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An Update on the Distribution of *Parelaphostrongylus tenuis* in the Southeastern United States

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ABSTRACT: An update is presented on the distribution of the meningeal worm (*Parelaphostrongylus tenuis*) of white-tailed deer (*Odocoileus virginianus*) in the southeastern United States. The parasite is widely distributed and common in all or much of Arkansas, Kentucky, Louisiana, Maryland, North Carolina, Tennessee, Virginia and West Virginia. It is also common in the northern half of Alabama and Georgia. In contrast, it is rare or absent along the Atlantic and Gulf coastal plains of Alabama, Georgia, Mississippi and South Carolina. It has been collected from a single deer in Florida.

Key words: Meningeal worm, *Parelaphostrongylus tenuis*, distribution, white-tailed deer, *Odocoileus virginianus*, management implications, regional survey.

The white-tailed deer (*Odocoileus virginianus*) is the definitive host for two nematodes belonging to the genus *Parelaphostrongylus* in the southeastern United States. The meningeal worm (*P. tenuis*) develops in the neural parenchyma of the central nervous system and matures in the cranial subdural space and venous sinuses (Anderson, 1963; Anderson, 1965a). The adult muscleworm (*P. andersoni*) occurs in the musculature of white-tailed deer and is most frequently found in the longissimus dorsi and hind limbs (Prestwood et al., 1974; Pybus and Samuel, 1984). White-tailed deer usually tolerate low levels of infection by either parasite without overt disease (Anderson, 1972; Prestwood and Nettles, 1977). Clinical manifestations arise only with massive levels of infection (Prestwood, 1970; Nettles and Prestwood, 1976). Larvae of both species may cause interstitial pneumonia when migrating through the lungs in large numbers, especially when in concert with larvae and adults of the lungworm *Dictyocaulus viviparus* (Anderson and Prestwood, 1981).

The meningeal worm causes severe neurologic disease in other species of North American cervids (Anderson, 1972), domestic sheep (*Ovis aries*) (Alden et al., 1975) and goats (Mayhew et al., 1976; Guthery et al., 1979), and a variety of exotic ungulates (Anderson and Prestwood, 1981; Rowley et al., 1987). The parasite is debilitating or lethal to moose (*Alces alces*) (Anderson, 1965b), elk (*Cervus elaphus*) (Carpenter et al., 1973), caribou and reindeer (*Rangifer tarandus*) (Anderson, 1971; Trainer, 1973), black-tailed deer (*Odocoileus hemionus*) (Nettles et al., 1977a), and fallow deer (*Dama dama*) (Kistner et al., 1977; Nettles et al., 1977b). The meningeal worm has been responsible for serious local declines in populations of moose and caribou as the parasite was introduced into new areas by expanding white-tailed deer populations during the past century (Anderson, 1972; Bergerud and Mercer, 1989).

Because of the marked pathogenicity of *P. tenuis* in aberrant hosts, the distribution and abundance of this nematode has considerable importance. In previous surveys, the presence of this parasite in the southeastern United States was recorded in 87 counties of 12 states (Prestwood and Smith, 1969; Prestwood et al., 1974). The present communication combines information from these sources with additional data obtained by review of Southeastern Cooperative Wildlife Disease Study files from 1974 through 1989. We herein report *P. tenuis* in an additional 66 counties throughout the Southeast and for the first time in South Carolina.

Deer were examined as described by Prestwood and Smith (1969) until 1980. Thereafter, an alternative procedure was

used whereby the skull was opened with a standard bone saw by a sagittal cut through the head offset approximately 3 mm from the median plane. The brain halves were subsequently removed and the meninges, venous sinuses, brain, and cranial vault examined. Because first stage larvae of *P. tenuis* and *P. andersoni* are indistinguishable (Prestwood et al., 1974; Pybus and Samuel, 1981), the presence of *P. tenuis* is based only on the recovery of the adult nematode.

A complete list of all deer examined for *P. tenuis* listed by county is given in Table 1 and represents a combined sample of 3,876 deer. The geographic distribution of *P. tenuis* is presented in Figure 1. The meningeal worm is widely distributed and common in all or much of Arkansas, Kentucky, Louisiana, Maryland, North Carolina, Tennessee, Virginia and West Virginia. It is common also in the northern half of Alabama and Georgia, and it has been found occasionally in northern Mississippi and northwestern South Carolina. It is absent or rare in the Atlantic and Gulf coastal plains of Alabama, Georgia, Mississippi and South Carolina. *P. tenuis* has been recorded from a single deer in Florida.

