good), (2) transitional (fair), and (3) suboptimal (poor) physical condition classes.

The main and interactive effects (Box et al., 1978) of the two independent variables of season and host physical condition were examined with a factorial ANOVA and subsequent MANOVA for each of the three common species of helminths and across the collective helminth fauna of these common species (dependent variables), respectively (PROC GLM, SAS). Three combinations of factors influencing the distribution of individual species of helminths and the collective helminth fauna were possible (season, condition, and season–condition). The relative importance of specific factors (main and/or interactive effects) was determined from the relative magnitudes of the total variance accounted for in that factor by ranking the values of the F statistics (for significant relationships only) generated across all combinations of the three independent variables (Tabachnick and Fidell, 1983).

Use of the terms significant or significantly in this study refers to statistical significance at $P < 0.05$. Copies of the raw and/or rank transformed data sets are available on request from Danny B. Pence.

RESULTS

The helminth fauna

Six species of gastrointestinal nematodes (*Haemonchus contortus* (Rudolphi, 1803); *Gongylonema pulchrum* (Molin, 1857); *Oesophagostomum venulosum* (Rudolphi, 1809); *Ostertagia ostertagi*

TABLE 1. Prevalences, intensities, and abundances of helminths in 86 adult female white-tailed deer from the YO Ranch, Kerr County, Texas.

Species of helminth	Prevalence: No. infected/no. examined	Prevalence: %	Intensity: $\bar{x} \pm$ SE	Intensity: Range	Abundance: $\bar{x} \pm$ SE	Abundance: Total no. individuals
Haemonchus contortus (A)[a]	53/86	62	105 ± 26	1–1,062	64.60 ± 16.80	5,559
Ostertagia ostertagia (A)	4/86	5	1 ± 0	1	0.05 ± 0.07	4
Apteragia odocoilei (A)	9/86	11	13 ± 7	1–47	1.30 ± 0.70	114
Cooperia sp.[b] (A)	1/86	1	2 ± 0	2	0.02 ± 0.07	2
Oesophagostomum venulosum (LI, C)	24/86	28	7 ± 2	1–27	1.80 ± 0.50	157
Gongylonema pulchrum (E, T)	74/86	86	13 ± 2	1–79	11.00 ± 2.00	947
Moniezia sp. (SI)	1/86	1	1 ± 0	1	0.01 ± 0.07	1
Taenia hydatigena (P, L, M)	6/86	7	1 ± 0.3	1–3	0.09 ± 0.07	8

[a] A = abomasum, E = esophagus, T = tongue, LI = large intestine, C = cecum, L = liver, M = mesentery, SI = small intestine, P = lungs.

[b] Immature female.

(Stiles, 1892); *Apteragia odocoilei* (Dikmans, 1931); and *Cooperia* sp.) and two cestodes (*Moniezia* sp. and *Taenia hydatigena* (Pallas, 1766)) were recovered. The prevalence, intensity and abundance data for these species are listed in Table 1.

Eighty-two of 86 (95%) white-tailed deer were infected with one to four ($\bar{x}$ = 2.1) species of helminths. There were 25, 29, 23 and five hosts with one, two, three and four species of helminths, respectively. A total of 6,792 individual helminths were recovered. Intensities varied from one to 1,097 ($\bar{x}$ = 80.2).

Patterns of dispersion of helminths

For each of the common species of helminths (*H. contortus, O. venulosum,* and *G. pulchrum*) the variance was significantly larger than the mean as determined from frequency distributions of numbers of individual helminths in each of the 84 hosts (Table 2). This is characteristic of an overdispersed distribution (Bliss and Fisher, 1953). The negative binomial parameter, k (Bliss and Fisher, 1953), was an inverse measure of the degree of overdispersion. This was very low in *H. contortus* and *O. venulosum,* indicating a high degree of aggregation of helminths within the host population (Table 2).

