1971

Protozoan and Helminth Parasites of White-Tailed Deer (Odocoileus virginianus) in Southern Illinois

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Protozoan and Helminth Parasites of White-tailed Deer (Odocoileus virginianus) in Southern Illinois

(TITLE)

BY

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B. S., Baldwin-Wallace College, 1970

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

Master of Science

IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
CHARLESTON, ILLINOIS

1971
YEAR

I HEREBY RECOMMEND THIS THESIS BE ACCEPTED AS FULFILLING
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have examined a thesis entitled

Protozoan and Helminth Parasites of White-tailed Deer

(*Odocoileus virginianus*) in Southern Illinois

Presented by

Sarah M. Mugwanya

a candidate for the degree of Master of Science

and hereby certify that in their opinion it is acceptable.

ACKNOWLEDGMENTS

I owe particular gratitude to Dr. B. T. Ridgeway who suggested the problem and whose guidance, criticism, and encouragement were invaluable. Special thanks are due to Dr. R. D. Andrews for the advice, assistance, and support offered on numerous occasions, and to Dr. G. T. Riegel for his role in making graduate study at Eastern Illinois University possible. Finally, I am grateful to the many members of the Department of Zoology who helped in numerous ways.

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INTRODUCTION

The present deer population in Illinois is a result of repopulation efforts by private and public agencies, and the rapid adaptations of the introduced white-tailed deer (Odocoileus virginianus) to local conditions. Beginning in 1957 a program of research and testing of deer was inaugurated in Illinois. As a result of this program several papers have been published dealing with various aspects of the biology of deer. Among the studies published are those of Andrews, R. D., 1969; Andrews, R. D., et al., 1964; Ferris, D. H., et al., 1961; Ferris D. H., et al., 1961b; and Ferris and Vert, 1964. To my knowledge, there are no recent studies dealing with the protozoan and helminth parasites, or host-parasite relations of Illinois white-tailed deer.

The present investigation was undertaken with the aim of contributing to an understanding of the kinds of parasites occurring in local deer. Knowledge of the effect of parasites on deer and/or other animals sharing the same range with the deer is a secondary objective.

LITERATURE REVIEW

The white-tailed deer (Odocoileus virginianus) is a host of many parasites, has a wide distribution, is very adaptable, and shares a number of parasites with wild and domestic ungulates. It also serves as an intermediate host for some parasites.

The geographical distribution of parasites in deer may depend on the presence of reservoir animals, such as, moose, elk, or livestock in particular regions, but not in others. Also involved are local characteristics of the region, for example, climate, soil, flora, topography and land use, which may be more favourable for parasitism in one area than in another.

According to Anderson (1962a), the white-tailed deer is host to about 66 parasites, and of the 66 only seven have been reported exclusively from the white-tailed deer in North America. These seven are, lungworms Leptostrongyle alepenae and Protostrongylus coburni; the trichostrongyles Ostertagia mossi and Ostertagia odocoilei; the strongyles Eucyathostomum longesubulatum, the fluke Paramphistomum liorchia; and the louse Lipoptena mazemae. Anderson (1962a) also notes that certain other parasites are restricted to cervidae, and a few are widely distributed in ungulates.

Parasite relationships between livestock and the white-tailed deer cannot be overlooked. Samuel (1967) and Samuel and Trainer (1969), reported that white-tailed deer and domestic ruminants possibly share many of the same parasites, but that only a few had been studied sufficiently to clarify the host role in the epizootiology of the disease

produced. Samuel (1967), found that of 33 helminths reported from white-tailed deer, 27 also occur in domestic ruminants. Anderson (1962b) also warns that there are many gaps in our knowledge of the incidence and distribution of deer parasites and the role they may play in causing disease and mortality resulting in declines of deer and livestock populations. In view of the rapidily expanding deer population the importance of deer disease and parasite relationships for domestic livestock has become increasingly apparent in recent years. Anderson (1962b) mentions that of 66 or more parasites of white-tailed deer, at least 36 are transmissible to domestic livestock in which many, (such as, the liver fluke and lungworms) can be highly pathogenic.

Anderson (1962b) points out that overpopulation, malnutrition, and severe parasitism go hand in hand and that transmission of parasites is largely a matter of chance encounter among susceptible deer and infective parasite stages. Anderson refers to the work of Volkernberg and Nicholson (1943), and Herman (1945b), who suggested that lack of browse on overpopulated ranges forces deer to graze more and chances of ingesting infective forms of parasites are increased. Several suggestions are made by Anderson for the eradication of disease in deer herds. Samuel (1967) points out that as food resource material is depleted, parasitic infections could become more important in their effect on the host. Longhurst and Douglas (1953), found that nutrition competition, resulting from poor range conditions, resulted in lack of ovulation and therefore lack of breeding in the Columbian black-tailed deer (Odocoileus hemionus columbianus). He also reports that malnutrition leads to poor physical condition, and animals in poor condition have larger numbers of parasites and are less able to withstand their effects.

Samuel and Trainer (1969), observed that prevalence of both Nematodirus filicollis and Eimeria spp. was highest in deer from the grassland-oak areas of Southern Wisconsin. These areas are dominated by grass and rich soils ideal for the production of agricultural crops. These conditions also force deer to graze rather than browse and are apparently conducive to transmission of Nematodirus and Eimeria.

The season of the year has been found to be of importance in deer parasitism, especially with regard to parasites possessing direct life cycles (Longhurst and Douglas, 1943; Boyden, 1961; and Samuel, 1969). Eggs laid by adult worms in the digestive tract and lungs pass out with the feces. The larval worms hatch out and after a series of developmental stages, if suitable conditions prevail, are ingested by a grazing deer or other animals. Thus moist months with other suitable conditions seem to facilitate the transmission of parasites with direct life cycles.

Age of the deer may play some role in infection, (Samuel 1967, 1969). Young animals, because of demand on their nutritive intake for growth, are in a relatively poor position to withstand attacks by parasites. Likewise they have no acquired immunity to parasites and their small size and lack of experience in foraging make it difficult for them to compete with older animals for food. Swanson (1959), Boyden (1961), and Samuel (1969) noted higher mortality among male fawns. Longhurst and Douglas (1943), in their study of the Columbian black-tailed deer, mention that the reasons for selectively high male fawn mortality are obscure. Male animals in general are known to have a slightly higher metabolic rate than females, and their food requirements may therefore be a trifle greater. None of the other authors gave or suggested reasons for high mortality rates among males.

On parasitism in the white-tailed deer, Forbes (1961) states that coccidia parasites are found in many animals including livestock, and while they are of minor clinical importance in many, they can be a serious affliction of some animals, particularly cattle. Coccidians produce lesions of the intestinal track and liver in the animals infected. Forbes (1961) says that tapeworms seldom cause mortality although severe infections cause deer to be in a poor physical shape and therefore more likely to be victims of other parasites. Stomach worms are blood suckers, and large numbers cause serious anemia or digestive irregularities, (Forbes, 1961). Incidence varies depending on distribution of the animals and there are fewer infections in deer than in livestock because deer are primarily browsing animals whereas cattle and other ruminants are largely grazing animals.

Anderson (1962b), summarizes the literature on nematode and arthropod parasites of the white-tailed deer. Three genera of Prostrongylinae have been reported from the white-tailed deer. Dikmans (1935) reported Prostrongylus sp. and Pneumostrongylus sp. in lungs of white-tailed deer in Michigan. Coburn (1935) also reported lungworms in white-tailed deer in Michigan. Dikmans (1935b), described the morphology and bionomics of Prostrongylus coburni and Pneumostrongylus alpenae on the basis of material sent to him by Coburn from Michigan. O'Roke (1936), also commented on the existence of P. coburni in Michigan. Goble (1941), gave a detailed account of tissue changes in the lungs of deer in Michigan infected with Dictyocualus and a species he called P. coburni. He concluded that about 51 per cent of the animals examined were infected with P. coburni and that the eggs and larvae were the principle cause of the histopathology found in the lungs. Cheatum (1942), and Goble (1943),

reported the presence of P. coburni in New York. Thirty per cent of deer killed by hunters were infected with what was identified as P. coburni, but 100 per cent of the animals found dead or dying were infected. Thus lungworms may be a significant mortality factor in deer.

Dougherty (1945), transferred P. alpenae to Varestrongylus. Dougherty and Goble (1946) made alpenae a type of the new genus Leptostrongylus. Cheatum (1947) noted that deer fed on mollucs infected with Leptostrongylus began passing larvae 67 days later. Large numbers of eggs and larvae were found in the lungs, but no adult worms were found. O'Roke and Cheatum (1950), reported that first stage larvae of L. alpenae were not infective to deer. Deer pastured where Buccinea retusa, Polygra albolabris, and other snails existed, became infected. Larvae appeared in the feces 49 days later. Thirty-five days were required for the larvae to reach the infective stage in snails. Cheatum (1951), cited the work of Goble (1941) whom he believed was working with L. alpenae, and reported that there was apparently a relationship between infestation of lungworms and the pneumonias frequently encountered in deer dying during winters in New York.

