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Gastro-Intestinal and Abdominal Helminths of White-Tailed Deer (Odocoileus virginianus) from Carroll and Jo Daviess Counties in Northern Illinois

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Gastro-Intestinal and Abdominal Helminths of White-Tailed Deer (Odocoileus virginianus) from Carroll and Jo Daviess Counties in Northern Illinois

(TITLE)

BY

Jeffrey Joseph Hodge

THESIS

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Gastro-Intestinal and Abdominal Helminths of White-Tailed Deer (*Odocoileus virginianus*) from Carroll and Jo Daviess Counties in Northern Illinois

Presented by

Jeffrey Joseph Hodge

a candidate for the Degree of Master of Science and hereby certify that in their opinion it is acceptable.

Gastro-Intestinal and Abdominal Helminths of White-Tailed Deer (*Odocoileus virginianus*) from Carroll and Jo Daviess Counties in Northern Illinois

Jeffrey J. Hodge

Abstract: Forty-four white-tailed deer shot by hunters in November and December, 1971, in Carroll and Jo Daviess counties in northwestern Illinois were necropsied for gastro-intestinal and abdominal helminths. Five species of gastro-intestinal nematodes were found: *Gongylonema pulchrum*, *Ostertagia odocoilei*, *Haemonchus contortus*, *Trichuris ovis* and *Nematodirus* sp. *Setaria yehi*, a filiariad nematode, was found in the abdominal cavity. *Moniezia benedeni* was the only cestode found. No trematodes were recovered. Differences in numbers and kinds of parasites found in northern Illinois and southern Illinois are discussed. Prevalence increased with host age for certain species of parasites and decreased or remained constant for others.

White-tailed deer (*Odocoileus virginianus*) have been studied for parasites throughout most of its range (Anderson 1962a and 1962b, Becklund and Walker 1970, Samuel 1968). Two studies of helminth infections (Mugwanya 1971, Cook 1972) have been carried out in extreme southern Illinois. Deer are widely distributed in Illinois and share parasites with domesticated ungulates as well as being intermediate hosts of others found in carnivores. Deer densities are highest in the two unglaciated regions of the state, the southern tip and the

northwestern corner. Differences in climate, physiography and land use suggest that the helminth fauna of northwestern Illinois deer may differ from that described by Mugwanya (1971) and Cook (1972) in southern Illinois. This is a report of the gastro-intestinal and abdominal helminths collected from deer in two of the northwestern counties.

MATERIALS AND METHODS

White-tailed deer were shot by hunters in Jo Daviess and Carroll counties during November and December, 1971. Deer were aged (Severinghaus 1949) sexed and weighed at check stations in each county. At the check stations the gastro-intestinal tract was removed and divided into eight sections for study: esophagus, rumen, reticulum, omasum, abomasum, small intestine, caecum and large intestine. Each section except the small intestine was cut open, scraped and flushed with water into large buckets. The small intestine was cut into six foot sections and each section flushed and scraped. The flushed material was allowed to decant in buckets and the supernatant fluid was poured off. The sediment was resuspended with water, allowed to settle and the second supernate was poured off. The remaining concentrate was poured into plastic bags and preserved with 10% formalin. Mucosal linings of the eight sections were also preserved in 10% formalin.

Later the concentrate from each section was examined in shallow dissecting pans with a 8x - 45x dissection scope. Nematodes found were preserved with 10% formalin and cestodes with AFA solution (Cable 1958). Nematodes were cleared in lacto-phenol and identified with the aid of keys constructed by Skryabin et al. (1954), Yamaguti (1961), Becklund and Walker (1967, 1968, 1969), and Levine (1968). Cestodes

were stained with Semichon's carmine (Cable 1958) and identified using keys from Wardle and McLeod (1952) and Yamaguti (1959).

RESULTS

Forty-four deer from Carroll and Jo Daviess counties in northern Illinois counties were examined for gastro-intestinal and abdominal cavity helminths. Age distribution of the deer was: ½ year = 20, 1½ year = 12 and 2½ year and older = 12.

No trematodes were found, but five gastro-intestinal nematodes, one abdominal nematode, and one cestode were isolated (Table 1). Most of the parasites were not widespread in this deer population. Only three species were found in over 20% of the deer, but Ostertagia odocoilei (=Spiculopteroides odocoilei) was present in 61.5%. The average number of helminths per deer was less variable. Less than four parasites per deer were recovered except for Ostertagia odocoilei (13.8) and Nematodirus sp. (8.1). The largest number of any one helminth found in a deer was O. odocoilei; an adult male had 84 in the abomasum. Nematodirus sp. was next with 52 worms in the small intestine of a female fawn.

The only part of the digestive tract to support more than one species of nematode was the abomasum. O. odocoilei outnumbered Haemonchus contortus by 10 to 1 in the trichostrongyle complex inhabiting the abomasum. Eight deer had both present. O. odocoilei was the only trichostrongyle present in eight deer and one deer had only H. contortus present.

