An Evaluation of Hunter-Killed White-Tailed Deer for Abomasal Parasite Count (APC) Studies

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Abstract: Abomasal parasite counts (APC) were determined on 467 white-tailed deer (*Odocoileus virginianus*) collected in summer and 436 deer collected in fall from 50 localities in the Southeast. APC values declined from summer to fall region-wide. Declines in APC values began on most areas in Mountain and Piedmont provinces by October and November, respectively; and in the Coastal Plain province declines in APC values began in November. These differences in the timing of declines in APC values precluded establishment of region-wide guidelines for interpretation of fall APC values. Since APC values did not decline until November in Coastal Plain and Piedmont provinces, the sampling period for APC studies can be extended into October in these provinces. Abomasal parasite counts performed in October or later in the Mountain province and in November or later in Piedmont and Coastal Plain provinces are lower than summer APC values and should be interpreted with caution.

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The Abomasal Parasite Count (APC) is used in the Southeast to obtain data on which management decisions for white-tailed deer (*Odocoileus virginianus*) are based (Eve and Kellogg 1977). Eve and Kellogg (1977) delineated the concept of the APC technique and established guidelines for interpretation of APC values. APC data can be obtained rapidly and are especially useful for gaining public support for management recommendations (Monschein 1977, Jeter 1979).

Requisite to the APC method are special summer deer collections which are expensive and sometimes objectionable to hunters or other lay groups. Use of hunter-killed deer for APC studies, therefore, would be desirable. Thus the purpose of this study was to compare summer and fall APC values in view of modifying the APC technique for use on hunter-killed deer.

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Methods

Between July 1967 and March 1981, paired deer collections were conducted on 50 localities in 3 physiographic provinces in 9 southeastern states. Twenty-three sites were located in the Coastal Plain, 9 in the Piedmont, and 18 in the Mountains (Soil Conserv. Serv. 1976). APC data were obtained during summer and fall during the same year at each locale. Multiple paired collections were made at 21 locations, thus providing 78 paired collections for comparison.

Where feasible, 5 adult deer comprised the sample from each location. As many as 15 deer were obtained in some samples, but in other instances <5 animals were available. Abomasums were collected from deer shot at night and from deer delivered to hunter checking stations.

During summer, most deer collections were performed from mid-June through early September; however, 1 collection was performed in mid-September and one in early October. During hunting seasons, deer collections were performed from October through December except for 5 collections performed from January through March. These latter 5 collections were treated as fall collections.

Abomasal parasites were collected and enumerated by standard methods (Prestwood et al. 1973, Eve and Kellogg 1977, Nettles 1981).

Individual deer parasite counts were transformed [transformed number = $\log_{10}$ (observed number + 1)] to approximate a normal distribution. Calculations were performed on $\log_{10}$ of arithmetic means of parasite numbers for the collections, that is, on $\log_{10}$ APC values.

Statistical analyses as available from Statistical Analysis Systems, General Linear Models Procedure (Barr et al. 1979) were utilized as follows to compare summer and fall APC values. 1. A "split plot" design analysis of variance (ANOVA) with physiographic province as the "whole plot" effect and comparison of mean summer abomasal parasite burden and mean fall abomasal parasite burden as the "split plot" effect was used to test differences in APC values between seasons. The term abomasal parasite burden is used here to avoid confusion with the term APC which includes a specification for a specific locale as defined above. The term APC should not be applied to a heterogeneous area as large as a physiographic province. 2. A paired *t* test was used to compare mean summer abomasal parasite burden and mean fall abomasal parasite burden for each physiographic province separately. 3. Linear regression of summer APC (dependent variable) on fall APC was performed to determine the relationship between summer and fall APC, and covariance analysis was used to ascertain differences between regressions for the 3 physiographic provinces. 4. Linear regression was used to determine if the relationship between summer and fall APC varied with month of fall collection; in this case fall collections were divided into 3 groups, namely, October, November, and December–March, and comparisons of summer versus fall APC were made between the groups. 5. Linear regression and covariance analysis were used to determine region-wide differences between summer and fall abomasal parasite burden by sex. In these analyses only 54 collections were available for comparison because some collections contained deer of only 1 sex.

Additionally, the percentage change and mean percentage change in APC values from summer to various months of fall collection, namely, October, November, December–March, were computed for each area within each physiographic province. A paired *t* test was used to compare changes in APC values between summer and each month of fall collection for each physiographic province separately.

Results

Abomasal parasite burdens were determined on 467 deer collected in summer and 436 deer collected during fall. Eight species of abomasal parasites were found as follows: *Apteragia odocoilei, A. pursglovei, Haemonchus contortus, Ostertagia dikmansi, O. mossi, Trichostrongylus askivali, T. axei,* and *T. dosteri.* Detailed data can be obtained from Couvillion (1981).