Dougherty (1945) described Pneumostrongylus tenuis on the basis of a single specimen from a small bronchiole in a white-tailed deer from Delmar, New York. Skulz (1951) made P. tenuis a type of the monotypic genus Odocoileostrongylus.

Two species of Dictyocaulus are reported from the white-tailed deer. Dictyocaulus viviparus, the cattle lungworm, was reported in deer in Michigan by Dikmans (1935a) and O'Roke (1936) and in New York by Whitlock (1939). Whitlock (1939), thought that the occurrence of Dictyocaulus spp. in white-tailed deer was accidental and dependent

upon the presence of deer on cattle or sheep grazing land. However, D. viviparus occurs rather commonly in Algonquin Park, Ontario, miles from either cattle or sheep, (Anderson, 1962b). Samuel (1969), reports D. viviparus as a rare nematode in deer.

Fascioloides magna has been reported in white-tailed deer in several places in North America: New York, Mississippi, Florida, Ontario, and Michigan.

Dicrocoelium denritiam was found by Mapes and Baker (1950), in the livers of three white-tailed deer in New York (Madison County) where this fluke parasitizes sheep and cattle. Paramphistomum cervi and P. liorchis were reported by Dikmans (1939) as parasites of white-tailed deer in North America.

Many of the trichostrongyles reported from Odocoileus virginianus are primarily parasites of livestock (Anderson, 1962b). Dikmans (1931) found Ostertagia in deer from Pennsylvania and Louisiana. He reported O. odocoilei, O. mossi, and O. circumacincta in 107 deer examined in Florida. Cheatum (1952) found Ostertagia sp. in only three of 206 fawns and three of 221 adult white-tailed deer examined in New York.

Haemonchus similis, a cattle parasite, was found in nine deer in Florida by Dinaburg (1939). Dikmans (1934) reported female Cooperia spp. from white-tailed deer in New York. Van Volkernberg and Nicholson (1943) found C. punctata and C. pectinata in the small intestine of deer in Texas.

Haemonchus contortus, essectially a sheep parasite, was reported in the stomach of deer in Florida, New York, and Texas by Dinaburg (1939). Whitlock (1939) noted its presence in deer presumably from Michigan, and Van Volkernberg and Nicholson (1943) recorded this species in deer in Texas.

Samuel (1969) recovered Spiculopteroides odocoilei in 172 of 176 (98 per cent) deer examined; H. contortus, O. mossi, and T. axei were recovered in 88, 68, 73 of 176 deer examined respectively in Texas. Dikmans (1939), mentioned Nematodiris sp. as a parasite of Odocoileus virginianus. Whitlock (1939), reported N. filicollis in deer in Michigan. Van Volkernberg and Nicholson (1943) found N. spathiger and N. filicollis in the small intestine of deer in Texas. Both species are livestock parasites. Finally, Van Volkernberg and Nicholson (1943) reported Trychostrongylus columbiformis in the small intestine of deer in Texas.

Samuel and Trainer (1969) reported two types of Trichostrongylid eggs. They recovered eggs of the thread neckworm N. filicollis from feces of 122 deer. Species identified at necropsy were: The stomach worms Ostertagia dikmans, O. mossi, and O. odocoilei; the stomach hairworm Haemonchus axei; and the large stomach worm H. contortus. Samuel (1969), also observed a definite pattern of adult nematode distribution within the abomasum. Longhurst and Douglas (1943) identified 39 kinds of parasites from sheep and deer and of these, 20 species were found common to both animals. Nematodes belonging to the genera Ostertagia, Trychostrongylus, and Dictyocaulus were represented.

According to Anderson (1962b), only three species of Strongylidae have been reported from white-tailed deer. Chabertia ovina was found by Dikmans (1934) in a deer from New York. Euchathostromum longesubulatum was found in the large intestine of 12 white-tailed deer in Florida (Dinaburg 1939). Oesphagostrumum venulosum was mentioned as a parasite in Michigan deer by Dikmans (1939), and by Whitlock (1939). Further notations are by Olen and Fenstermacher (1943), in Minnesota, and by Samuel and Trainer (1969), in Wisconsin. Samuel and Trainer (1969) also reported the meningeal worm Odocoileostrongylus tenuis in 105 deer fecal samples.

Apparently the only spiruroids reported from white-tailed deer are species of Gongylonema (Anderson, 1962b). Dikmans and Lucker (1935), identified Gongylonema pulchrum from the esophagus and tongue of a deer from North Carolina. Dinaburg (1939), subsequently found G. verrucosum in four animals in Florida. Both these spiruroids occur in the wall of the alimentary tract of domestic ruminants. Eggs are released through an opening into the lumen of the gut, and beetles and roaches serve as intermediate hosts. The eggs are ingested by these insects when feeding on feces contaminated with eggs. Samuel (1969), reports Gongylonema pulchrum as a rare nematode that occurs in deer.

Dinaburg (1939), reported Capillaria sp. in six white-tailed deer and Trichuris sp. from a single deer in Florida. Cheatum (1952), also found Trichuris spp. in the intestine of deer in New York. Samuel (1969), also found Trichuris ovis in deer in Texas, and reported it as a rare nematode of white-tailed deer. Trichuris spp. and Capillaria spp. are difficult to locate in the host and they may occur more commonly than the paucity of records indicate (Anderson, 1962b).

The larvae of Taenia hydatigena of dogs and of wolves is a common parasite of the liver and mensenteries of white-tailed deer in Ontario (Anderson, 1962b), and have been reported in Zoo deer in Kansas, Minnesota, British Columbia, and in New York. Cheatum (1952), reported acute and fatal hepatitis caused by migrating larvae. Honess and Winter (1956) claimed, "in extremely heavy infections the viceral organs are knotted together by the cysts until their function is impaired." Sweatman and Plummer (1957), however, found no evidence of tissue damage in lambs. Sweatman (1957a), also showed that infection in lambs conferred immunity. Unfortunately, similar studies using deer have not been made (Anderson, 1962b).

Taenia lyris was reported to have intermediate stages occurring in deer by Skinter (1935).

Thysanosoma actinoides is found in the small intestine of white-tailed deer, mule deer, and antelope, as well as livestock, in North America according to Dikmans (1939). Allen (1959), published evidence that Liposcelis bosty, Choquotrilus sp., and Rhyodocus sp. (Psocoptera corrodentia) are suitable intermediate hosts.

Moniezia benedini, and Moniezia expansa have been found rarely in white-tailed deer in Minnesota (Whitlock, 1939); Rankin (1946), made a similar observation in Massachusetts, although they occur commonly in many other wild and domestic ruminants. Olsen and Fenstermacher (1943) did not recover Moniezia from deer examined in Minnesota, but they found it commonly in moose in the same area. Oribatid mites serve as intermediate hosts. Samuel (1969), noted that deer of the Welder Reserve served as intermediate hosts for the parasite Taenia hydatigena, and mensenteries or liver surfaces of nine per cent of 272 deer were infected. Thynosoma actinoides was found in four per cent of 257 deer . Samuel also detected eggs of M. benedini from three deer, but adult tapeworms were recovered in 61 small intestines examined.

Honess (1956), lists Eimeria arlongi, Eimeria intricata, and Eimeria parva as parasites found in Roe deer. Martin (1909), reported Eimeria zurnii as a parasite found in deer. Dallberg and Guettinger (Samuel, 1966) reported E. zurnii in three white-tailed deer in Wisconsin. Samuel and Trainer (1969), also reported Eimeria spp. in deer in Pennsylvania. Samuel (1969) recovered two species of Eimeria, one of which had not been reported from white-tailed deer before. Samuel (1969) mentions

that his data showed that deer achieved a partial immunity to the coccidia, possibly because of ingestion of small numbers of oocysts over a period of time. Adults carried light infections and were apparently the reservoirs of infection for the young. Deer were most frequently infected during the winter. Fawns were exposed mainly in the fall and early winter; food shortage and severe weather increased prevalence and abundance of parasites according to Samuel (1969).

MATERIALS AND METHODS

Fecal samples were collected from deer (Odocoileus virginianus), killed in southern Illinois by hunters in the 1970 deer season, during November 20, 21, 22 and December 11, 12, 13. Collections were taken at Illinois Department of Conservation Deer Check Stations in Hardin, Massac, Pope, and Saline counties. Fecal samples were taken from all non-field dressed or incompletely field dressed deer. When possible, two fecal samples were collected from each deer. Each sample was identified with the accession number of the deer to permit correlation of parasite data with age and sex data. Samples were preserved according to the methods of Levine (1961). One fecal sample was placed in a labeled vial containing 10 ml. of a 2.5 per cent potassium dichromate solution. The second sample was placed in a vial containing a solution of MIF-Stain (Merthiolate Iodine Formaldehyde Stain) composed of 4.7 ml. MF solution and 0.30 ml. of a five per cent Lugol's solution. Vials were refrigerated for transportation to the laboratory at Eastern Illinois University, Charleston, Illinois.