The incidence of parasitism was related to the age of the deer in most cases (Table 2). Gongylonema pulchrum was found only in yearling deer. The incidence of Setaria yehi (=Setaria cervi, see Becklund and Walker 1970) and Nematodirus sp. showed significant decreases in yearlings and adults. Haemonchus contortus was found to be significantly higher

Table 1. Gastro-intestinal and abdominal helminths recovered from 44 deer in Carroll and Jo Daviess counties in northern Illinois.

Species	Location	Incidence of Parasitism		Parasites per deer	
		No. infected / No. examined	Percent	Mean ± SD	Range
NEMATODA					
Ostertagia odocoilei	Abomasum	27/44	61.5	13.8±19.1	1-84
Nematodirus sp.	Small intestine	11/44	25.0	8.1±15.1	1-52
Haemonchus contortus	Abomasum	10/44	22.7	3.7± 3.9	1-13
Gongylonema pulchrum	Esophagus	4/34	18.8	1.5± 1.0	1- 3
Setaria yehi	Abdominal cavity	6/44	13.6	2.0± 1.3	1- 4
Trichuris ovis	Large intestine	2/44	4.5	3.0± 2.8	1- 5
CESTODA					
Moniezia benedeni	Small intestine	8/44	18.2	1.0± 0	-

Table 2. Age-group differences in the incidence of gastro-intestinal and abdominal helminths infecting white-tailed deer from Carroll and Jo Daviess counties in northern Illinois.

Species	½ Year		1½ Year		2½ Years and Older		Total	
	No. infected / No. examined	Percent Infected	No. infected / No. examined	Percent Infected	No. infected / No. examined	Percent Infected	No. infected / No. examined	Percent Infected
NEMATODA								
Ostertagia odocoilei	11/20	55.0	9/12	75.0	7/12	58.3	27/44	61.5
Nematodirus sp.	9/20	45.0	1/12	8.3	1/12	8.3	11/44	25.0
Haemonchus contortus	6/20	30.0	3/12	25.0	1/12	8.3	10/44	22.7
Gongylonema pulchrum	0/16	0.0	4/ 9	44.5	0/ 9	0.0	4/34	18.8
Setaria yehi	4/20	20.0	1/12	8.3	1/12	8.3	6/44	13.6
Trichuris ovis	1/20	5.0	1/12	8.3	0/12	0.0	2/44	4.5
CESTODA								
Moniezia benedeni	5/20	1.0	1/12	8.3	2/12	16.7	8/44	18.2

in fawns and yearlings but lower in adults. Other genera found, Moniezia benedeni and Trichuris ovis were present in only limited numbers and had no definite age relationship.

DISCUSSION

The seven species of gastro-intestinal parasites in northern Illinois deer were similar to that of other studies. Eleven species were found in Wisconsin (Samuel and Trainer 1969), ten in southern Illinois (Cook 1972), eight species in Pennsylvania (Samuel and Beaudoin 1966, Beaudoin et al. 1970), six species in Florida (Dinaburg 1939) and Texas (Samuel 1969), and five species in South Dakota (Boddicker and Hugghins 1969).

There was a distinct difference between the parasite fauna from Carroll and Jo Daviess counties and that reported from southern Illinois by Cook (1972). Four species were found in southern Illinois (Cook 1972) that were not found in northern Illinois. Several factors may have caused this reduction in parasite species. One factor may be better livestock management programs. Longhurst and Douglas (1953) and Samuel (1968) reported experimental cross-infections between livestock and deer. Such cross-infections in the wild would be less likely if domestic livestock are wormed regularly and farmers rotate pastures. There is no information from cattle in northwestern Illinois, but parasitism in dairy cattle is becoming more widely recognized in southern Wisconsin (Cox and Todd 1962) and Iowa (Zimmermann and Hubbard 1961) and more cows are being treated by veterinarians. Reduced worm populations in dairy cattle indicate greater management care and better and more sanitary feeding procedures. Wisconsin dairy cattle harbor helminths that are the same as those found throughout the United States,

which indicates that a climatic barrier does not limit the geographical distribution of these parasites in cattle (Cox and Todd 1962). These data suggest there are fewer parasite species in northern Illinois livestock therefore fewer species in northern Illinois deer. Species such as Strongyloides sp., Capillaria sp., Cooperia sp., Oesophagostomum sp., Skyabnema sp., Anoplocephala sp., and Ostertagia mossi favor livestock as host and only infect deer if the opportunity for transmission exists. All of these parasites were reported from southern Illinois (Mugwanya 1971, Cook 1972) but were not found in northern Illinois. Either these species were not present in northern Illinois deer or the incidence was so low that they were overlooked because of the small sample size. If these parasites are absent in northern Illinois and present in southern Illinois deer, this gives further support to the theory that northern Illinois livestock have less parasites. Other factors may limit the chance of deer coming in contact with certain species. Such factors are the colder-dryer climate of northern Illinois (King and Winters 1952) which may inhibit survival of egg or larval stages of the parasites.