The occurrence of meningeal worm in the southeastern United States appears to be associated with certain major soil types (FAO—Unesco, 1975). Of the soil types that have widespread distribution within the region, *P. tenuis* tends to be present in orthic acrisols and dystric cambisols and absent in ferric, plinthic and gleyic acrisols. It should be noted, however, that other major environmental attributes such as physiographic provinces, forest types, and land use patterns also have a similar spatial distribution in the Southeast. Whether the apparent association of *P. tenuis* with soil type reflects inherent soil properties or these other environmental attributes is not known.

The presence of the meningeal worm in an infected deer population was usually detected by the postmortem examination

TABLE 1. Distribution of the meningeal worm in the southeastern United States.

State	County or parish	Number infected/ Number examined	Percent infected
Alabama	Baldwin	0/26	—
	Barbour	0/15	—
	Bibb-Hale	28/63	44
	Calhoun	69/91	76
	Calhoun-Cleburn	23/36	64
	Choctaw	0/5	—
	Clarke	0/27	—
	Coosa	0/1	—
	Dale	0/5	—
	Greene	0/11	—
	Lawrence-Winston	1/5	20
	Marengo	0/13	—
	Montgomery	0/5	—
	Pickens	0/26	—
	Sumter	0/21	—
	Tuscaloosa	0/1	—
Arkansas	Arkansas	0/26	—
	Ashley	3/20	15
	Ashley-Union	3/5	60
	Bradley	5/7	71
	Clark	2/6	33
	Crittenden	4/5	80
	Desha	3/13	23
	Faulkner	2/2	100
	Franklin	2/3	67
	Fulton	5/5	100
	Grant	1/2	50
	Howard	5/5	100
	Izard	1/5	20
	Jefferson	1/5	20
	Johnson	2/3	67
	Lafayette	4/5	80
	Lee	0/1	—
	Logan	11/18	61
	Montgomery	3/10	30
	Ouachita	3/4	75
	Phillips	3/4	75
	Pike	4/4	100
	Poinsett	0/5	—
	Pope	3/7	43
	Prairie	2/5	40
	Pulaski	3/4	75
	Sebastian	3/5	60
	Sharp	4/6	67
	Stone	43/47	91
	Union	5/9	56
	Yell	0/1	—
Florida	Baker	0/1	—
	Brevard	0/5	—
	Broward	0/37	—
	Baker-Columbia	0/23	—

TABLE 1. Continued.

State	County or parish	Number infected/ Number examined	Percent infected
Florida (cont.)	Citrus	0/5	—
	Citrus-Hernando	0/21	—
	Clay	0/12	—
	Collier	1/20	5
	Duval	0/11	—
	Escambia	0/5	—
	Franklin	0/16	—
	Gadsen	0/11	—
	Jackson	0/1	—
	Lake	0/10	—
	Levy	0/10	—
	Liberty	0/5	—
	Marion	0/23	—
	Monroe	0/5	—
	Orange	0/5	—
	Osceola	0/5	—
	Taylor	0/1	—
	Wakulla	0/20	—
	Walton	0/40	—
Georgia	Bartow	1/1	100
	Burke	0/5	—
	Camden	0/10	—
	Catoosa	3/6	50
	Charlton	0/5	—
	Chatham	0/31	—
	Clarke	67/141	46
	Clinch-Echols	0/17	—
	DeKalb	1/6	17
	Doughtery	1/5	20
	Elbert	1/2	50
	Fannin	1/1	100
	Floyd	6/7	86
	Gilmer	21/29	72
	Greene	3/6	50
	Habersham	38/41	93
	Harris	4/5	80
	Houston	0/4	—
	Jackson	1/2	50
	Jasper-Jones	22/41	54
	Jeff Davis	0/10	—
	Jefferson	0/1	—
	Liberty-Long	0/60	—
	Lumpkin	38/49	76
	Madison	0/1	—
	McDuffie	42/61	69
	McIntosh	0/27	—
	Morgan	2/2	100
	Muscogee	0/5	—
	Oconee	3/3	100
	Putnam	42/57	74
	Rabun	13/28	46
	Richmond	1/20	5

TABLE 1. Continued.

