The Prevalence of Two Common Internal Parasites in White-tailed Deer With and Without Significant Interaction With Domestic Sheep

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ABSTRACT: The objective of this study was to evaluate the prevalence of two internal parasites (strongylate nematodes and *Nematodirus spp*.) in white-tailed deer (*Odocoileus virginianus*) sharing a home range with domestic sheep (*Ovis aries*), compared to deer likely having minimal contact with sheep. Fecal samples were collected from sheep (n=75), deer (n=99) within 300m of the sheep center, and deer (n=98) located 1.3km away from the livestock center, over a 7-week period during the summer. Sheep had the highest ($p<.001$) number of strongylate eggs (1,212.7 ± 2.8/g) compared to deer near the livestock facility (13.9 ± 0.3/g) or deer located away from the sheep center (18.3 ± 0.3/g). Eggs of *Nematodirus spp.* were greater ($p<.001$) in sheep (33.7 ± 0.5/g) compared to deer samples collected near the sheep center (5.1 ± 0.2/g) and deer away from the sheep facility (3.0 ± 0.1/g). Additionally, strongyle and *Nematodirus spp.* egg counts were different ($p<0.001$) in the fecal samples collected from deer residing closer to the sheep facility compared to those located farther away. Results of this study suggest the interactions of white-tailed deer and domestic sheep does not influence the prevalence of these internal parasites within the deer.

KEY WORDS internal parasites, sheep, white-tailed deer

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INTRODUCTION

Strongylate nematodes representing at least three superfamilies, Ancylostomatoidea, Strongyloidae and Trichostrongyloides, are among the most characterized gastrointestinal tract (GIT) parasites studied among ruminants (Hoberg et al. 2001). While variation in life cycles of parasites exist, typically eggs passed through the feces of the host animal species hatch into the larvae stage. Following a period of development the infective larvae stage are present on forages consumed by a host animal. Adult parasites typically attach and feed upon the mucosal lining of a specific region of the gastrointestinal tract depending upon species (Cotter 2018, Thamsborg et al. 2016).

Gastro-intestinal parasitism is one of the most common infections in livestock.

Parasitic infection in sheep cause substantial decrease in meat, milk, and wool production (Coulson et al. 2018). In an extensive review of studies, sheep infected with nematodes collectively had 15% lower weight gain, 10% reduction in wool production, and 22% lower milk yield (Mavrot et al. 2015). Losses to the sheep and cattle industry in Australia exceed $1 billion annually (Roeber et al. 2013). The extensive use of anthelmintic drugs to control GIT parasites has resulted in resistance of various nematode species (Chintoan-Uta et al. 2014, Shalaby 2013). Continuous grazing of parasite infected areas as well as parasite resistance to anthelmintic drugs further complicates control of strongylate nematodes in sheep and goats (Singh et al. 2017).

The presence of over 29 strongylate nematodes and an additional four groups at the genus level have been documented in the GIT of white-tailed deer (Campbell and VerCauteren 2011, Hoberg et al. 2001, Prestwood et al. 1976). While most deer present limited clinical signs (Davidson 2006), animals experiencing haemonchosis are usually fawns characterized with numerous GIT parasites (Davidson et al. 1980, Prestwood and Kellogg 1971). While significant literature exists, lack of standardization in parasite egg evaluation (Paras et al. 2018, Dryden et al. 2005), necropsy techniques, identification and taxonomy of species (Brooks and Hoberg 2000) remain challenges when working with wildlife species.

While domestic sheep and white-tail deer share numerous strongylate nematode species, work conducted in West Virginia (Prestwood et al. 1976) and in the Southeastern United States (Pursglove et al. 1976) suggest the parasites observed are distinctive and host specific species. McGhee and coworkers (1981) suggested similarity in morphological characteristics of at least one common parasite (*Haemonchus contortus*) indicates deer, cattle and sheep are infected with the same organism. Direct transmission of *H. contortus* between deer and domestic sheep in the United Kingdom has been accomplished (Chintoau-Uta et al. 2014). The concept of many strongylate nematodes being identified as generalists, capable of infecting a number of domestic and wild ruminants has been reported (Winter et al. 2018, Walker and Morgan 2014).

It was hypothesized that white-tailed deer with home ranges encompassing a confined flock of domestic sheep would have a higher GIT parasite load compared to deer with home ranges not likely encountering the sheep. Therefore, the objective of this study was to determine the prevalence of eggs from two GIT parasites (strongylate nematodes and *Nematodirus spp*.) in white-tailed deer sharing a home range with a flock of domestic sheep compared to deer likely having minimal contact with the domestic livestock species.

STUDY AREA

This study was conducted on the main college campus located within the 1,215ha Berry College Wildlife Refuge (BCWR) of the 11,340ha comprising the Berry College Campus in northwestern Georgia, USA. The BCWR had a deer population estimated at 25 deer/km^2 (D. Booke, Georgia Dept. of Natural Resources, pers. comm.). The BCWR was within the Ridge and Valley physiographic province with elevations ranging from 172m to 615m, (Hodler and Schretter 1986). It is characterized by campus-related buildings and facilities for the 2,100 student body, and is interspersed with expansive lawns, hay fields, pastures, woodlots, and large forested tracts managed for timber production.

Fecal samples of sheep were obtained at the Berry College Sheep Center (34º18’09.6"N 85°11’52.7"W). Approximately 100 Katahdin sheep are maintained at this 17ha facility on a year-

round basis. Pastures for grazing consist of fescue (*Schedonorus phoenix*), orchard grass (*Dactylis glomerata*), and Bermuda grass (*Cynodon spp.)* Forested areas surrounding the sheep center include various species of pines (*Pinus spp*.), oaks (*Quercus ssp.)* and hickories (*Carya spp*.). Fencing does not impede deer access to any pastures on the facility. Fecal samples of deer were collected within a 1.7ha area adjacent to the sheep center.