The number of parasites per deer was lower (15) in northwestern Illinois than Cook (1972) found (40) in southern Illinois. Carroll and Jo Daviess counties have some of the highest land in Illinois with Charles Mound being 1,241 feet above sea level. In this unglaciated area only about 25% of the land is forested (King and Winters 1952). The area has large stretches of grazing land intersperced with cultivated areas. The northern Illinois deer herd is neither overpopulated nor suffering from malnutrition because of the agricultural foods available. With large areas to graze deer are not as likely to come in

contact with domestic livestock. Another factor lowering the number of parasites per deer is an inhibitory reaction among parasites (Turner et al. 1962, Samuel 1969). Since some species of the trichostrongyle abomasal complex were not found and H. contortus was found in lower numbers there may be an inhibitory factor. O. odocoilei was found in 19 deer where H. contortus was not present.

The helminths found in northern Illinois deer are placed in three categories based on host specificity. Ostertagia odocoilei is the only helminth in this survey that has been reported exclusively from white-tailed deer in North America. This stomach worm is widespread throughout deer range; it has been reported from Pennsylvania, Louisiana, New York, Florida, Texas, Wisconsin, and South Dakota. O. odocoilei incidence has ranged from 3.6% (Boddicker and Hugghins 1969) to as high as 98% (Samuel 1969). O. odocoilei has been reported from Pennsylvania deer (Dikmans 1931, Samuel and Beaudoin 1966, Beaudoin et al. 1970), in Louisiana (Dikmans 1932), New York (Dikmans 1931), Florida (Dinaburg 1939), from Texas (Samuel 1969), Wisconsin (Samuel and Trainer 1969) and in South Dakota (Boddicker and Hugghins 1969).

Trichuris ovis is in the second category, i.e., nematodes preferring livestock but sometimes infecting deer (Levine 1968). Levine (1968) reports T. ovis as being non-pathogenic. Only Cook (1972) has found a higher incidence with a 5% infection in southern Illinois. The incidence in northern Illinois deer was only slightly lower with 4.5% infection. Samuel and Beaudoin (1966) found 3.3% in Pennsylvania, Samuel and Trainer (1969) reported 4% in Wisconsin, and Mugwanya (1971) 4.3% in southern Illinois deer.

The third category is parasites infecting ruminants in general; this category includes all but two of the parasites found in northern

Illinois deer. Gongylonema pulchrum, a spiruroid nematode, has been reported in white-tailed deer more in recent years than in the past. Samuel and Beaudoin (1966) who reported a 65% incidence, believed that G. pulchrum has been simply overlooked in past studies because of this helminth being imbedded in the wall of the esophagus. Furthermore, I found that it is sometimes difficult to obtain an intact esophagus from hunters during the hunting season. Samuel (1969) found only 0.57% rate of infection from 301 deer shot in south Texas during hunting season, and Emerson (1969) found a 50% infection in 10 deer collected from central and east Texas with help from Texas Parks and Wildlife Department. G. pulchrum was found in 457 of 788 (57.9%) deer from 13 southeastern states (Prestwood et al. 1970). Incidence in southern Illinois (46%) was found in significantly greater number in older deer and in yearling deer (18.8%) in northern Illinois. G. pulchrum has a lengthy sexual development, indirect life history and is a tissue parasite as an adult (Beaudoin et al. 1970). This contributes to a greater incidence in older deer. G. pulchrum is regarded as non-pathogenic to their host (Levine 1968).

Haemonchus contortus along with O. odocoilei make up the trichostrongyle complex of the abomasum in these northern Illinois deer. The incidence of this large stomach worm is nearly the same in northern Illinois (22.7%) as Cook (1972) found in southern Illinois (22.4%). Both these reports are lower than other surveys done by Samuel and Trainer (1969) in Wisconsin with a 31% incidence, Dinaburg (1939) in Florida, with a 37.5% incidence, Samuel (1969) and Emerson (1969) with 88 and 90% respectively. Infection levels exceeding 1,000 mature Haemonchus in deer may cause haemonchosis which in turn may result in

older fawn mortality (Samuel 1968). Severe infections of H. contortus along with O. odocoilei may cause enteritis, haemorrhage, diarrhea, anaemia, leading to digestive disturbances, emaciation, weakness, and death mainly because these nematodes are blood suckers (Anderson 1962a). The maximum number found in this study and in southern Illinois (Cook 1972) was thirteen. There appeared to be pathological damage to neither the mucosa of the abomasum nor to the deer population in Illinois.