On arrival at the laboratory, the dichromate samples were stirred and poured out into Petri dishes in order to facilitate sporulation. An additional 10 ml. of potassium dichromate solution was added to each sample. The Petri dishes were covered, and placed on shelves at room temperature for ten days after which they were transferred to a cooler at 43°F. Oxygen is necessary for sporulation of oocysts, so the Petri

dishes were loosely covered to permit air circulation. The MIF-Stain samples, still in vials, were stored in the laboratory at room temperature. Samples were withdrawn as needed for parasite examination.

Modification of Sheafher's Sugar Floatation Technique (Benbrook and Sloss, 1961) was used. No formaldehyde was added to the sugar solution since it was used soon after preparation. Standard 75x25 mm. slides, 18x18 mm. coverslips and a binocular microscope, with 10x and 45x objectives, were used to examine the fecal samples.

The MIF-Stain sample to be examined was poured into a paper cup. About 15 ml. of the sugar solution were added to the sample in the paper cup. The mixture was thoroughly stirred and poured through a four-layered cheese cloth into another paper cup. To ensure that all the useful filtrate passed through the cheese cloth, fecal debris on the cheese cloth was pressed with a headed glass rod until almost dry. The filtrate was then poured into a 15 ml. test tube and centrifuged at 1500 r.p.m. for six minutes.

A dichromate sample to be examined was treated in the same way as MIF samples, except that before the sugar solution was added the sample was concentrated by centrifuging at 1500 r.p.m. for six minutes. The supernatant was decanted and approximately 15 ml. of the sugar solution were added to the sediment and thoroughly mixed. The sample was then passed through a cheese cloth and treated as the MIF-Stain sample described above.

The method of Benbrook and Sloss (1961), for transferring parasite eggs, larvae, and oocysts, from the test tube onto a slide was used. The area of the slide under the 18x18 mm. coverslip was examined for parasite eggs, oocysts, or larvae, using the 10x and 45x objectives of

the microscope. One preparation from each deer sample was examined. General characteristics (e.g., state of development, nature of wall, number of sporocysts, and inclusions), measurements (length, width, thickness of wall), and a sketch of each parasite seen were recorded. Photographs of parasites seen were taken, with attention given to scale, using Kodak Panatomic X film. Based on data obtained, eggs were divided into groups according to size and shape. The mean and standard deviation of measurements of each group were calculated. The Student's t-test was used to determine if there were significant differences between apparently similar groups.

In this study, six months old deer are referred to as fawns, one and a half years old deer are referred to as juveniles, while two and a half, three and a half, and four and a half years old deer are called adults.

RESULTS

Two fecal samples were examined from each of 116 deer examined from four southern Illinois counties. All deer sampled were considered to be part of one population since the four counties of Hardin, Massac, Pope, and Saline are contiguous. The number of samples collected from each county differed. This was largely because the number of deer killed, per county, varied. Deer ages ranged from six months to four and a half years old, inclusive (Table I).

Microscopic examination for eggs, larvae, or oocysts revealed fifteen probable species of helminths and protozoans. Parasites were recovered in 94 of the 116 deer examined. Twenty times (17.4 per cent) parasites were recovered from both the MIF-Stain and potassium dichromate samples. Fifty-four times (46.5 per cent) parasites were recovered only from the MIF-Stain samples, and 20 times (17.4 per cent) parasites were recovered only from the potassium dichromate samples.

Protozoans

Only coccidian protozoans were detected from the 116 samples examined. Three probable species of coccidia were detected (Table II). Upon sporulation, all oocysts exhibited four sporocysts, each containing two sporozoites.

Species 1:

Species 1 was recovered from ten (8.6 per cent) of all deer examined. Seven so infected were males and three were females. A representative of

Table I

Age, number, and sex distribution of 116 white-tailed deer (*Odocoileus virginianus*) killed in four southern Illinois counties, in the Fall of 1970.

Age in Years	Total	Male	Female
1/2	53	31	22
1-1/2	32	25	7
2-1/2	23	16	7
3-1/2	5	5	0
4-1/2	3	2	1

Table II

Incidence of coccidia observed in fecal samples collected from 116 white-tailed deer (Odocoileus virginianus) from four southern Illinois counties, in the Fall of 1970.

	Total		Fawns						Juveniles						Adults					
			Total		Male		Female		Total		Male		Female		Total		Male		Female	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Species 1	10	8.6	10	18.8	7	22.5	3	13.6	-	-	-	-	-	-	-	-	-	-	-	-
Species 2	27	23.2	16	13.7	12	38.7	4	18.2	7	21.8	5	20	2	28.5	4	12.4	3	13.0	1	12.5
Species 3	3	2.5	3	5.66	2	6.45	1	4.54	-	-	-	-	-	-	-	-	-	-	-	-

this species is shown in Figure 1. Oocysts of this species were oval with rough thick walls and a micropyle one-sixth the width of the oocyst diametre. The greatest width was 29.4 to 33.6 microns (average, 31.0 microns). The greatest length of the oocysts varied from 46.2 to 58.8 microns (average, 47.6 microns).

Species 2:

Species 2 was seen most frequently. It was detected from 27 (23.2 per cent) of all deer examined. Sixteen infected animals were fawns; seven were juveniles, and four were adults. Incidence of infection was highest in juveniles and in males. The oocysts of Species 2 were also ovoid in shape, having a micropyle that appeared to be covered by a clear opercular plug. The oocyst walls were quite smooth and thin. A sporocyst residium could be observed in some oocysts. The greatest length varied from 29.4 to 42.0 microns (average, 38.4 microns). The greatest width ranged between 21.0 and 33.6 microns with an average of 22.9 microns. The average thickness of the oocyst wall was 2.8 microns (Figure 2).

Species 3:

Species 3 was detected from only three deer (2.5 per cent) of all deer examined. All infected deer were fawns; two males and one female. These coccidia oocysts were spherical in appearance, and no micropyle was seen. The oocyst walls were thin to the point of being membranous. The diametre of those measured ranged between 21.0 and 25.2 microns (Figure 3).

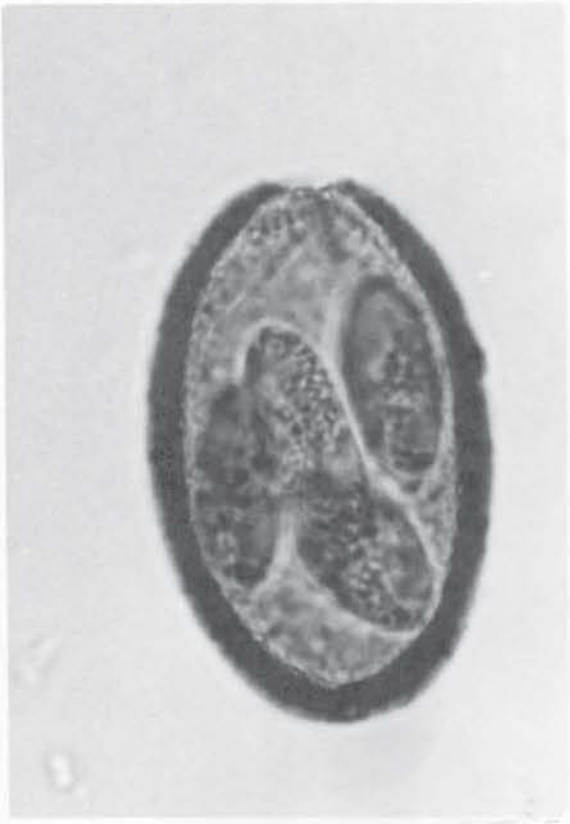
Cestodes

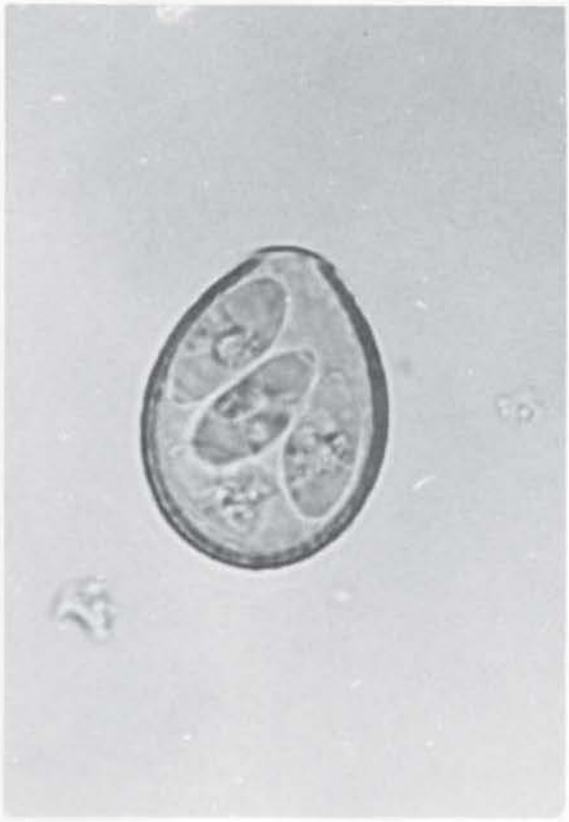
Two kinds of cestode eggs were detected (Table III).

