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PREVALENCE OF *PARELAPHOSTRONGYLUS TENUIS* IN WHITE-TAILED DEER IN NORTHERN NEW YORK

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ABSTRACT: The prevalence and distribution of "brainworm" (*Parelaphostrongylus tenuis*) were examined in northern New York (USA) from 1986 to 1989. Sixty nine (46%) of 151 white-tailed deer (*Odocoileus virginianus*) heads examined, contained adult *P. tenuis*. The proportion of infected individuals was not significantly different between males and females. Prevalence was significantly greater in the adult age class as compared to the juvenile age class ($P < 0.01$). Deer pellet samples were examined for prevalence of *P. tenuis*-like larvae. Pellet samples in New York had an overall prevalence of 60%. The effects of precipitation and host density on prevalence of *P. tenuis* in deer was not significant.

Key words: Meningeal worm, *Parelaphostrongylus tenuis*, white-tailed deer, *Odocoileus virginianus*, prevalence, survey.

INTRODUCTION

Parelaphostrongylus tenuis, whose normal host is the white-tailed deer (*Odocoileus virginianus*), causes a syndrome in moose (*Alces alces*) known as moose sickness, which is often fatal (Anderson, 1964). Considerable regional information on the ecology, prevalence and distribution of *P. tenuis* in both deer and moose populations has been accumulated (Anderson, 1963; Dudak et al., 1965; Karns, 1967; Behrend and Witter, 1968; Prestwood and Smith, 1969; Behrend, 1970; Carpenter et al., 1972; Gilbert, 1973, 1974; Thurston and Strout, 1978; Kocan et al. 1982; Brown, 1983; Upshall et al., 1987; Dew, 1988; Thomas and Dodds, 1988).

Moose sickness has been implicated in the decline of moose populations in Nova Scotia, New Brunswick, Maine and Minnesota (Anderson, 1972). However, the specific combination of factors necessary for *P. tenuis* to cause a major moose epizootic is unclear. While it is clear that some moose inhabiting deer range may succumb to moose disease, the long-term coexistence of sympatric moose and deer populations remains uncertain. Currently, both moose and deer populations are thought to be expanding throughout the northeastern United States. This suggests that, at least under present conditions, moose and deer populations can co-exist.

The objectives of this study were to examine ecological factors that potentially control *P. tenuis* infection and to determine the present prevalence and distribution of *P. tenuis* in northern New York (USA) to aid in assessing the feasibility of reestablishing a moose population in that region.

MATERIALS AND METHODS

Field work was concentrated in a 47,000 km^2 region of northern New York, composed principally of the Adirondack Mountains (43°10′ to 45°00′N, 75°55′ to 73°20′E). A total of 151 white-tailed deer and two moose were examined for adult *P. tenuis* from January 1986 to April 1989. Animals were collected from 13 counties and 38 townships in northern New York State. Collections were obtained from fall hunter-killed deer and from deer killed by automobiles, predators and other mortality agents during various times of the year. Heads revealing severe cranial trauma were excluded from the analysis. Both moose examined died of natural causes. One moose died from a systemic bacterial infection and the other from complications resulting from a broken leg.

Examination for adult *P. tenuis* in deer followed methods outlined by Behrend (1970). Heads were examined immediately after collection or held in cold storage until examination could be completed. Sex and age of each animal were recorded in addition to the presence or absence of adult *P. tenuis*. Age was determined using tooth wear and replacement (Severinghaus, 1949). Animals <2 yr of age were classified as juveniles and animals ≥2 yr of age were classified as adults.

When possible, fecal specimens were collected from deer and moose on which cranial examinations were performed. Deer pellets were also obtained from live-captured animals on the Huntington Wildlife Forest (Newcomb, New York 12852, USA) (Mathews, 1989), and from wintering areas throughout northern New York. The majority of the pellets were collected during winter months, off snow.