Nematodirus sp. the common intestinal round worm, has been found in the northern part of white-tailed deer range from Michigan (Whitlock 1939, Swanson 1959), through Wisconsin (Dahlberg and Guettinger 1956, Samuel and Trainer 1969), and Pennsylvania (Samuel and Beaudoin 1966, Beaudoin et al. 1970). The incidence of Nematodirus sp. in livestock is low (6%) in southern Illinois (Mansfield 1958) and even lower (1.5%) in central Illinois (Levine and Aves 1956). Therfore, deer may not come into contact with this species. Samuel and Trainer (1969) found that Nematodirus sp. was more prevalent from the grassland and oak areas of southern Wisconsin which is similar to northern Illinois. The physiography of the southern Illinois region is an extension of the Ozark highlands and is the most extensively forested area in the state (King and Winters 1952). Nematodirus sp. has not been reported previously from white-tailed deer in Illinois. The incidence in northern Illinois deer (25%), however, is higher than most surveys. Only Samuel and Trainer's findings (1969) with 29% were higher.

Setaria yehi, a non-pathogenic helminth (Levine 1968), was found in 13.6% of the northern Illinois deer examined. Cook (1972) found 17% clinging to the outside of the digestive tract of southern Illinois deer. Samuel (1969) reported 4% in 176 Texas deer, Boddicker

and Hugghins (1969) reported 1% in 83 South Dakota deer, and Samuel and Beaudoin (1966) reported an even lower incidence of 0.83% in 120 deer from Pennsylvania. Little is known about the life history of this filiariad in relation to the vector, therefore, it is hard to explain these high incidences in Illinois. It is almost certain that helminths of the abdominal cavity are often overlooked or lost when extracting the digestive tract. The incidence in northern Illinois, for example, probably would have been higher, if the gut had been removed more carefully.

Moniezia benedeni was the only cestode encountered in this survey. The incidence in northern Illinois deer, 18.2%, was greater than any previous report; such as Cook (1972) with 15% in southern Illinois, 2-4% in Wisconsin deer (Samuel and Trainer 1969), 2% in South Dakota (Boddicker and Hugghins 1969), and 13% in southern Illinois (Mugwanya 1971). Moniezia spp. were found to be the most common tapeworm in southeastern United States with 29 deer (3.5%) being infected (Prestwood 1971). Moniezia was found in 13.8% of yearling Wisconsin dairy cattle and was not found in younger animals because management practices confined calves to pens away from the intermediate hosts (Cox and Todd 1962). Zimmermann and Hubbard (1961) found a 13.5% infection of 96 samples taken from a group of beef calves kept on feedlots in northeastern Iowa. With free living orbatid mites living in the soil as the probable intermediate host of M. benedeni, it is easy to see the reason for these high percentages (Cheng 1964). Cheng (1964) considers M. benedeni as a non-pathogenic cestode.

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APPENDIX -- LITERATURE REVIEW OF GASTROINTESTINAL AND ABDOMINAL PARASITES OF WHITE-TAILED DEER

Deer were common in Illinois before the 1800's but were exterminated by 1910 by the pressure of settlement (Andrews and Calhoun 1968). Restocking by the United States Forest Service and the Illinois Department of Conservation and habitat changes have reestablished the herd to the point where the deer are now hunted in all but a few central counties. In recent years, due to the increasing deer herds, deer-livestock disease and parasite relationships have become increasingly important. Many of the parasites of deer are transmissible to domestic livestock and some, such as liver flukes and lungworms, can be highly pathogenic (Anderson 1962b).

Becklund and Walker (1970) report that 137 parasite species, not including blood-sucking diptera such as simulids, tabnanids, culicids, etc., have been recovered from North American deer and 103 of these have been found in white-tailed deer. Only seven parasites have been found exclusively in white-tailed deer in North America (Anderson 1962a). These are lungworms Leptostrongylus alpenae and Protostrongylus coburni, and trichostrongyles Ostertagia mossi and O. odocoilei, the strongyle Eucyathostomum longesubulatum, the fluke Paramphistomum liorchis and the louse fly Lipoptena mazamae. Of the 103 parasites of white-tailed deer 44 are arthropods, 9 are protozoans, 3 cestodes and 11 nematodes are not associated with the digestive system and abdominal cavity. This is a review of those helminths found in the digestive tract and in the abdominal cavity.

NEMATODES

Esophagus

White-tailed deer have two nematode parasites of the esophagus Gongylonema pulchrum and Gongylonema verrucosum. G. pulchrum has been found in cattle, sheep, goats, and pigs from North America (Anderson 1962a, Samuel 1968). The parasite is found imbedded in the wall of the esophagus. Anderson (1962b), in a general review of the parasites, says eggs are released through an opening into the lumen of the gut, and beetles and roaches serve as intermediate hosts. G. pulchrum was first reported from deer in North Carolina (Dikmans and Lucker 1935, Schilling 1938). Since that time it has been found throughout the southeastern United States. This parasite was found in 65% of 72 Pennsylvania deer (Samuel and Beaudoin 1966) in one study and in 59% of 189 deer in another study (Beaudoin, Samuel and Strome, 1970). Samuel (1969) found 57% of 301 deer shot in south Texas had the parasite and Emerson (1969) reported a 50% infestation in 10 deer from the same state. Prestwood, Smith and Mahan (1970) examined the upper digestive tracts of 788 white-tailed deer shot from 13 southeastern states. Alabama had the highest incidence with 92% of 172 deer being infected; the incidence in Arkansas was 86% of 22, in Florida 69% of 141, in Georgia 58% of 373, in Kentucky 61% of 23, in Louisiana 59% of 61, in Maryland 75% of 115, in Mississippi 82% of 22, in North Carolina 51% of 135, in South Carolina 46% of 151, in Tennessee 82% of 11, in Virginia 88% of 40 and in West Virginia 61% of 33. Cook (1972) found 46.3% of 39 deer examined in southern Illinois to be infected with G. pulchrum; greater numbers of worms were present in older deer.