State	County or parish	Number infected/ Number examined	Percent infected
Georgia (cont.)	Stewart	0/5	—
	Telfair	0/5	—
	Towns	12/18	67
	Twiggs	1/3	33
	Ware	3/20	15
	White	6/6	100
	Whitfield	1/1	100
	Wilkes	2/2	100
Kentucky	Bullitt	5/5	100
	Bullitt-Hardin	113/150	75
	Christian-Trigg	2/5	40
	Edmonson	31/45	69
	Franklin	1/2	50
	Madison	2/4	50
	Trigg	3/5	60
Louisiana	Allen	41/54	76
	Assumption	2/3	67
	Bienville-Jackson	1/18	6
	Caldwell	0/5	—
	Cameron	1/5	20
	Claiborne	1/5	20
	Concordia	0/23	—
	Grant	1/44	2
	Iberia	3/10	30
	Iberville	0/2	—
	LaSalle	0/5	—
	Lincoln	0/5	—
	Madison	1/20	5
	Madison-Tensas	0/41	—
	Morehouse	4/10	60
	Natchitoches	2/5	40
	Ouachita-Union	3/5	60
	Plaquemines	0/12	—
	Rapides	23/41	56
	Tensas	0/20	—
	Union	12/22	55
	Vermilion	8/10	80
	Vernon	43/60	72
	Winn	11/11	100
Maryland	Allegany	6/7	86
	Allegany-Garrett	53/77	69
	Anne Arundel	1/3	33
	Baltimore	3/4	75
	Calvert	1/1	100
	Cecil	4/7	57
	Charles	1/6	17
	Dorchester	18/35	51
	Frederick	4/7	57
	Garrett	2/2	100
	Hartford	141/199	71
	Kent	14/58	24

TABLE 1. Continued.

State	County or parish	Number infected/ Number examined	Percent infected
Maryland (cont.)	Montgomery-Prince Georges	2/5	40
	Prince Georges	11/20	55
	Somerset	2/3	67
	Talbot	1/10	10
	Washington	3/3	100
	Wicomico	7/10	70
	Worchester	14/14	100
Mississippi	Bolivar	40/58	69
	Coahoma	3/5	60
	Holmes	0/5	—
	Issaquena	0/5	—
	Leflore	0/7	—
	Noxubee	0/5	—
	Sunflower	0/3	—
	Warren	0/4	—
	Washington	0/5	—
	Wilkinson	0/5	—
North Carolina	Anson	0/5	—
	Avery	1/1	100
	Bertie	0/8	—
	Bladen	0/5	—
	Burke	13/20	65
	Caldwell	99/125	79
	Clay	1/3	33
	Craven	1/5	20
	Currituck	4/5	80
	Dare	0/6	—
	Granville	1/1	100
	Hyde	1/18	6
	McDowell	1/1	100
	Montgomery	12/21	57
	Northampton	0/5	—
	Richmond	0/3	—
	Yancey	5/6	83
South Carolina	Aiken	0/2	—
	Allendale	0/5	—
	Barnwell	0/15	—
	Beaufort	0/20	—
	Berkeley	0/27	—
	Charleston	0/21	—
	Chesterfield	0/5	—
	Clarendon	0/5	—
	Colleton	0/5	—
	Georgetown	0/9	—
	Hampton	0/8	—
	Jasper	0/5	—
	McCormick	1/55	2
	Oconee	0/1	—
	Pickens	1/1	100
	Spartanburg	0/6	—
	Williamsburg	0/2	—

TABLE 1. Continued.

State	County or parish	Number infected/ Number examined	Percent infected
Tennessee	Blount	5/5	100
	Carter	0/1	—
	Clay	1/1	100
	Franklin	3/6	50
	Grainger (in *Odocoileus hemionus*)	1/2	50
	Haywood	0/10	—
	Henry	2/5	40
	Humphreys	2/5	40
	Montgomery	0/8	—
	Obion	5/8	63
	Polk	36/43	84
	Shelby	0/8	—
	Union	10/11	91
Virginia	Accomack	1/5	20
	Augusta	16/19	84
	Bath	2/2	100
	Caroline	2/122	2
	Craig	17/19	89
	Cumberland	0/1	—
	Fairfax	4/5	80
	James City	0/23	—
	Nansemond	0/5	—
	Norfolk	2/10	20
	Nottoway	0/23	—
	Prince George	0/7	—
	Prince William	3/5	60
	Prince William-Stafford	27/32	84
	Warren	5/5	100
West Virginia	Brooke	0/1	—
	Doddridge	2/3	67
	Grant	8/10	80
	Hampshire	4/5	80
	Hardy	30/47	64
	Lewis	3/5	60
	Marshall	7/10	70
	Mineral	1/6	17
	Monroe	5/15	33
	Pendleton	7/12	58
	Pocahontas	15/24	63
	Preston	1/1	100
	Taylor	0/2	—
	Tucker	8/10	80
	Tyler	2/5	40
	Upshur	5/5	100
	Wirt	9/20	45
	Wood	3/5	60