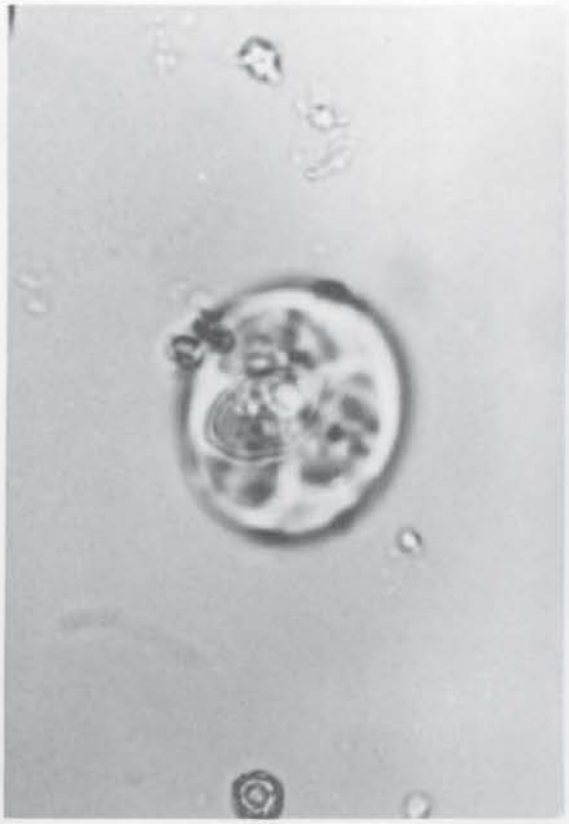
Figure 1--*Eimeria* sp. recovered from ten fawns from four southern Illinois counties, in the fall of 1970.

Figure 2--*Eimeria* sp. detected from 27 white-tailed deer from four southern Illinois counties, in the fall of 1970.

Figure 3--*Eimeria* sp. recovered from three white-tailed deer from four southern Illinois counties, in the fall of 1970.







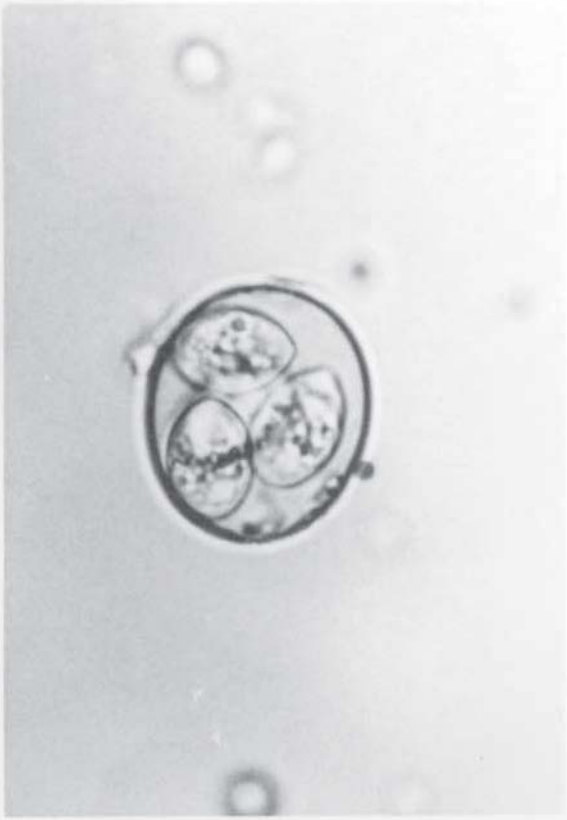


Table III

Incidence of helminths observed in fecal samples collected from 116 white-tailed deer (Odocoileus virginianus) from four southern Illinois counties, in the Fall of 1970

	Total		Fawns						Juveniles						Adults					
			Total		Male		Female		Total		Male		Female		Total		Male		Female	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Cestode																				
Species 1	6	5.2	5	9.4	3	9.67	2	9.1	1	3.12	1	4.0	-	-	-	-	-	-	-	-
Species 2	13	11.2	10	18.8	8	25.8	2	9.1	1	3.12	1	4.0	-	-	2	6.4	2	8.0	-	-
Nematode																				
Species 1	5	4.31	1	1.8	1	3.22	-	-	1	3.12	1	4.0	-	-	3	9.67	1	4.3	2	25.0
Species 2	13	11.2	6	11.3	6	19.3	-	-	3	12.0	2	8.0	1	14.2	4	12.9	3	13.1	1	12.5
Species 3	3	2.5	-	-	-	-	-	-	1	3.12	1	4.0	-	-	2	6.4	2	8.6	-	-
Species 4	2	1.7	1	1.8	1	3.22	-	-	-	-	-	-	-	-	1	3.2	1	4.3	-	-
Species 5	4	3.44	1	1.8	1	3.22	-	-	2	6.25	1	4.0	1	14.2	1	3.2	-	-	1	12.5
Species 6	2	1.7	-	-	-	-	-	-	2	6.25	2	8.0	-	-	-	-	-	-	-	-
Species 7	4	3.44	-	-	-	-	-	-	2	6.25	2	8.0	-	-	2	6.4	1	4.3	1	12.5
Species 8	1	.86	-	-	-	-	-	-	1	3.12	1	4.0	-	-	-	-	-	-	-	-
Species 9	5	4.31	3	5.6	2	6.4	1	4.54	-	-	-	-	-	-	2	6.4	1	4.3	1	12.5

Species 1:

Species 1 had a round shape, thick smooth walls, and the eggs appeared gray in colour. The eggs contained embryos within horned pyriform apparatus, with each embryo possessing six embryonic hooks. This species was recovered from six (5.3 per cent) of the 116 deer examined. All but one of the deer infected were fawns (Figure 4). The diametre of these cestode eggs averaged 70.3 microns (range, 69.3 to 71.4 microns). The walls were 10.5 microns thick.

Species 2:

Species 2 was recovered from 13 (11.2 per cent) of 116 deer examined. The eggs of this species were square in shape, thick walled, and gray in colour. The eggs contained embryos within pyriform apparatus; each embryo possessing six embryonic hooks. It was recovered from ten fawns, one juvenile, and from two adults. Eleven of the infected deer were males (Figure 5). The length of the eggs measured 50.4 to 69.3 microns and the walls were 8.4 microns thick.

Nematodes

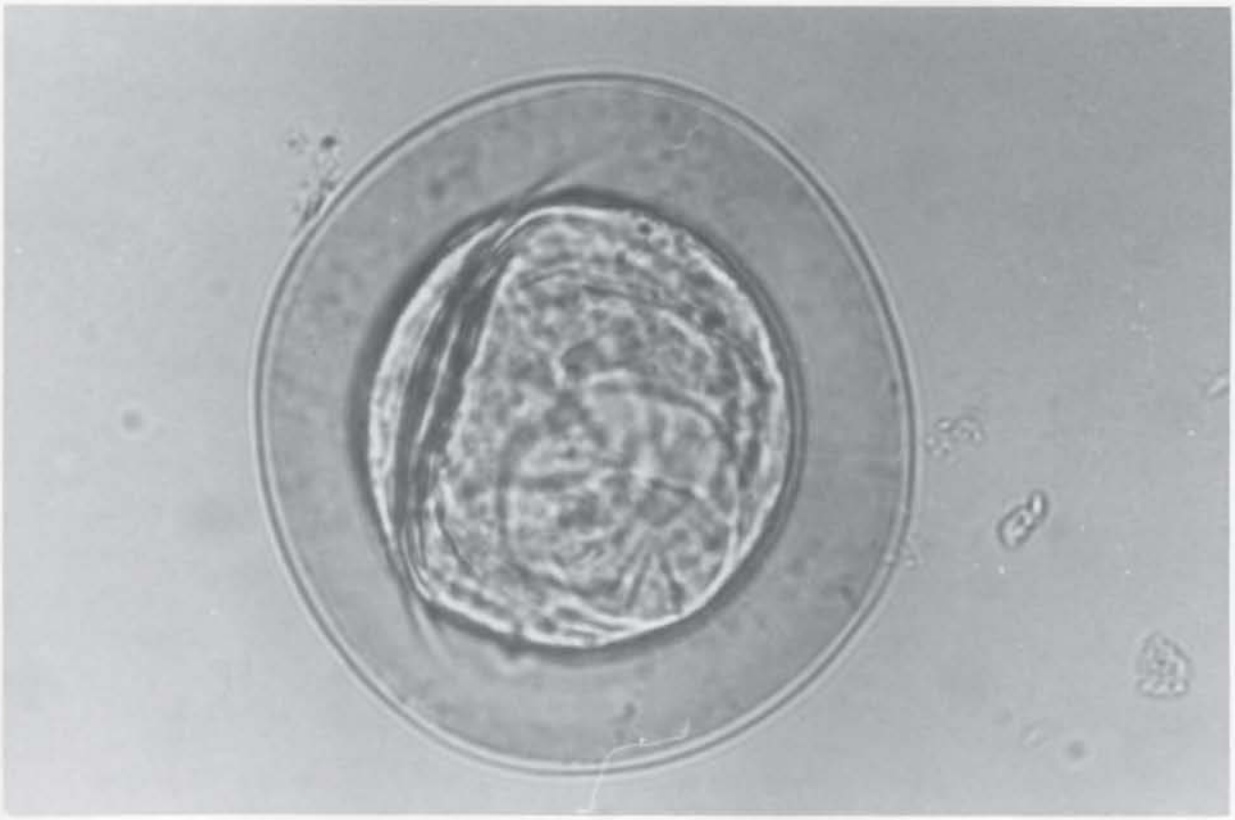
Microscopic examination for eggs and larvae revealed nine probable species of nematodes. Incidence of infection and distribution of these species is shown in Table III.