The second worm found in the esophagus, Gongylonema verrucosum, also occurs in cattle, sheep and goats (Anderson 1962a, 1962b). G. verrucosum was found in 21% of 172 deer in Alabama, 42% of 141 deer in Florida, 38% of 373 deer in Georgia, 33% of 61 deer in Louisiana, 4.5% of 22 deer in Mississippi, 6.5% of 135 deer in North Carolina and 16% of 151 deer in South Carolina (Préstwood et al. 1970). G. verrucosum was always found concurrently with G. pulchrum, but G. verrucosum was more numerous in deer in coastal plains in contrast to the G. pulchrum being found in deer from mountainous habitats (Prestwood et al. 1970). G. verrucosum has also been reported from Florida deer (Dinaburg 1939, Dikmans and Lucker 1935).

Abomasum

Nine species of nematodes are found in the abomasum of white-tailed deer. Most of the trichostrongyles found in the white-tailed deer are livestock parasites and heavy infections in sheep and cattle may cause enteritis, haemorrhage, diarrhea, anaemia, leading to weakness and sometimes death. Longhurst and Douglas (1953) reported that the trichostrongyles caused scouring and losses in the mule deer Odocoileus hemionus, especially fawns, in some localities in California and Wyoming. Deer can easily pick up these parasites by grazing because these trichostrongyles are transmitted by eggs or larvae in the feces of livestock or wild ungulates (Anderson 1962b).

Two species of Haemonchus have been reported from deer. H. similis and H. contortus are trichostrongyles essentially parasitic in sheep but have also been found in white-tailed deer, moose, elk, caribou, antelope, musk-ox, bighorn, bison, cattle, goats and pigs (Anderson 1962a). Whitelock (1939) found H. contortus in Michigan deer but

considered the sheep stomach worm to cause no serious damage to these deer. Robinson et al. (1967) reported this parasite from Texas and Emerson (1969) found a 90% incidence in 10 deer from the same state. H. contortus was reported in Florida by Hayes, Greer and Shotts (1958) and by Dinaburg in 37.5% of 308 deer (1939). Dahlberg and Guettinger (1956) found H. contortus in Wisconsin deer found dead in yards and also from deer shot by hunters. Samuel and Beaudoin (1966) found 2.7% of 113 deer in Pennsylvania to be infected with H. contortus. There was an 88% infection of 176 deer shot in South Texas (Samuel 1969). Samuel and Trainer (1969) reported 31% of 26 deer examined by necropsy were infected with the stomach worm. Boddicker and Hugghins (1969) reported 2% of the 83 white-tails examined by visceral examination in South Dakota were infected with H. contortus. H. contortus was found in 22.4% of 40 deer shot in southern Illinois (Cook 1972).

The second Haemonchus parasite, H. similis, was found in 3% of 308 deer in Florida by Dinaburg (1939). Obeliscoides cuniculi, another stomach worm, has been reported by Maples and Jordan (1966) from the abomasum of white-tailed deer in Arkansas and Georgia.

Five species of Ostertagia have been reported from the stomach of white-tailed deer; these are: O. odocoilei (=Spiculopteroides odocoilei), O. mossi, O. dikmansi, O. ostertagi, and O. circumcincta. In addition, unidentified Ostertagia have been reported by several workers. Cheatum (1952) found Ostertagia sp. in 1.4% of the 427 deer examined in New York but these infections, compared to those found in cattle, were light. Samuel and Trainer (1969) by necropsy found 77% of 26 deer were infected with Ostertagia sp. in Wisconsin. Mugwanya (1971) reported 5.2% of 116 deer shot in southern Illinois were infected

with Ostertagia sp. O. odocoilei was found in abomasums of white-tailed deer from Pennsylvania (Dikmans 1931, Samuel and Beaudoin 1966, Beaudoin et al. 1970). Dikmans (1932) reported the same species from Louisiana and New York (1934). Dinaburg (1939) reported 35% of 308 deer examined in Florida were infected with O. odocoilei, and an additional 11 deer contained only female specimens that were not identified. O. odocoilei was recovered from 98% of 176 white-tailed deer abomasums from south Texas by Samuel (1969). Boddicker and Hugghins (1969) found 3% of 83 white-tailed deer shot in South Dakota were infected with O. odocoilei. Cook (1972) reported 67.5% of 40 deer were infected with this parasite in southern Illinois.