Log_{10} transformation of individual deer parasite counts reduced the data to a normal distribution. Transformation reduced the coefficient of skewness from 3.86 to −0.86, and the coefficient of kurtosis was reduced from 25.38 to 3.86.

For the southeastern region, the arithmetic mean summer abomasal parasite burden ($\bar{x} = 1100$) was greater ($P < 0.01$) than the mean fall abomasal parasite burden ($\bar{x} = 783$); however, the magnitude of the difference between the means for the 2 seasons varied among physiographic provinces (Table 1). There was no difference between mean summer and mean fall abomasal parasite burden in the Coastal Plain ($P > 0.05$), but the summer abomasal parasite burden was higher than the fall abomasal parasite burden in Piedmont ($P < 0.05$) and Mountain ($P < 0.01$) provinces.

Regression analysis revealed a positive relationship between APC for the 2 seasons ($P < 0.01$). However, little of the variability in summer APC was explained by the linear regression model ($r^2 = 0.18$).

The relationship between summer and fall APC did not change significantly with month of fall collection when comparisons were made on a region-wide basis. When changes in APC values from summer to various months of fall collection were examined within each physiographic province, however, APC values declined in different temporal patterns during the interval from summer to December–March (Table 2).

In the Coastal Plain, October APC values generally were greater ($P < 0.05$) than summer APC values, but there was no difference ($P > 0.05$) between November and summer APC values. December–March APC values were lower ($P < 0.01$) than summer APC values in the Coastal Plain province. In the Piedmont province, there was no difference ($P > 0.05$) between October and summer APC values, but November APC values were lower ($P < 0.05$) than summer APC values. There was no difference ($P > 0.05$) in December and summer APC values in the Piedmont province. In the latter case, the small sample size limited the value of the statistical test. In the Mountain province, there was no difference ($P > 0.05$) between October and

Table 1. Overall Mean Summer and Fall Abomasal Parasite Burdens of White-Tailed Deer (*Odocoileus virginianus*) in 3 Physiographic Provinces in the Southeastern United States (1967–1981)

Physiographic Province	Abomasal Parasite Burden		Difference (Summer–Fall)	Fall Burden/ Summer Burden
	Summer	Fall		
Coastal Plain	989	891	98	0.89
Piedmont	1,320	978	342	0.74
Mountain	1,180	603	577	0.51

Table 2. Percentage Change of Abomasal Parasite Counts (APC) from Summer to Various Months of Fall Collection (October, November, December–March) in the Coastal Plain, Piedmont, and Mountain Physiographic Provinces

Coastal Plain	Piedmont	Mountain
	October	
+358[a]	+89[a]	+25
+212	+75[a]	− 7
+147	+30	−13
+ 61	+23	−24
+ 45	+ 5	−65[a]
+ 23	−28[a]	−68[a]
− 13		
− 28		
Avg. +101	Avg. +32	Avg. −25
SD[b]	NSD[c]	NSD
	November	
+121[a]	+11	− 5
+ 55[a]	− 5	−10
+ 47	−41[a]	−19
+ 29	−42	−20
+ 21[a]	−50[a]	−26
+ 16	−65[a]	−28
+ 5		−44[a]
+ 4		−45[a]
+ 4[a]		−50
− 25		−53[a]
− 31[a]		−57[a]
− 37		−63[a]
− 44		−63[a]
− 51[a]		−65[a]
− 52		−66[a]
− 62[a]		−66[a]
− 64[a]		−69[a]
− 71[a]		−73[a]
Avg. − 8	Avg. −32	Avg. −46
NSD	SD	SD
	December–March	
− 5[a]	−42[a]	−29
− 19	−77[a]	−33[a]
− 25		−43
− 25		−68[a]
− 41[d]		−69[a]
− 57[d]		
− 58[a]		
− 60[a]		
− 71[a]		
Avg. − 42	Avg. −60	Avg. −48
SD	NSD	SD

[a] Exhibited change in APC category.
[b] SD = Summer and fall APC significantly different ($P < 0.05$).
[c] NSD = Summer and fall APC not significantly different ($P > 0.05$).
[d] "Summer" collection conducted in October.

summer APC values, but November and December–March APC values were lower ($P < 0.01$) than summer APC values.

There was no difference ($P > 0.05$) in abomasal parasite burdens between male and female deer.

Discussion

Several facets of this study that are in agreement with previous APC studies merit brief mention. First, the data reaffirm the need for transformation of abomasal parasite data for application of standard statistical tests. Second, analyses did not reveal differences in abomasal parasite burdens between male and female deer. Third, the seasonal decline in abomasal parasite burdens is compatible with previous studies of seasonal variations in APC values of white-tailed deer (Baker 1974, Eve and Kellogg 1977, Taylor 1977).