The second deer fecal sample collection site encompassed a 1.8ha area, on the main college campus (34º17'48.9"N 85°11'21.6"W) approximately 1.3km south of the Sheep Center. This area is characterized by the presence of numerous building, roads and parking lots typical of a college campus with expansive lawns containing fescue (*Schedonorus phoenix*), white clover (*Trifolium repens*), and Bermuda grass (*Cynodon dactylon*), extensive areas of horticultural gardens, as well as numerous species of native and non-native trees.

METHODS AND MATERIALS

Fecal samples were collected from deer and sheep weekly, over a 7-week period from 6-11-2018 to 7-27-2018. Random fecal samples (n=10) were collected from mature Katahdin ewes at the Sheep Center, by insertion of two fingers of a latex gloved hand into the rectum and removing 5-10g of material. Following observed defecation, fresh fecal samples (5-10g) were collected weekly from deer (n=10-15) at the two collection sites. The GPS location of each deer fecal sample collected was recorded (IPhone8, Apple Inc., Cupertino, CA) within the respective collection sites.

All fecal samples were placed in sealable plastic bags, refrigerated (5C) and evaluated within 72h of collection. Fecal samples were evaluated by two independent observers to determine the number of strongylate nematodes and *Nematodirus spp.* eggs/g of fecal material using a conventional McMaster's fecal float protocol as described by Vadlejch and coworkers (2011).

Statistical analysis was performed using the Poission distribution function for animal species and location. Wald Chi-Square test was used to test model effects and to compare levels of factors within the model.

RESULTS and DISCUSSION

Sheep had the highest ($p<0.001$) number of strongylate nematode eggs (1,212.7 ± 2.8/g) compared to deer near the livestock facility (13.9 ± 0.3/g) or deer located away from the sheep center (18.3 ± 0.3/g). Eggs of *Nematodirus spp.* were greater ($p<0.001$) in sheep (33.7 ± 0.5/g) compared to deer samples collected near the sheep center (5.1 ± 0.2/g) and deer away from the sheep facility (3.0 ± 0.1/g). Additionally, strongyle and *Nematodirus spp.* egg counts differed ($p<0.001$) in the fecal samples collected from deer residing closer to the sheep facility compared to those located farther away (Table 1).

The home range of deer in the study area has been reported to average 44ha (Gulsby et al. 2011). Thus, it is likely that the two locations selected for collecting deer fecal samples were sufficiently separated to minimize significant interaction among the deer. Results of this study suggest the interactions of white-tailed deer and domestic sheep does not influence the prevalence of these internal parasites within the deer. While differences in parasite numbers between fecal samples of deer from the two sites were evidence, the biological significance may be limited considering the relative low parasitic egg numbers observed.

Table 1: Number of Strongyle and Nematodrius Spp. Eggs Observed in Fecal Samples Collected From Sheep, White-Tailed Deer Near the Sheep Center, and White-Tailed Deer on the Main Campus (1.3 km away)

Parasite	Sheep Sheep Center		White-Tailed Deer Sheep Center		White-Tailed Deer Main Campus	
	n	Mean±SE (eggs/g)	*n*	Mean±SE (eggs/g)	*n*	Mean±SE (eggs/g)
Strongyles	75	1212.7 ± 2.8[a]	99	13.9 ± 0.3[b]	98	18.3 ± 0.3[c]
Nematodirus spp.	75	33.7 ± 0.5[a]	99	5.1 ± 0.2[b]	98	3.2 ± 0.1[c]
Different superscripts within each row differ by (P<0.001)						

The concept of numerous strongylate nematodes being identified as generalists, capable of infecting a number of domestic and wild ruminants (Winter et al. 2018, Walker and Morgan 2014), suggests frequent interaction between deer and domestic sheep could result in higher parasitic infection rates due to cross transmission. However, results of the current study tend to support other findings suggesting these parasites are distinctive and host specific species (Prestwood et al. 1976, Pursglove et al. 1976). While the eggs of these types of parasites are distinctive at the family or genus level, determination of specific species is not feasible using light microscopy (Walker and Morgan 2014, Prestwood et al. 1976).

Sheep subjected to continuous grazing in a confined parasite-infected area create significant challenges in attempting to control or break the life cycle of these parasites (Singh et al. 2017). In addition, the use of anthelmintic drugs may result in parasite resistance, increaseing the difficulty in controlling these types of organisms (Singh et al. 2017, Chintoan-Uta et al. 2014, Shalaby 2013).

Forage selection behaviors generally classify sheep as grazing animals feeding primary on grasses and other low growing plants while deer are browsing animals feeding on a wide variety of plants including forbs, shrub leaves and stems (Shipley 1999). Many plants included in the diet of a deer have been reported to include natural anthelmintic compounds such as tannins (Hoste et al. 2006, Waller et al. 2001). While foraging behavior differs, the fact that deer are often observed browsing within the sheep pastures might suggest differences in natural genetic resistance. Genetic resistance of white-tailed deer to the parasites has been reported (Ditchkoff et al. 2005).

Results of this study suggest that the interaction of white-tailed deer and domestic sheep does not support the concept that either species acts as a reservoir for the other species as related to these internal parasites. Thus, there is not a basis to warrant management practices to eliminate or minimize interaction of these species on the basis of control of these internal parasites.

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