Deer ages ranged from 15 to >87 mo ($\bar{x}$ = 55). Mean ages for the six collection periods from August 1981 through August 1982 were 69, 41, 53, 63, 48, and 55 mo, respectively. Rank abundances of two of the three common species of helminths, *H. contortus* and *G. pulchrum,* were significantly correlated with age ($P < 0.05$; $r = 0.24$ and 0.26, respectively). Rank abundances decreased with increasing age. Unfortunately, the apparent relationship of helminth abundances with host age was not further examined because (1) young animals (especially fawns) could not be collected on the study area and (2) there was no apparent biologically meaningful reason for age differentiation of animals >15 mo of age. Consequently, in the following analyses from the 84-sample data set, all hosts were treated as reproductively mature adult females.

Host physical condition was highly correlated with the season of collection (Table 3). Deer collected in the winter and early spring (January and March) were in optimal (21/27) or transitional (6/27)

TABLE 2. Determination of overdispersion and measure of the degree of aggregation in three common species of helminths from adult female white-tailed deer in the Texas Edwards Plateau based on the frequency distribution of numbers of individuals of each species of helminth from the 84-sample data set.

Species of helminth	Mean/variance ratio	k
Haemonchus contortus	1:376[a]	0.17
Oesophagostomum venulosum	1:12[a]	0.16
Gongylonema pulchrum	1:17[a]	0.69

[a] Variance significantly larger than mean, $P < 0.05$, χ^2 analysis.

TABLE 3. Number of adult female white-tailed deer from the Texas Edwards Plateau collected in each of three condition classes across four seasons.

Season	Condition class: Optimal	Transitional	Suboptimal	*n*
Winter	21	6	0	27
Spring	0	3	11	14
Summer	0	3	25	28
Fall	1	11	3	15
n	22	23	39	

stages of physical condition. By the end of spring (as reflected in the June collections) these deer were in suboptimal (11/14), or in a transitional stage (3/14) presumably progressing toward this physical condition state. Collections in the summer of 2 yr (August 1981, 1982) indicated that most deer were in suboptimal condition (25/28) or approaching that state (3/28). By fall as reflected in the October collection it appeared that most deer were in a transition stage (11/15) from the summer suboptimal physical condition (3/15 remained in this category) toward the optimal condition (1/15) achieved during the winter months.

In order to examine the main and interactive effects of the extrinsic and intrinsic variables, the 84-sample data set of rank abundances of three common species of helminths was divided in a fashion that allowed all possible combinations of the three host conditions and four season variables (Table 4). Because host condition was highly correlated with season of collection there were empty cells in certain levels of this 3 × 4 factorial design. Thus, there were nine of 12 total combinations of these variables. Deer in the categories of suboptimal condition in winter, optimal condition in spring, and optimal condition in summer were not collected. A factorial ANOVA and subsequent MANOVA determined main and interactive effects of the intrinsic variable of host condition and the extrinsic variable of season on the rank abundances of each of the three common species of helminths and across the collective helminth fauna of the three common species of helminths, respectively.

Effects of habitat variables

Results of the MANOVA indicated that the main effect of a single significant factor, season, contributed to overdispersion across the collective population of three common species of helminths (Table 5). With the factorial ANOVA, overdispersion could not be attributed to factors resulting from the action of either of the independent variables (host condition and season) in one of the three common helminth species, *G. pulchrum* (Table 5). The rank abundances of both *H. contortus* and *O. venulosum* varied across the main effect of season, but not across the main effect of host condition or the interactive effects of these two variables (Table 5). From Table 4 the average rank abundances of *H. contortus* and *O. venulosum* were much higher in summer irrespective of condition class. Likewise, the lowest rank abundances occurred in winter, with rank abundances of both species somewhat intermediate between these extremes during the spring and fall.

DISCUSSION

All species of helminths recovered in the present study have been reported from

TABLE 4. Average rank abundances of three common species of helminths across the main and interactive effects of four season and three condition classes of adult female white-tailed deer from the Edwards Plateau of Texas.