Since deer herd densities were roughly equal for the 2 seasons in each collection site, other variables which affect parasite survival, transmission, and establishment must account for seasonal differences in APC values. Climatic changes which reduce the number of infective larvae present and/or inhibit larval development, and seasonal changes in host resistance as a result of improvement in deer nutrition probably are of primary importance.

Climatic factors determine: (1) the proportion of eggs which become infective larvae; (2) whether and how rapidly larval development occurs; and (3) the longevity of larvae. Two factors, temperature and precipitation, are of particular relevance to the free-living phase of the life cycle of abomasal trichostrongyles (Michel 1969).

The limits for optimum pasture transmission of *Ostertagia* spp. are 5cm (2 inches) or more precipitation and a mean monthly mean temperature of 6 to 20 C (43–68 F) (Levine 1963). For the Southeast, total precipitation averages 5–10 cm (2–4 in.) in October and November and 10–20 cm (4–8 in.) in July and August (Environ. Sci. Serv. Admin. and Environ. Data Serv. 1968). Development and transmission of trichostrongyles may be diminished by this lowered fall precipitation even though the level of precipitation is within the range cited by Levine.

Temperatures below the range for optimum transmission occur in all physiographic provinces during fall. The mean date of first autumn freeze occurs from early- to mid-November in the Coastal Plain (Environ. Sci. Serv. Admin. and Environ. Data Serv. 1968), thus optimum conditions for parasite survival and transmission probably are present beyond late summer in this province. In contrast, the mean date of first autumn freeze occurs 1–3 weeks earlier in the Piedmont and Mountain provinces. Thus in these provinces the period for optimum parasite survival and transmission probably is shorter. Decreases in APC values in deer in the Southeast from summer to fall probably are closely related to decreases in temperature and to a lesser degree decreases in precipitation during fall.

Environmental factors, especially low temperatures, also are important in the phenomenon of *in vivo* 4th stage larval inhibition (Michel 1974). When a stimulus for arrested development of *O. ostertagi* (chilling of 3rd stage larvae at 4 C) is applied for 3 weeks, more than ⅓ of the infective larvae will be arrested, and after ≥8 weeks at this temperature the proportion of arrested larvae rises to ⅔ (Dunn 1978). In white-tailed deer in Canada, Baker (1974) deduced that *A. odocoilei, O. dikmansi,* and *O. mossi* exhibited arrested development during winter months when the mean monthly maximum temperature was less than 10 C (50 F). During the period when populations of inhibited larvae increased there was a concomitant decrease in adult nematode burdens. Probably, the inhibition phenomenon occurs in certain regions of the Southeast where fall temperatures are low enough to induce larval inhibition. To some degree, the differences between summer and fall abomasal parasite burdens in the Southeast probably are related to seasonal larval inhibition.

An additional variable which probably affects APC values is the seasonal change in nutritional status of deer herds. The relationship between host nutrition and level of parasitism is such that deficiencies in host diet have the effect of rendering the host more vulnerable to parasitic infections (Cameron 1956, Noble and Noble 1971). Michel (1969) noted that nematode populations were influenced by development of host resistance and implied that seasonal changes in nutritional status could compromise host resistance to nematode infections.

In the Southeast, late summer/early fall is a critical period for deer because the quality of forage wanes from spring through summer as browse plants mature. Vegetation progressively declines in digestibility and nutritive value (Quicke and Bentley 1959, Eve and Kellogg 1977). During late summer resistance to nematode infection probably declines concomitantly with the nutritional status of deer. In contrast, as the nutritional status of deer improves during fall with onset of mast availability resistance to nematode infection probably increases.

Because the timing of declines in APC values is not uniform throughout the Southeast, region-wide guidelines for interpretation of fall APC data are not appropriate. In addition, even though declines were uniformly present during December–March, the magnitudes of declines were highly variable (−5% to −77%) further precluding development of useful region-wide fall or winter guidelines.

Since APC values did not decline during October in Coastal Plain or Piedmont provinces, the sampling period for APC studies may be extended into October in these provinces. However, current guidelines for interpretation of APC values should not be used in these regions in November or afterwards because APC values are decreasing. Further, low APC values (<1500) in October should not be used to make management recommendations for deer harvests in the Mountain province because pronounced declines are expected by that time.

Winter APC determinations additionally are advantageous for evaluating deer herds where haemonchosis is suspected. When *H. contortus* are found in adult deer in overpopulated deer herds losses of fawns to haemonchosis may be occurring (Davidson et al. 1980).

This study indicates that hunter-killed deer can be used for APC studies with constraints discussed herein. Although fall APC data are not as uniformly applicable throughout the Southeast as late summer APC data, use of hunter-killed deer for APC studies has certain economic and public relations advantages. When judiciously applied, fall APC studies can be a valid tool for deer herd health assessment programs in the Southeast.

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