O. mossi was reported in white-tailed deer from Pennsylvania (Dikmans 1931, Samuel and Beaudoin 1966, Samuel 1968, Beaudoin et al. 1970). Dikmans (1934) reported finding the parasite in New York. Its incidence has been reported from Wisconsin as part of the trichostrongyle complex (Samuel and Trainer 1969). Samuel (1969) again found 68% of 119 deer from Texas were infected with O. mossi. This parasite has been reported from the abomasum of 35% of 40 deer in southern Illinois (Cook 1972).

Becklund and Walker (1968) gave a description of the male O. dikmansi recovered from the abomasum of white-tailed deer in Pennsylvania and additional males were found in collections from Georgia, Louisiana, and Ontario. O. dikmansi has been reported from Wisconsin (Samuel and Trainer 1969) and again in Pennsylvania (Beaudoin et al. 1970).

Dahlberg and Guettinger (1956) found Ostertagia ostertagia from the abomasum of deer from Wisconsin and said that deer were remarkably free from important losses to disease and parasites.

O. circumcincta was collected from white-tailed deer in New York (Dikmans 1934) and identified by the U. S. Bureau of Animal Industry.

Trichostrongylus axei was reported from the abomasum of 70% of 176 Texas deer (Samuel and Trainer 1968, Samuel 1969). Samuel and Trainer (1969) found 50% of 14 Wisconsin deer examined by necropsy were infected with this same nematode.

Small intestine

Seven species of nematodes are found in the small intestine: Capillaria sp., Cooperia sp., Monodontus louisianensis, Nematodirus filicollis, Nematodirus odocoilei, Trichostrongylus sp., and Strongyloides sp.

Capillaria sp., females only, were recorded by Dinaburg (1939) in 2% of 308 deer killed in Florida in connection with a tick eradication program. Samuel and Beaudoin (1966) reported a 12% infection in 120 deer examined by autopsy and egg flotation. They detected Capillaria sp. by egg flotation in 13 deer that were negative by autopsy and concluded that the flotation technique used as a supplement to autopsy routines should increase the accuracy of the diagnosis. Capillaria sp. is a small nematode and light infestations can be easily overlooked by autopsy procedures. Samuel and Trainer (1969) recorded 4% of 24 deer examined by necropsy in Wisconsin were infected with Capillaria sp. They also examined 681 fecal samples and found 4% infection. Beaudoin et al. (1970) recovered 2% from 54 deer collected at the Letterkenny Depot and 21% from 61 deer collected around the Stone Valley Recreation Area. Examination of feces was the method of diagnosis in both the geographically separated populations of

white-tailed deer in central Pennsylvania. Capillaria sp. was detected from 3.2% of 116 deer, by Mugwanya (1971) in southern Illinois. Cook (1972) then confirmed this finding with 5% of 40 deer in southern Illinois being infected.

Samuel (1968) and Anderson (1962a, 1962b) in a general review of Cooperia, report that C. punctata and C. pectinata occur in deer, cattle, sheep and goats. Cooperia sp. was recorded by Dikmans (1934) from a white-tail in New York. Cook (1972) then found 5% of 40 southern Illinois deer had Cooperia sp. in their small intestines.

Chitwood and Jordan (1965) described Monodontus louisianensis, a hookworm from the small intestine of O. virginianus on the basis of three male and four female worms collected from white-tailed deer in Louisiana.

Nematodirus filicollis is a common intestinal round worm of cattle, sheep, goats, deer and antelope (Anderson 1962b). Most reports in deer are N. filicollis but Becklund and Walker (1967) examined many specimens and in every case re-identified them as N. odocoilei. Whitlock (1939) reported Nematodirus filicollis in deer in Michigan. According to Whitlock there was no apparent damage to those deer. Swanson (1959) later reported finding a 13% incidence in 47 deer from the George Reserve deer herd in Michigan. Of 24 deer killed in Wisconsin and examined by necropsy, 29% were infected with N. filicollis (Samuel and Trainer 1969). They also reported finding 10% of the 681 deer feces examined by the flotation method to be infected. Beaudoin et al. (1970) examined 54 and 61 deer from two areas in Pennsylvania and found 2 and 15% respectively were infected with N. filicollis. Dahlberg and Guettinger (1956) found Nematodirus sp. in Wisconsin but explained there was no significant loss due to this parasite of the small intestine.

Strongyles are rarely found in white-tails and can probably be assumed unimportant parasites in this species (Anderson 1962b). Mugwanya (1971) reported 1.7% of 116 deer shot in southern Illinois had Strongyloides sp. present in the small intestine. There was a low incidence in Texas deer (Glazener and Knowlton 1967).

Large intestine and caecum

Seven nematodes have been reported from the large intestine of white-tailed deer: Chabertia ovina, Eucyanthostomum longesubulatum, Oesophagostomum cervi, O. columbianum, O. venulosum, Skrjabinema parva, and Trichuris ovis.