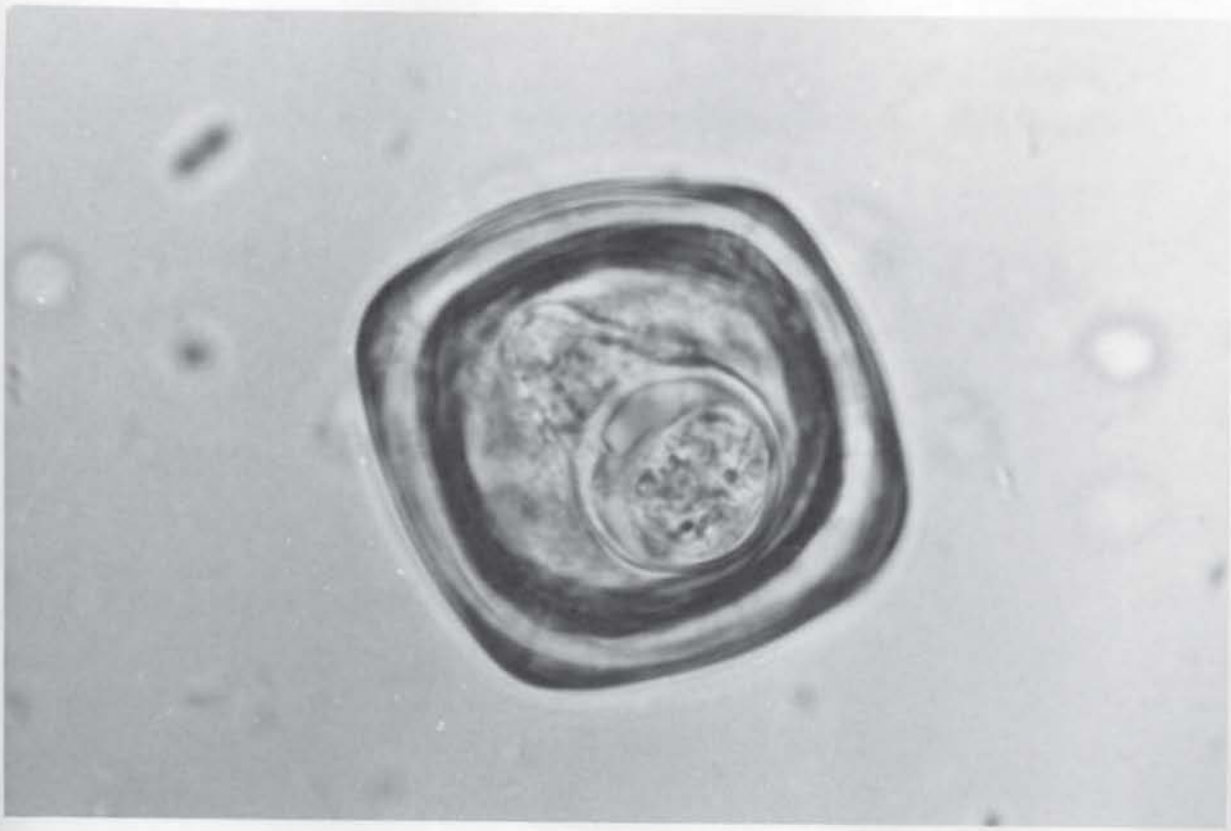
Species 1:

Fecal samples from five deer showed larval nematodes either hatched or at the point of hatching. In most cases the nematode larvae were coiled, making it difficult to take accurate measurements. However, measurements of one larva was taken and it was 273 microns long. The posterior end of the worm measured exhibited what may be a hooked process,

Figure 4--*Anoplocephala* sp. detected from six white-tailed deer from southern Illinois, in the fall of 1970.

Figure 5--*Moneizia benedeni*, detected from 13 white-tailed deer from southern Illinois, in the fall of 1970.





but no clear definition of the structure could be obtained (Figure 6). The nematode eggs of this species, before hatching, were round in shape having thick smooth walls with a larva coiled inside (Figure 7). Only one adult deer showed hatched larval nematodes. One male fawn, one male juvenile, and two female adults were infected with this species. Incidence of infection was highest in the adults. The diametre of the larva containing eggs averaged 63.0 microns.

Species 2:

The eggs of this species were oval in shape, had thin smooth walls with no plugs, micropyle, or operculum. The cellular masses were undifferentiated (Figure 8). Thirteen deer (11.2 per cent) showed presence of this species: six were male fawns; two were male juveniles; one a female juvenile; three male adults; and one a female adult. The greatest length varied from 79.8 to 88.0 microns (average, 84.4 microns). The greatest width measured 29.9 to 46.2 microns (average, 39.2 microns).

Species 3:

Species 3 was recovered from three (2.5 per cent) of 116 deer examined. One male juvenile and two male adults were infected. Here the eggs were oval in shape, with thin smooth walls, no plugs, micropyle, or operculum. The cellular masses were undifferentiated (Figure 9). Eggs measured 50.4 to 56.7 by 29.4 microns.

Species 4:

Species 4 had elongated and oval shaped eggs. The walls were thin, smooth, with no plugs, micropyle or operculum. The eggs contained tightly coiled slender embryos (Figure 10). Measurements of the eggs of this species were 58.8 to 65.1 by 25.3 to 27.3 microns (average, 61.3 by 26.0 microns).

Figure 7--*Dictyocaulus* egg recovered from four of 116 deer examined from four southern Illinois counties, in the fall of 1970.

Figure 6--Nematode larva of *Dictyocaulus* sp. recovered from one of 116 deer examined from southern Illinois, in the fall of 1970.