Habitat variable	*Haemonchus contortus*	*Oesophagostomum venulosum*	*Congylonema pulchrum*	*n*
Season				
Winter	28 ± 4	35 ± 5	45 ± 4	27
Spring	31 ± 4	39 ± 4	37 ± 3	14
Summer	62 ± 6	55 ± 5	49 ± 5	28
Fall	40 ± 5	36 ± 4	33 ± 3	15
Condition				
Optimal	27 ± 2	32 ± 3	43 ± 2	22
Transitional	38 ± 6	37 ± 4	36 ± 4	23
Suboptimal	53 ± 7	52 ± 6	47 ± 5	39
Season–condition				
Winter–optimal	25 ± 4	32 ± 5	43 ± 4	21
Winter–transitional	38 ± 3	42 ± 4	53 ± 5	6
Spring–transitional	24 ± 4	31 ± 4	32 ± 1	3
Spring–suboptimal	33 ± 4	42 ± 4	38 ± 6	11
Summer–transitional	52 ± 3	54 ± 4	20 ± 2	3
Summer–suboptimal	64 ± 6	55 ± 5	52 ± 6	25
Fall–optimal	57 ± 0	31 ± 0	43 ± 0	1
Fall–transitional	39 ± 4	31 ± 4	32 ± 3	11
Fall–suboptimal	41 ± 3	59 ± 4	32 ± 2	3

white-tailed deer in other regions, especially in the southeastern United States (Prestwood et al., 1970, 1973; Prestwood, 1971; Prestwood and Ridgeway, 1972; Pursglove et al., 1976). However, in white-tailed deer from the Texas Edwards Plateau there were fewer species comprising the helminth fauna, especially abomasal trichostrongyles, compared to the above and other studies from southern Texas (Glazener and Knowlton, 1967; Foreyt and Todd, 1972; Foreyt and Samuel, 1979). The lack of diversity in the helminth community of white-tailed deer from the Texas Edwards Plateau is of particular interest because the deer share common range with a much larger number of domestic and exotic ungulate species compared to other regions where the helminth fauna of white-tailed deer has been delineated. In the nearby Texas Panhandle, the net severity of environmental factors (low rainfall, high temperatures in summer, high evapotranspiration rates) are suggested as the reason for the disparity of helminth species recovered from sympatric mule deer (*Odocoileus hemionus* (Rafinesque)) and Barbary sheep (Gray et al., 1978). Similar conditions prevail in the semiarid environment of the study area in the Texas Edwards Plateau which probably explains the absence of several trichostrongylid species commonly found in white-tailed deer from the warmer, wetter environments of southern Texas and the southeastern United States.

The gastrointestinal nematode fauna was dominated by only three species (*H. contortus*, *O. venulosum*, and *G. pulchrum*) at >25% prevalence in the white-tailed deer from the Texas Edwards Plateau. While *Cooperia* sp., *A. odocoilei*, and *O. ostertagi* are considered pathogenic at high abundances in white-tailed deer (Prestwood and Pursglove, 1981), the prevalences of these species were very low (<11%) and they are considered to be of little consequence to the welfare of the

TABLE 5. MANOVA and factorial ANOVA generated F values from main and interactive effects of host physical condition and season factors across the 84-sample data set of rank abundances for three common species of helminths from white-tailed deer in the Edwards Plateau of Texas.

Factor	MANOVA[a]	Factorial ANOVA[b]		
		Haemonchus contortus	*Oesophagostomum venulosum*	*Gongylonema pulchrum*
Season	2.0[c]	17.4[c]	8.1[c]	1.9
Condition	0.9	1.0	3.0	1.3
Season–condition	1.2	0.9	1.1	1.2

[a] df = 3,75.
[b] df = 8,75.
[c] $P < 0.05$.

deer herd in the Texas Edwards Plateau. Although *O. venulosum* is not a deer pathogen, it is considered to be pathogenic in sheep and cattle (Levine, 1980; Prestwood and Pursglove, 1981). Similarly, infections with *G. pulchrum* are considered inconsequential in white-tailed deer in view of their apparent nonpathogenicity (Prestwood and Pursglove, 1981).