Chabertia ovina was found by Dikmans (1934) in a deer from New York. Anderson (1962a, 1962b) reports this parasite has been found in sheep and goats and reviews the parasite in white-tailed deer.

Eucyanthostomum longesubulatum was found in the large intestine of 4% of 308 white-tailed deer in Florida by Dinaburg (1939).

Oesophagostomum venulosum, the nodular worm, has been found in moose, elk, deer, sheep and goats (Anderson 1962a). O. venulosum was reported by Dikmans and Lucker (1935) as being found in white-tailed deer in North Carolina. Whitlock (1939) also mentioned its occurrence in Michigan deer. Schilling (1938) reported O. venulosum from white-tailed deer on the Pisgah National Game Preserve in North Carolina. Swanson (1959) reports 19% of 47 deer shot from the George Reserve deer herd in Michigan were infected with O. venulosum. Samuel and Beaudoin (1966) reported 15% of 120 deer examined by the egg flotation technique and autopsy method were infected with O. venulosum. They also found that the flotation technique did not increase diagnostic

accuracy for O. venulosum because this method does not detect the presence of male or immature female worms. Payne, Maples and Smith (1967) reported O. venulosum was always found in association with O. cervi in the caecum or colon of white-tailed deer. They necropsied 69 white-tailed deer from Louisiana, Alabama, Maryland, Mississippi, North Carolina, Virginia, and West Virginia; 22 of the deer were infected. Beaudoin et al. (1970) used both egg flotation and autopsy methods in Pennsylvania and found a 2% incidence in 55 deer from one area and a 24% incidence in 62 deer in another area. Finally, Cook (1972) reported 2.5% of 40 deer shot in southern Illinois had these worms in the caecum.

O. columbianum has been reported by Emerson (1969) in 10% of 10 white-tailed deer collected in Texas.

A third species of Oesophagostomum, O. cervi, has been reported in seven southeastern states (Payne et al. 1970). This was the first documented identifications of O. cervi since the species was first described by Mertts in 1948 from the red deer, Cervus elaphus. Payne et al. (1970) reported that 40% of 10 deer killed in Alabama were infected, 45% of 11 deer in Louisiana, 30% of 10 deer in Maryland, 40% of 10 deer in Mississippi, 12.5% of 8 deer in North Carolina, 10% of 10 deer in Virginia, and 40% of 10 deer killed in West Virginia making a total of 32% infections from 69 deer.

Olsen and Fenstermacher (1943) found Oesophagostomum sp. in only one out of 79 white-tails autopsied in Minnesota. Erickson et al. (1961) also found this species in the large intestine of one of 88 white-tails examined by autopsy in Minnesota. Oesophagostomum sp. was reported in 7% of 14 deer examined by necropsy in Wisconsin deer

by Samuel and Trainer (1969) and eggs of this parasite were found in 12% of 116 deer examined in southern Illinois (Mugwanya 1971).

Dikmans (1942) mentioned Skrjabinema parva in O. virginianus from New York. Samuel and Trainer (1969) reported finding eggs in feces of 1% of 681 deer and they isolated the adult worms from 7% of 14 deer in Wisconsin. Mugwanya (1971) found 2.6% of 116 deer shot in southern Illinois were infected with Skrjabinema sp.

Trichuris ovis is difficult to locate in the host, hence they probably occur more frequently than reports would indicate (Anderson 1962b). T. ovis, a whipworm, was found in only 1 out of 47 deer examined from the George Reserve deer herd in Michigan (Swanson 1959) and in 3.3% of 120 deer in Pennsylvania (Samuel and Beaudoin 1966). The flotation process did not increase accuracy in the diagnosis of T. ovis (Samuel and Beaudoin 1966). Dinaburg (1939) reported Trichuris sp. from one deer out of 308 examined in Florida. Cheatum (1952) also found Trichuris sp. in the intestines of deer in New York. Samuel (1969) reported 3% of 281 deer shot in south Texas had this whipworm in their large intestine. Samuel and Trainer (1969) reported 4% incidence in 681 Wisconsin deer examined by the flotation technique were infected with Trichuris sp. They also found 7% of 14 Wisconsin deer examined by necropsy were infected with T. ovis. Mugwanya (1971) reported 4.3% of 116 southern Illinois deer had Trichuris sp. eggs. Later 5% of 40 southern Illinois deer were found to be infected with T. ovis (Cook 1972).

Abdominal cavity

Two species of nematodes have been reported from the peritoneal cavity of white-tailed deer and these are Setaria cervi and S. yehi.

Setaria yehi has been collected from O. virginianus in Alabama, Georgia, Maryland, New Jersey, Texas, and Wisconsin (Becklund and Walker 1969). Yeh (1959) also reported the parasite from deer in Georgia and New Jersey.