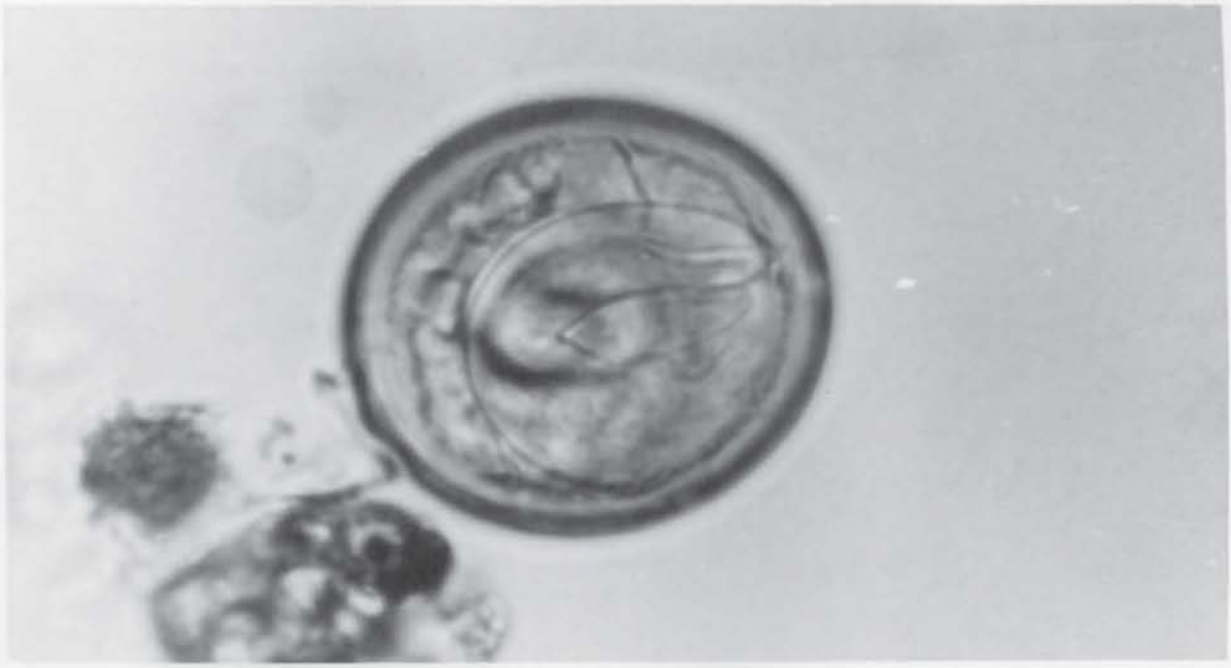
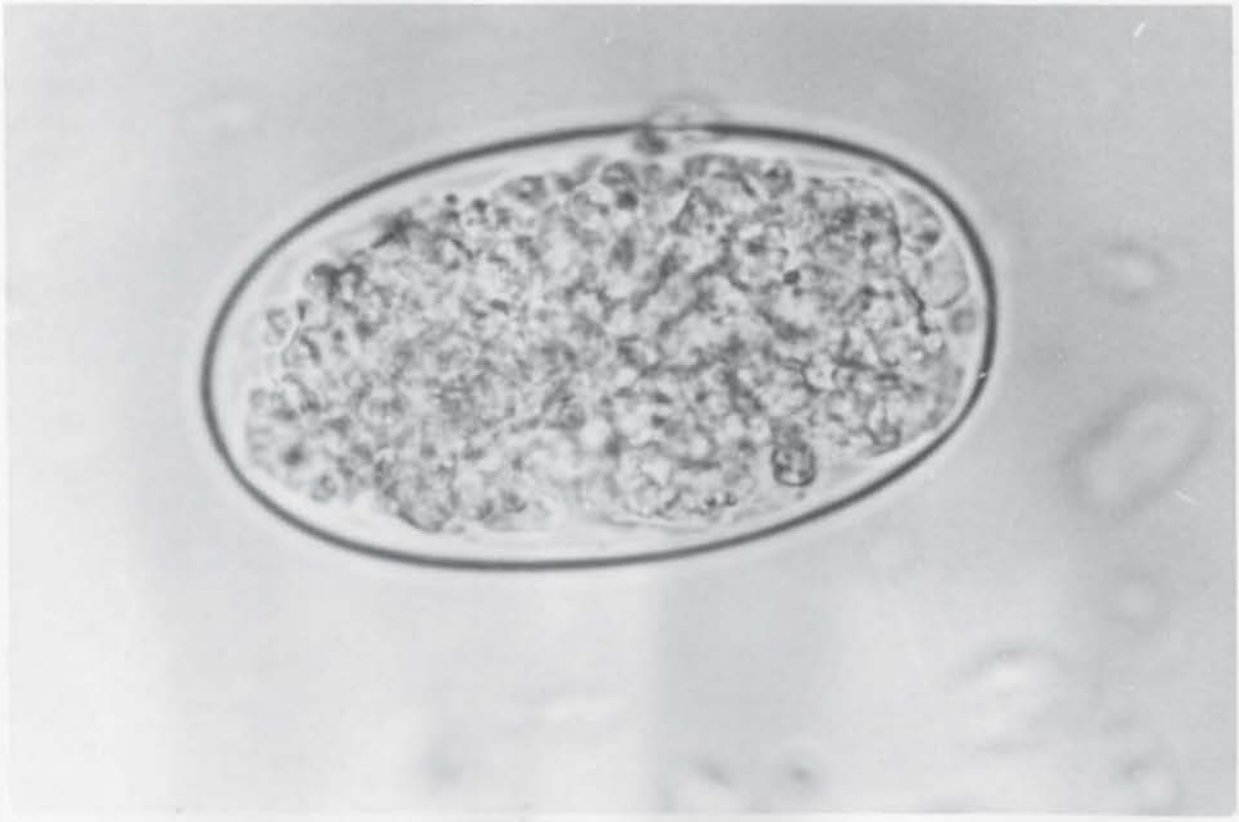


Figure 8--*Oesophagostomum* sp. recovered from 13 of 116 deer examined from four southern Illinois counties, in the fall of 1970.

Figure 9--*Skrjabinema* sp. detected from three of 116 white-tailed deer examined from four southern Illinois counties, in the fall of 1970.



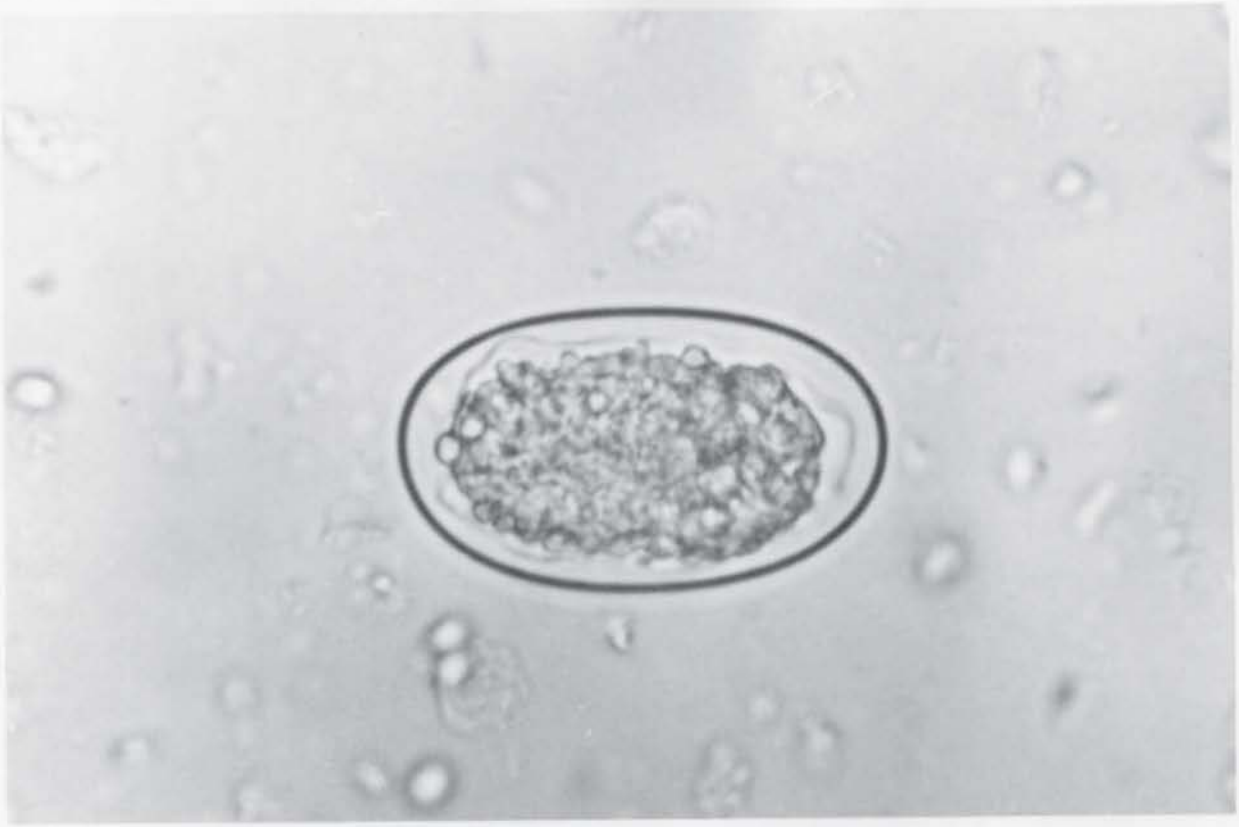
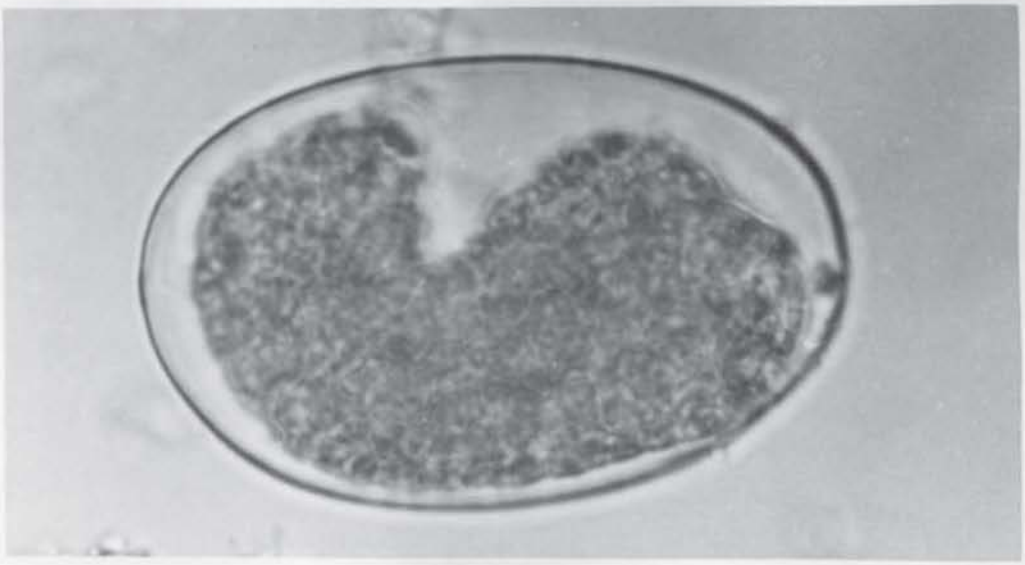
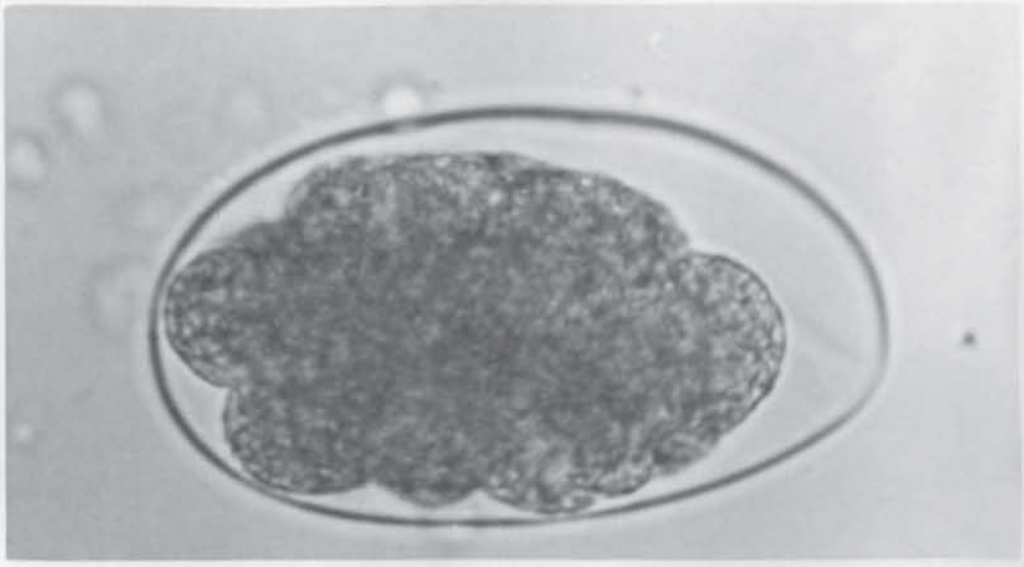