Haemonchus contortus was the only abundant pathogenic abomasal nematode (Prestwood and Kellogg, 1971) recovered in the present study. Of the nine ubiquitous species of stomach worms with direct life cycles (Eve and Kellogg, 1977) infecting about 98% of the white-tailed deer in the southeastern United States (Eve, 1981), *H. contortus* was the only common (>10% prevalence) species found in the deer herd from the Texas Edwards Plateau. It has been indicated that (1) *H. contortus* is pathogenic in white-tailed deer and that pathogenicity is density-dependent, (2) that first winter fawns are particularly vulnerable to a haemonchosis/malnutrition syndrome, and (3) that this nematode may function to regulate host population growth rate in certain deer herds in the southeastern United States (Davidson et al., 1980). The impact of *H. contortus* on the white-tailed deer herd in the Texas Edwards Plateau is difficult to assess. While the mean abundance of >200 nematodes in these deer is somewhat below that level of near 1,000 (75 nematodes/kg body weight) where pathogenic effects become detectable (Davidson et al., 1980), it should be noted that in four of 15 deer collected during one August period *H. contortus* intensities ranged from 487 to 1,062. Additionally, all deer collected in the present study were >15 mo of age, well past the time during the first year of life when immunologically naive fawns first subjected to environmental and nutritional stresses in the early fall would be expected to (1) harbor many times the number of nematodes found in adults of the herd and (2) demonstrate pathogenic effects based on smaller body weight and higher nematode intensities. Since the fawning season in this region is June–July (Waid, unpubl. data), which is the period of poorest nutritional condition for adult female deer, the just-weaned summer fawns could acquire and carry heavy infections of *H. contortus* through the late fall and early winter. Whether a haemonchosis/malnutrition syndrome develops during this period in these fawns remains conjectural. Unfortunately, we could not collect deer <1 yr of age from the study area.

The potential for white-tailed deer to serve as reservoirs of helminths for other domestic and exotic species seems to be somewhat limited on this ranch. The abundances of *Moniezia* sp., *T. hydatigena*, *Cooperia* sp., and *O. ostertagi* were very low (<6% prevalence). Additionally, white-tailed deer are considered to be poor reservoirs for *O. ostertagi* (McGhee et al., 1981). *Apteragia odocoilei* appears to be specific for the Cervidae. *Gongylonema pulchrum* appears to be non-pathogenic for other ruminants as well as white-tailed deer (Levine, 1980). Of the two remaining abundant species, both *H. contortus* and *O. venulosum* are pathogenic in domestic and probably exotic ruminants (Levine, 1980; Prestwood and Pursglove, 1981). However, extreme variability is exhibited by homologous and heterologous strains of *H. contortus* across various host species. Therefore, we concur with the conclusion of Prestwood and Pursglove (1981) that any conclusions regarding reservoir status of white-tailed deer are purely speculative until more precise data on the infectivity and pathogenicity of strains of *H. contortus* are available for domestic and wild ruminant species.

When analyzed for main and interactive effects, season was the only independent variable that had a significant main effect on the abundances of *H. contortus* and *O. venulosum*, but not on *G. pulchrum*. Although the independent variable of host condition did not significantly affect the abundances of these species of helminths when treated as a main effect, or as an interactive effect with season, average rank abundances of both *H. contortus* and *O. venulosum* were higher when most deer were in suboptimal condition. This, however, corresponded to the summer season when average rank abundances of both helminths were highest and the decrease in host condition during this period probably resulted from the physiological stress placed on female deer well into the lactation phase of the reproductive cycle. While season and host physical condition are somewhat overlapping variables, season was the only significant variable which influenced the aggregation of numbers of individuals in two of the three common gastrointestinal helminths in white-tailed deer from the Edwards Plateau of Texas.

Mean abomasal parasite counts (APC's), primarily *H. contortus*, for both August collections and the October collection were <300. This was well within the range suggested by Eve (1981) to indicate suboptimum deer densities in the southeastern United States. However, Rollins (1983) estimated white-tailed deer densities on the YO Ranch at one per 5 ha. Additionally, dietary habits of these deer appeared to reflect a habitat that was overgrazed (Waid, 1983). This is supported by the ranch's history of moderate to heavy stocking rates with several species of livestock and exotics under a continuous system of grazing. This disparity indicates that APC's are not a sensitive indicator of deer herd welfare on the YO Ranch. Eve (1981) indicated that caution should be exercised in the use of APC's for monitoring deer herd condition in areas other than the southeastern United States. Results of the present study concur with the findings of Moore and Garner (1980) that APC values and physical condition of desert mule deer, *O. hemionus hemionus* (Rafinesque), from the Trans Pecos of Texas (1) were not related in a manner reported for white-tailed deer in the southeastern United States and (2) that the value of APC's for determining herd status was questionable for deer in the arid regions of southwest Texas.