Setaria cervi, the second abdominal nematode, has been found in New Jersey (Mangold 1958) and South Dakota (Boddicker and Hugghins 1969). Olsen and Fenstermacher (1943) found female specimens in only one of 79 deer examined in Minnesota. Setaria sp. was found in 1 out of 88 deer examined in Minnesota (Erickson et al. 1961) and in Pennsylvania (Samuel and Beaudoin 1966, Samuel 1967) and in Texas (Emerson 1969). This filarioid is rare in Ontario having been taken one or two times and never in deer autopsied in Algonquin Park (Shoho 1958, Anderson 1962b). Life cycles for Setaria have not been studied enough to find how the parasite is spread. Vectors for S. equina and S. digitata in horses and cattle are mosquitoes (Anderson 1962b) but the vector for S. yehi is unknown. Whitlock (1939) found that deer in the upper Peninsula of Michigan have Setaria sp. in their peritoneal cavity, but that it was not found in large numbers nor did it cause any injury. Samuel and Beaudoin (1966) did not find Setaria sp. eggs present in the feces but found an 0.83% incidence in the abdominal cavity of 120 deer in Pennsylvania. Finally Emerson (1969) found a 50% incidence in 10 deer examined in Texas.

TREMATODES

There are five trematodes reported from white-tailed deer in the United States and Canada. There are Paramphistomum liorchis (rumen fluke), Heterobilharzia americana (blood fluke), Fasciola hepatica, Fascioloides magna, Dicrocoelium dendriticum (liver flukes), and an intestinal fluke Zygocotyle lunata (Becklund and Walker 1970).

Paramphistomum liorchis has been reported from five southeastern states (Prestwood et al. 1970). Of 788 deer examined 7.3% were infected with P. liorchis. P. liorchis was found in the rumen and occasionally immature forms were present in the small intestine of deer. Migrating trematodes were said by Prestwood et al. (1970) to produce inflammation and edema at the site of infection. Florida had the highest incidence of 24% of 141 deer infected, next was South Carolina with 11% of 151 deer, then 7.7% of 373 deer in Georgia, 2.9% of 61 deer in Louisiana and 2.7% of 172 deer in Alabama were infected.

Zygocotyle lunata has been recorded only once (Swanson 1959) in 3 deer from the George Reserve deer herd located in Michigan.

CESTODES

Seven species of tapeworms have been recovered from O. virginianus, but only four species have been found in the small intestine. Cestodes found in white-tails are Moniezia benedeni, M. expansa, Thysanosoma actinioides, Anoplocephala sp., Cysticercus lyncis, C. tenicollis and Echinococcus granulosus. Cysticercus sp. and Echinococcus granulosus are larval stages in wild and domestic ruminants infecting organ and muscle tissue.

Anoplocephala sp. eggs were recovered from 5.2% of 116 deer in southern Illinois (Mugwanya 1971).

Moniezia benedeni has been found in white-tails in Massachusetts (Rankin 1946) and in Minnesota (Whitlock 1939). Boddicker and Hugghins (1969) found 2% of 83 white-tails to be infected in North Dakota. Samuel and Trainer (1969) found 4% of 24 deer examined in Wisconsin by necropsy to be infected with M. benedeni. They also found 2% of 681 deer examined by egg flotation to be infected. Of 372 deer from

South Texas, 3 were infected with M. benedeni (Samuel 1969). Mugwanya (1971) found eggs in 12% of 116 Illinois deer. Cook (1972) confirmed this by finding a 15% incidence in 40 deer.

Moniezia expansa has been reported from Massachusetts (Rankin 1946) and in Minnesota (Whitlock 1939). Swanson (1959) reported 2% of 47 deer from Michigan were infected with M. expansa. Dahlberg and Guettinger (1956) reported findings of M. expansa from studies done on 233 deer from Wisconsin. Samuel and Beaudoin (1966) found 1.7% infection from 120 deer shot in Pennsylvania.

Moniezia sp. have been reported in North Carolina by Schilling (1938). Prestwood (1971) explains that Moniezia sp. were the most common tapeworms found in southeastern white-tailed deer and were found in 3.5% of 822 examined. Prestwood (1971) found these cestodes in Arkansas, Florida, Georgia, Louisiana, Maryland, Mississippi, North Carolina, South Carolina, Texas and Virginia. Both M. benedeni and M. expansa occurred but could not be separated because of poor fixation.

Thysanosoma actinioides is found in the small intestine of O. virginianus as well as livestock (Dikmans 1939). Dahlberg and Guettinger (1956) also report findings of T. actinioides from studies done on 233 deer from Wisconsin. T. actinioides was found in 1% of 83 deer shot in North Dakota (Boddicker and Hugghins 1969). Samuel (1969) also reported it in south Texas white-tailed deer. Prestwood (1971) reported 0.6% of 822 white-tails from Arkansas were infected. The low incidence of adult cestodes in southeastern white-tailed deer reflects the browsing rather than grazing habits of deer (Prestwood 1971). She says also that the intermediate host does not live well in forest as do the deer.

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