Pellet samples were frozen until time of examination. All feces were examined for presence of first stage *P. tenuis*-like larvae using the standard Baermann technique. Larvae were identified on the basis of internal and external morphology (Anderson, 1963). First stage larvae of *P. tenuis*, *P. andersoni*, and *P. odocoilei* are indistinguishable. Although *P. andersoni* and *P. odocoilei* have not been reported from this region, we were not confident that all larvae observed were *P. tenuis*. Therefore, in addition to examining deer carcasses for adult *P. tenuis*, portions of the inside and outside loin and thigh muscles from fresh specimens were removed and examined for presence of *P. andersoni* (Pybus and Samuel, 1984).

Statistical Analysis System (SAS Institute, 1985) computer software was used for quantitative analysis. A chi-square goodness of fit test was used to determine significant differences between and among individuals, between seasons and cause of death and between areas where collections were made. Regression analysis was used to examine the effects of precipitation and male deer harvest on prevalence of *P. tenuis*. Statistical significance was determined at $P \leq 0.05$.

RESULTS

Sixty nine (46%) of 151 deer heads examined contained adult *P. tenuis*. The proportion of infected individuals was not significantly different among males (48%) and females (45%). Prevalence was significantly greater ($P < 0.01$) in the adult age class (58%) as compared to the juvenile age class (33%). Fawns (i.e., deer <1 yr of age) had a prevalence of 36%. Twenty (77%) of 26 deer that contained adult *P. tenuis* in the cranium also passed larvae in their feces. Eight deer passed larvae in their feces, but no adult nematodes were found in their cranium. No significant differences were found between infected and uninfected deer with respect to season collected and cause of death. Neither of the two moose examined were infected with adult nematodes.

We examined 2,133 deer and 12 moose pellet samples for the prevalence of *P. tenuis*-like larvae. Deer pellet group collections from 14 counties and 61 townships in northern New York had a prevalence of 60%. Although the distribution of *P. tenuis* was ubiquitous, prevalences varied significantly between townships ($P < 0.01$) ranging from 14% to 88%. Seventy six of 92 (83%) pellet samples collected from live captured deer in the spring were positive for *P. tenuis*-like larvae. *Parelaphostrongylus tenuis*-like larvae were not found in any of the moose pellets examined.

Portions of the loin and thigh muscles from 56 deer were examined for presence of *P. andersoni*. No adult *P. andersoni* or lesions were found in any of the specimens examined.

The effects of precipitation and male deer harvest on prevalence of *P. tenuis* in deer were not significant. Only 3% of the variation in the regression model was explained by these two variables.

DISCUSSION

Data from this study suggest that *P. tenuis* infection in deer has declined in northern New York since the late 1960's. Behrend (1970) reported an overall infection rate of 77% from the same general area, based on cranial examinations. Prevalence in white-tailed deer in our study (46% cranial, 60% pellet) are lower than or equal to all rates reported previously in northeastern North America. Behrend and Witter (1968), Gilbert (1973), Thurston and Strout (1978), Brown (1983) and Upshall et al. (1987) reported prevalences of 84%, 72%, 62%, 51% and 60%, respectively.

Gilbert (1973) suggested that sex related behavioral differences in cover type selection during fawn rearing could predispose females to greater contact with intermediate gastropod hosts. Studies by Karns (1967) and Behrend and Witter (1968) also revealed a higher prevalence in females than males. However, in this study, no statistically significant difference in prevalences occurred between males and females.

The higher occurrence of *P. tenuis* in the adult segment of the deer population in this study is similar to the results of other studies (Dudak et al., 1965; Behrend and Witter, 1968; Behrend, 1970; Gilbert, 1973). These studies suggest that as an animal ages, the cumulative probability of infection increases. To our knowledge, no information exists on the longevity of adult *P. tenuis* within its definitive host. If adult *P. tenuis* can live indefinitely within their host and produce larvae, then it can be assumed that once a deer is infected, it remains infected. Therefore, any great change in the prevalence of *P. tenuis* within the deer population is due primarily to a change in the prevalence of *P. tenuis* in fawns. In this study, only 36% of the fawns were infected as compared to 66%, 42% and 64% in previous studies conducted by Behrend and Witter (1968), Behrend (1970), and Thurston and Strout (1978), respectively.