There are many reasons why APC's may not be reflective of overall herd condition, but these may be related particularly to the overdispersed distribution of many, if not most, populations of helminths. Anderson (1978) reviewed the evidence for aggregation in parasite populations and provided theoretical evidence that overdispersion was probably the rule rather than the exception in most parasite populations. More recent studies on the helminth faunas of many host species have confirmed this hypothesis (Anderson, 1982) and there appear to be many extrinsic and intrinsic variables acting as main or interactive effects to generate overdispersion (Pence and Windberg, 1984). The most frequently examined variables include host age, sex and physical condition and the extrinsic variable of season, which acts across the collective host population. In addition to physical condition, the above variables (age, sex, and season) when treated as main effects are well documented as factors that influence abomasal helminth abundances in deer (Baker and Anderson, 1975; Eve and Kellogg, 1977; Foreyt and Samuel, 1979; Davidson et al., 1980; Moore and Garner, 1980; Demarais et al., 1983).

Results of previous studies on the structure of the helminth community in other hosts (Pence and Windberg, 1984) suggest the importance of considering the interactive as well as main effects of various important intrinsic and extrinsic variables which delineate host subpopulations on the abundances of the various helminth species comprising that community. The original interpretation of Eve and Kellogg (1977) that only adult deer collected in late spring through early fall should be used to evaluate deer herd condition based on APC's suggests that at least the factors of host age across seasons influence the abundance of abomasal helminths. This was in part substantiated by Couvillion (1981) who found dramatic and erratic declines in abundances of helminths in deer collected in fall and winter and by Demarais et al. (1983), who demonstrated that the sample sizes required to adequately reflect host physical condition based on APC's far exceeded those based on body measurements of white-tailed deer collected in winter in Mississippi. Obviously, the net action of these, and perhaps other intrinsic and extrinsic variables, are contributory to the high variability observed in data sets of APC's across a particular deer herd. Until the patterns of distribution of each common species of helminth across all possible host subpopulations (as delineated by main and interactive effects of meaningful independent habitat variables) are determined for deer from a specific geographic region, there is little quantitative basis for selecting a particular host subpopulation in which abundances of all, or selected species of, abomasal helminths could serve to monitor herd condition at limited host sample sizes in which there is low variability in helminth abundances across the sample.

There are many reasons for diversity in species and numbers of individuals in a helminth fauna across the geographic range of its host (Pence et al., 1983). The few species and low abundances of abomasal helminths in white-tailed deer in the present study and in mule deer from the Texas Panhandle (Gray et al., 1978) and the Texas Trans Pecos (Moore and Garner, 1980) further restricts the use of APC's as an indicator of herd condition. *Haemonchus contortus* was the predominant, or only, abomasal helminth recovered in these studies. The unstable to erratic environmental conditions, especially precipitation, characteristic of these semiarid to arid regions are not conducive to trichostrongylid life cycles and transmission. This is undoubtedly contributory to the considerable variability observed in helminth abundances both between and within years and to the disparity of species of helminths from deer in these regions. Thus, climate is probably a major factor responsible for the incongruence of APC's and physical condition observed in deer from west Texas.

It should be emphasized that our study area, the YO Ranch, is somewhat atypical of many ranches in the Texas Edwards Plateau and, especially, the Texas Parks and Wildlife Department's Wildlife Management Areas, in terms of (1) stocking rates of both domestic and exotic species and (2) overgrazing. Also, range management practices may vary dramatically across adjoining ranches. However, heavy stocking rates with domestic sheep and goats and continuous overgrazing are common in this region. Therefore, we feel that results of the present study can be extrapolated to deer herds on many ranches in the Texas Edwards Plateau.

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