Figure 10--*Strongyloides* sp. recovered from two of 116 deer examined from southern Illinois, in the fall of 1970.

Figure 11--*Ostertagia* sp. recovered from four of 116 deer examined from four southern Illinois counties, in the fall of 1970.

Figure 12--*Ostertagia* sp. found in the fecal samples of two of 116 deer killed in southern Illinois, in the fall of 1970.





Species 5:

In this species the eggs were oval in shape, had thin smooth walls, with no plugs, micropyle, or operculum, and the cellular masses were undifferentiated (Figure 11). These eggs measured 71.4 to 73.1 by 33.6 to 42.5 microns (average, 71.6 by 31.5 microns). This species was detected from four (3.4 per cent) out of 116 deer examined (Table III).

Species 6:

The eggs were ovoid with smooth walls. No plugs, micropyle, or operculum were present. The cellular masses were slightly differentiated. The eggs measured 75.0 to 77.3 by 29.4 to 33.6 microns (average, 76.14 by 30.7 microns). This species was recovered from only two male juveniles (1.7 per cent) of the 116 deer examined (Figure 12).

Species 7:

Species 7 was elongated and had oval shaped eggs with thick rough walls. The eggs were double plugged, and the cellular masses were undifferentiated (Figure 13). Eggs measured 54.6 to 60.9 by 21.0 to 25.2 microns (average, 58.1 by 25.0 microns). These eggs were recovered from four (3.4 per cent) of 116 deer examined: two were male juveniles, and two were adults (male and female).

Species 8:

Species 8 had oval shaped eggs with thick rough walls, which were double plugged and were embryonated (Figure 14). This species was recovered from only one male juvenile of the 116 deer examined (.8 per cent).

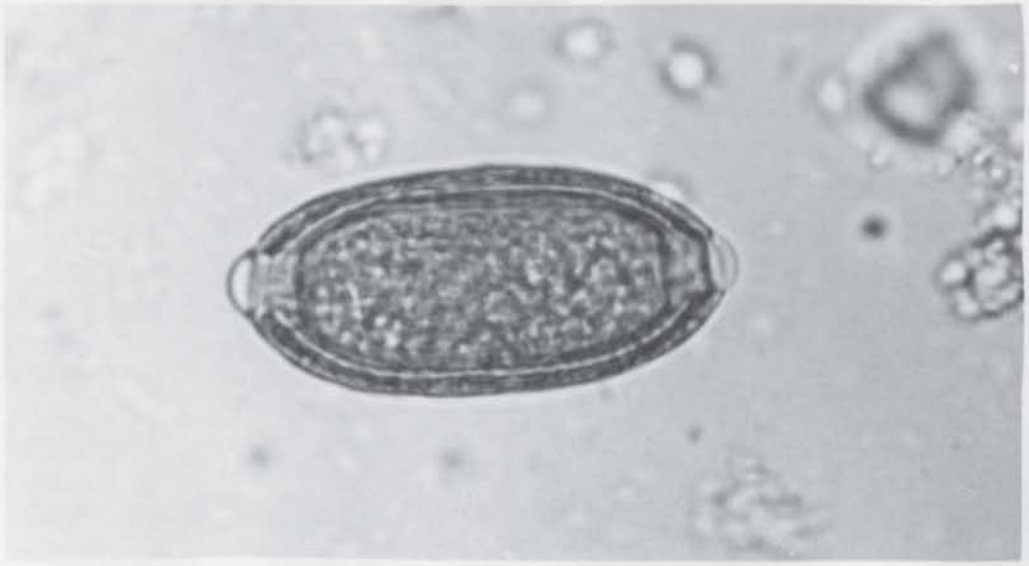
Species 9:

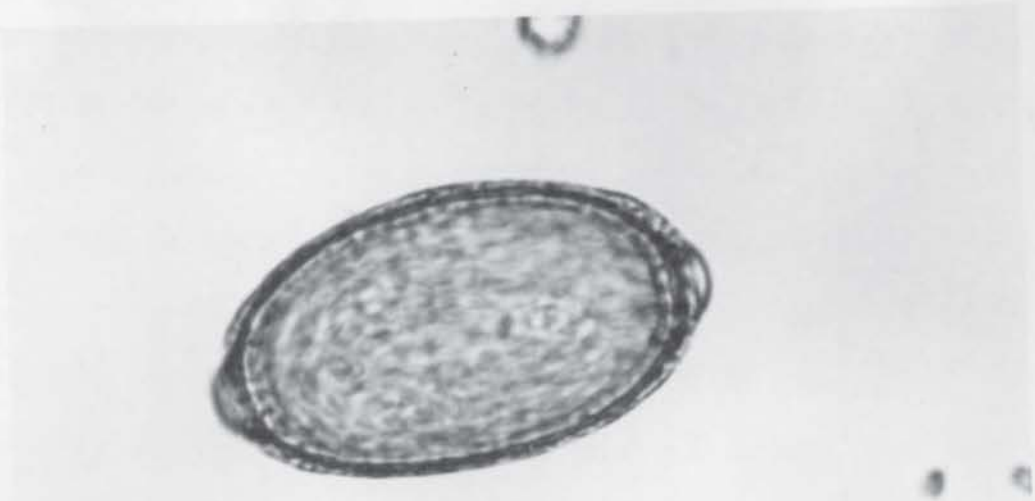
The eggs of this species were oval in shape, narrowing at both ends. They had large opercular double plugs, thick smooth walls, and undifferentiated cellular masses. The eggs measured 71.4 to 88.2 by 23.5 to 42.0 microns (Figure 15). Two male fawns, one male adult, one female adult, and one female fawn were infected (4.3 per cent of 116).

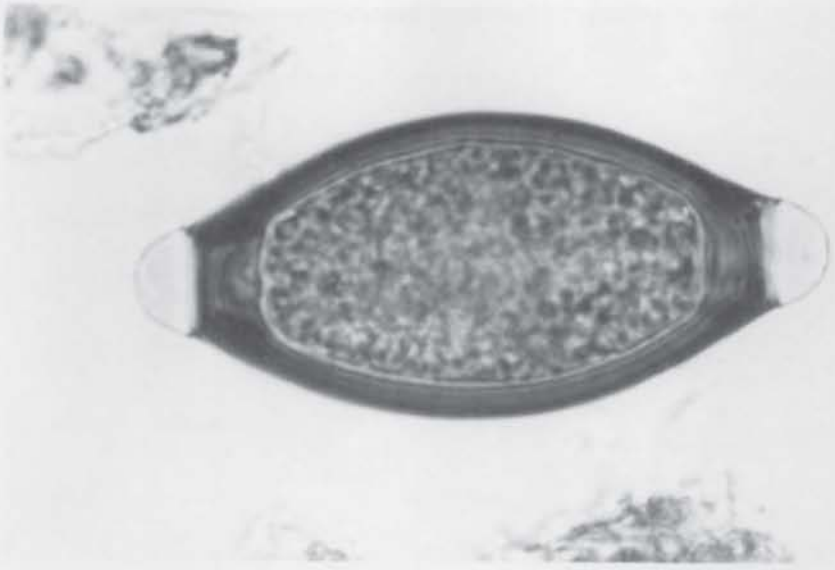
Figure 13--*Capillaria* sp. observed in fecal samples of four white-tailed deer examined from southern Illinois, in the fall of 1970.