Previous studies have shown that *P. tenuis* infection occurs in late spring and early fall when gastropod hosts are presumably most abundant (Anderson, 1963; Behrend and Witter, 1968; Upshall et al., 1986). In this study however, no significant results were found between infected and uninfected deer with respect to season collected or cause of death.

The utility of fecal material as an indicator of *P. tenuis* infection is controversial (Bindernagel and Anderson, 1972; Upshall et al., 1987). The problem in determining the prevalence of *P. tenuis* in deer and moose feces is accurate identification of first stage (L_1) larvae of *P. tenuis*. These larvae can be confused with those of two other metastrongylids, *P. odocoilei* and *P. andersoni* (Anderson, 1963; Prestwood, 1972; Platt, 1978; Upshall et al., 1987). To date, *P. odocoilei* has been observed only in the western United States and western Canada (Platt, 1978; Gray and Samuel, 1986). The distribution of *P. andersoni* in white-tailed deer is disjunct. It has been found in the southeastern United States (Prestwood et al., 1974) and southeastern British Columbia (Pybus and Samuel, 1981). *Parelaphostrongylus andersoni* also occurs naturally in caribou (*Rangifer tarandus*) in central and northern Canada (Lankester and Fong, 1989). While adult *P. andersoni* were not recovered in this study, we do not assume that the parasite does not occur in New York. It is possible that *P. andersoni* occurs in deer in the northeastern United States; therefore, some misidentification of L_1 larvae using fecal sampling may be confounding our results.

Eight deer were found to be passing first stage *P. tenuis*-like larvae in this study although, no adult nematodes were observed. Although, it is possible that the larvae observed could have been *P. andersoni*, it is also possible that some adult *P. tenuis* were missed during examination because adults are known to "wander" to some extent within their host (Anderson, 1963). Therefore, adult nematodes located in other areas than those examined in this study could account for the larvae being passed in the deer when no adults were observed.

As revealed in this study, considerable regional differences in the prevalence and distribution of *P. tenuis* exists. It has been suggested that deer density is the controlling factor in the transmission of *P. tenuis* to moose (Karns, 1967; Behrend and Witter, 1968). Brown (1983) showed that the infection rate of *P. tenuis* is more closely associated to the frequency of occurrence of *P. tenuis* in deer rather than deer density. Additional studies indicate that other factors such as precipitation, habitat type, soil type, abundance of suitable gastropod hosts, and the degree of ecological separation between moose and deer are more important in controlling the transmission of *P. tenuis* (Telfer, 1967; Gilbert, 1973; Saunders, 1973; Lankester, 1974). Examination in this study of male deer harvest (which is an indicator of deer density) and precipitation on the prevalence of *P. tenuis* in deer revealed no statistically significant results. Although significant results were not observed with respect to prevalence and deer density, the high prevalence (83%) of *P. tenuis*-like larvae in the live-captured deer in this study occurred in an area with a relatively high deer density (i.e., 6.8/km²) (Mathews, 1989).

Between 1935 and 1980, an estimated 15 to 21 moose entered New York State (Hicks, 1986). Of these, five were shot, two migrated elsewhere, and the fate of the others in unknown (Hicks, 1986). Since 1980, six moose mortalities have been documented. Three were illegally shot, one died during relocation and two died of natural causes. No moose mortalities have been the result of *P. tenuis* infection. However, *P. tenuis* is known to be a major cause of mortality of moose on the southern limits of their range in eastern North America (Anderson, 1970). From a management perspective, the key question is whether or not *P. tenuis* is abundant enough to preclude occupation of northern New York by moose. Considerable regional variation in the prevalence and distribution of *P. tenuis* exists in northern New York. This variation and the dearth of information available regarding other potentially important ecological factors responsible for the transmission of *P. tenuis* in northern New York make feasibility analyses difficult. Therefore, reestablishment of a long-term moose population in northern New York State remains uncertain.

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