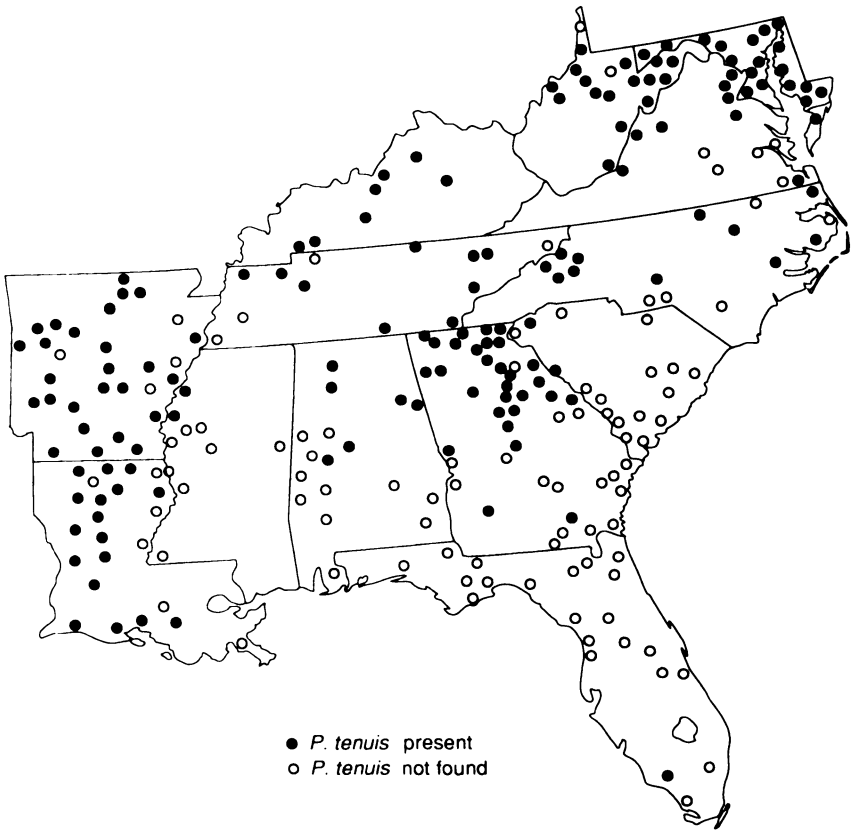

FIGURE 1. Distribution of *Parelaphostrongylus tenuis* in the southeastern United States as determined by the recovery of the adult nematode from white-tailed deer. Map reflects counties and sample sizes in Table 1.

of a sample of five deer. Review of our records revealed that in areas where *P. tenuis* has been found, it was detected 95% of the time in the first five deer examined. However, there were notable exceptions. In McCormick County, South Carolina, one deer of 55 (deer number 49) examined for the meningeal worm was infected. Also, in a two-parish area of Louisiana (Madison and Tensas), only one of 81 deer examined (deer number 59) was infected. Only two of 122 deer examined in Caroline County, Virginia, were infected with *P. tenuis*. Thus, in certain areas it may be necessary to obtain a substantial sample of deer before the presence of the parasite is revealed. Therefore, the meningeal worm is probably more widely distributed than indicated.

Considerable speculation exists as to whether the meningeal worm has expanded its range. Some authors have expressed concern that the parasite might eventually spread through aspen parklands and extend to the foothills of the Rocky Mountains in Canada (Anderson, 1972; Bindernagel and Anderson, 1972). In the southeastern United States, insufficient evidence exists to state that *P. tenuis* has expanded its range since its distribution was described earlier (Prestwood and Smith, 1969; Prestwood et al., 1974). Although this parasite is reported herein for the first time in South Carolina, its presence there was predicted earlier (Prestwood and Smith, 1969). However, the meningeal worm has since been recovered from Dougherty and Ware Counties, Georgia (Fig. 1), which are located in the Atlantic Coastal Plain. This possibly rep-

resents a southern extension of the range of *P. tenuis*.

The single record of the meningeal worm in Florida was obtained in 1968. Since that time, 193 additional deer from the state have been examined for *P. tenuis* with negative results, suggesting that the parasite has not become established or spread there. The presence of the meningeal worm in Florida is believed to have been the result of an introduction of infected deer into this area from Wisconsin (Anderson and Prestwood, 1981), where *P. tenuis* is present (Samuel and Trainer, 1969).

The meningeal worm continues to be an important factor in the distribution and management of North American cervids and exotic ungulates. Extreme caution should be exercised when relocating North American cervids or introducing exotic ungulates into areas where the meningeal worm exists. Native cervids other than white-tailed deer and exotic ungulates may be subject to high mortality when relocated or introduced into areas where the meningeal worm is present. White-tailed deer captured from areas where the parasite is present should not be used to restock uninfected areas.

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