Figure 14--*Capillaria* sp. recovered from fecal sample of one of 116 deer examined from southern Illinois, in the fall of 1970.

Figure 15--*Trichuris ovis* recovered from five of 116 white-tailed deer examined from southern Illinois, in the fall of 1970.







DISCUSSION

The results of this study show that the examined white-tailed deer from southern Illinois harbour several kinds of parasites. Two factors that may play a significant role in parasitism in these deer are, the geographical characteristics of the area, and the presence of livestock on the same range as deer. Soil and climatic conditions in southern Illinois are best suited to timber and livestock production; however, a limited amount of cultivation is practiced (Andrews, R. D. et al., 1964). Cattle, sheep, and deer are found scattered over the four county area involved in the study. The highest densities of cattle and sheep are found in the more open areas while the higher densities of deer are found in the more heavily wooded areas. Interspersion of forest, pasture, and cultivated crops prevents complete separation of deer and livestock. Deer in the four counties graze more than browse.

From the results, except for Dictyocaulus sp. and Anopolcephala sp., all the parasites recovered from white-tailed deer in this study were primarily cattle and/or sheep parasites. Sharing the grazing range and the grazing feeding behaviour of livestock, may be important factors influencing parasitism in southern Illinois white-tailed deer.

The results obtained also show that more fawns than juveniles or adults carried infections. This is in agreement with other studies (Samuel, 1967, 1969; Boyden, 1961; and Longhurst and Douglas, 1953). Likewise the incidence of multiple infections were greater in fawns.

Seventeen of 53 fawns (33.7 per cent); six of 32 juveniles (18.7 per cent); and five of 31 adults (16.1 per cent) carried multiple infections. The higher rates of infections, as well as multiple infections, in young fawns could be a result of their lack of immunity either as a consequence of parasitiasis or age immunity. Generally very young animals cannot mobilize their body defenses against invasion as efficiently as adults. For example, very young animals do not produce antibodies at first; depending rather on those acquired from their mothers. Other factors contributing to the high mortality rate in fawns are: competition for food; lack of experience in foraging; and higher nutrient requirements for growth. All these factors place young fawns in a position inferior to adults and may markedly reduce their physical vigor, which in turn may reduce their resistance to parasitic invasion.

Incidence of infection was higher in males than in females. Several studies have reported higher mortality rates in males than in females; Anderson (1962b), Samuel (1969), and Longhurst and Douglas (1953). No clear reasons are known why males have higher mortality rates than females. Longhurst and Douglas (1953) mention that male animals generally have a higher metabolic rate than females and therefore their food requirements may be a little more than that of females. There is need for investigation in this area.

Positive identification of coccidia species is difficult, and in many cases impossible, unless one has knowledge of the endogenous stages of the life cycle, and the specific site occupied by the protozoan in the host tissue. However, the three apparently different kinds of oocysts recovered during the present study were observed to contain four sporocysts, each enclosing two sporozoites. Such characteristics identify

the coccidia as belonging to the genus Eimeria. Eimeria zurnii has been reported from deer in Wisconsin (Dallberg and Guettinger, 1956), and Samuel (1969) suggested E. zurnii as one of the species found in Welder Wildlife Refuge deer. The spherical shape, lack of a micropyle, and thin oocyst wall observed in one species of coccidium taken in the present study, (Species 3, Figure 3) indicate that it may be Eimeria zurnii. However, the fact that E. zurnii is the most pathogenic coccidium in cattle (Levine, 1961), and because white-tailed deer in southern Illinois graze in common with cattle, it is unlikely that this coccidium could be present and unnoticed. A very low incidence of infection among deer, and the widespread use of anticoccidial drugs on livestock, may account for its cryptic occurrence. One cannot discount the implication that white-tailed deer are reservoir hosts of E. zurnii.

The possibility of one coccidia species being Eimeria auburnensis may now be considered. "Species 1" (Figure 1) was observed to be elongated ovoid, with a heavy yellowish mammillated (rough) oocyst wall. The micropyle was wide and clear, and no oocyst residium could be seen. While Eimeria auburnensis has not been reported from white-tailed deer, it is one of the commonest coccidia of cattle in North America (Levine, 1961) and deer may well be host to it. Certainly the description of oocysts of E. auburnensis given by Levine (1961) and by Davies et al., (1963) conforms closely to the morphology of "species 1" (Figure 1), in this paper.

It must be remembered that without knowledge of the biological characteristics of the parasites, relegation to species is speculation. One cannot so readily place the third kind of oocyst (Figure 2) observed during the present investigation. It would seem best to assign it to Eimeria sp. until further data can be gathered.

Moniezia benedeni is primarily a parasite of the small intestine of domestic livestock and wild ruminants. It is not impossible that deer from southern Illinois could be hosts to this parasite because of their close association with cattle and sheep. Deer from southern Illinois graze more than browse and could therefore easily pick up this parasite while grazing. M. benedeni was reported for the first time from white-tailed deer by Samuel and Trainer (1969) in deer from Wisconsin. Anoplocephala sp., on the other hand (to my knowledge), has not been reported from white-tailed deer before. Anoplocephala is a horse parasite. Horses are rare in southern Illinois, but on the other hand horses and deer have similar feeding behaviour and similar intestinal physiology, thus making Anoplocephala sp. a likely parasite to occur in deer. It cannot conclusively be said here that this cestode species (Figure 4), was indeed Anoplocephala sp. Recovery of the adult worm from the gut of deer, collected from the same locale, may furnish positive evidence.

Dictyocaulus sp. are primarily deer parasites. Oesophagostomum spp., (nodular worm of cattle), are primarily cattle parasites but have been rarely reported in white-tailed deer. Skrjabinema spp. are common sheep and cattle parasites reported for the first time from the white-tailed deer in Wisconsin by Samuel and Trainer (1969). Strongyloides spp. are primarily sheep parasites. To my knowledge, Strongyloides have not previously been reported from the white-tailed deer. Ostertagia spp. are primarily livestock parasites but have been reported to occur in white-tailed deer. Capillaria spp. and Trichuris spp. have been rarely reported from the white-tailed deer, but as Anderson (1962b) points out, "they are difficult to locate in the host and the paucity of reports does not necessarily mean they do not occur more often."

The above helminth parasites were identified using Kates and Shorb (1943), Morgan and Hawkins (1960), and Samuel and Beaudoin (1965). Several factors need mention concerning identification of eggs observed in fecal samples: 1) More than one species of a particular parasite may occur together in a host; 2) Preservation techniques and floatation techniques may alter the shape and appearance of helminth eggs to some degree and therefore "key" characteristics may not exactly fit observed characters; and 3) A knowledge of the morphology of the adult worms is useful in order to check egg determinations against postmortem findings. Such identification of adult worms could be obtained by carrying out autopsy examinations on deer. To my best knowledge, eggs in this study were identified to genus as accurately as possible using available data and apparatus. But identifications based on just egg stages should be verified by recovery of adult worms.

Except for Anoplocephala sp. and Strongyloides sp. all other parasites identified in this study have been reported from white-tailed deer before. Except for Anoplocephala sp. all are cattle or sheep parasites. The white-tailed deer has been reported to share certain parasites with livestock and wild ruminants (Anderson, 1962b, and Samuel, 1967). Since deer in southern Illinois use the same grazing land with cattle and sheep, it is not impossible that these parasites do occur in the white-tailed deer from this region. Strongyloides spp., although not reported from white-tailed deer before, are sheep parasites, that could easily be picked up by deer while grazing on the sheep range.

As populations of white-tailed deer continue to increase in Illinois, more attention must be given to their possible role as reservoir hosts for diseases transmissable to man and domestic animals. At present,

the potential for further refined studies relating parasitological findings to host density, climatic conditions, plus other environmental factors, is unlimited.

SUMMARY AND CONCLUSION

A study of the endoparasites of white-tailed deer (Odocoileus virginianus), from four counties in southern Illinois, was carried out during the fall and winter of 1970. Sugar floatation techniques were employed to examine 116 fecal samples collected from deer killed during the hunting season.

Data were collected on age and sex of deer, and parasites observed in the fecal samples. On analysis, 14 kinds of parasites were identified: three coccidian species, all belonging to the genus Eimeria; two genera of cestodes, Anoplocephala, and Moneizia; nine species of nematodes, distributed among the genera Dictyocaulus, Oesophagostomum, Skrjabinema, Strongyloides, Ostertagia, Capillaria, and Trichuris. One cestode genus, one nematode genus, and one species of Eimeria may represent new host records for white-tailed deer. Incidence of infection was highest in fawns for all parasite species except one, Eimeria sp., which showed higher incidence of infection in juvenile deer. A total of 94, of the 116 deer examined, were infected with parasites.

White-tailed deer from southern Illinois harbour several kinds of parasites which were found to be common to both deer and livestock. Such a situation may result, in part, from the fact that deer and livestock in the locality share a common range and common grazing behavior. Results of this study reenforce the assertion that Odocoileus virginianus may be important reservoirs of parasitic diseases transmissible to domestic animals.

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