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ENDOPARASITES AND SELECTED INFECTIOUS AGENTS IN BOBCATS *(Felis rufus)* FROM WEST VIRGINIA AND GEORGIA[1]

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Abstract: A total of 143 bobcats *(Felis rufus)* from West Virginia and 10 bobcats from Georgia was examined for parasites and selected infectious agents. A total of 31 species of parasites was recovered including 1 protozoan, 1 trematode, 4 cestodes, 1 acanthocephalan and 24 nematodes. Results indicate bobcats are important definitive hosts for *Sarcocystis* sp. and *Toxoplasma gondii.* Thirteen species *(Paragonimus kellicotti, Spirometra mansonoides, Taenia macrocystis, T. rileyi, Capillaria putorii, Toxascaris leonina, Toxocara mystax, Ancylostoma braziliense, A. tubaeforme, Oslerus rostratus, Molineus barbatus, Physaloptera rara,* and *Troglostrongylus wilsoni)* were considered common components of the helminth fauna of southeastern bobcats. Host age and/or host density had significant relationships ($P \leq 0.05$) to the prevalences of infection of some parasites. *Salmonella* spp. were isolated from six bobcats, and *Yersinia enterocolitica* was isolated from a single bobcat. Bobcat populations studied did not have overt clinical parasitism or disease during the fall and winter.

INTRODUCTION

Traditionally, the bobcat *(Felis rufus)* has been treated as a varmint with few or no restrictions on harvests. In recent years, however, public attitude towards the bobcat has shifted dramatically with expression of greater concern for the species. The commercial export of bobcat pelts was limited by the 1973 Convention on International Trade in Endangered Species. This controversial action was taken because the Endangered Species Scientific Authority (ESSA) found there were insufficient data on the current status of the bobcat. Subsequent postal surveys of game biologists[4,7] also noted the desirability of better information. In response to this need, greater emphasis is being given to bobcat research and management by wildlife resource agencies.

Among the numerous facets of bobcat ecology, knowledge of parasites and diseases is fragmentary and outdated. Although the parasite fauna reported from bobcats is diverse (2 protozoans, 4 trematodes, 15 cestodes, 3 acanthocephalans, 30 nematodes, and 6 arthropods), relatively few bobcats have been studied and many studies were not designed to recover all internal parasites. Surveys of bobcats for bacterial and viral infections have been almost totally lacking. The only documentation of infectious diseases in bobcats consists of isolated case reports of feline panleukopenia and rabies.[6,17]

In view of need for current knowledge of parasites and diseases of bobcats, the present study was undertaken to survey for parasites and selected infectious diseases of bobcats from West Virginia and

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Georgia. In addition, parasite data were analyzed with respect to various host parameters such as age, sex, density, physical condition, and food habits.

MATERIALS AND METHODS

Skinned, frozen bobcat carcasses were obtained from trappers and hunters with the assistance of the West Virginia and Georgia Departments of Natural Resources during the fall and winter of 1977-78 and 1978-79, respectively. Bobcats from West Virginia were identified by game biologists in the Department of Natural Resources as originating from regions with low (N=23), moderate (N=53), or high (N=67) bobcat population densities. A standardized necropsy procedure[2] included: (1) determination of age class, sex, and weight; (2) evaluation of general physical condition by degree of musculature and fat deposits; and (3) recovery, enumeration, and identification of all helminths. Age was determined by tooth eruption and cementum annuli, and animals were grouped into three age classes (<1, 1-2, and >2 years) for analysis. Bobcats collected from West Virginia consisted of 34 adult males, 37 juvenile males, 39 adult females, and 33 juvenile females. Animals were graded in poor (4), fair (37), good (47), very good (29), and excellent (25) condition. Condition of one animal was not assessed. Ten bobcats obtained from Georgia were examined using the same procedure.

Fecal samples from each bobcat were stored in 2.0% potassium dichromate at 4 C, and Sheather's sugar flotation technique was used to concentrate intestinal protozoa from feces prior to identification. Serum samples were tested for antibodies to *Toxoplasma gondii* by the indirect hemagglutination method (IHA) described by Oertley and Walls.[10] Trematodes and cestodes were stained with Mayer's haematoxylin or carmalum, dehydrated in alcohol, cleared in xylene, and mounted on microscope slides. Nematodes were cleared in

TABLE 1. Parasites recovered from 143 bobcats from West Virginia and 10 bobcats from Georgia.

Parasite	West Virginia		Georgia	
	Prevalence (%)	Intensity Mean (Range)	Prevalence (%)	Intensity Mean (Range)
PROTOZOA				
Sarcocystis sp. (I)*	38	NA	-	NA
TREMATODA				
Paragonimus kellicotti (L) (75815)†	16	14 (1-91)	10	2 (2)
CESTODA				
Mesocestoides variabilis (I)	6	202 (1-1123)	10	1 (1)
Spirometra mansonoides (I)	2	1 (1)	10	11 (11)
Taenia macrocystis (I)	1	5 (3-6)	90	26 (3-109)
Taenia rileyi (I)	71	18 (1-154)	90	23 (3-88)
ACANTHOCEPHALA				
Acanthocephala	4	1 (1)	-	-

TABLE 1. (continued)

NEMATODA				
Ancylostoma braziliense (I) (75827)	19	11 (1-57)	-	-
Ancylostoma tubaeforme (I) (75826)	17	4 (1-45)	40	7 (2-15)
Angiostrongylus gubernaculatus (L) (75816)	20	3 (1-18)	-	-
Capillaria aerophila (L) (75818)	25	2 (1-5)	-	-
Capillaria putorii (S) (75820)	35	18 (1-213)	10	1 (1)
Citellinema sp. (S)	1	14 (14)	-	-
Cyathospirura chevreuxi (S) (75823)	1	2 (1-13)	-	-
Cylicospirura felineus (S) (75822)	10	3 (1-10)	-	-
Cyrnea sp. (S)	-	-	10	1 (1)
Gongylonema pulchrum (S)	1	24 (24)	-	-
Metathelazia sp. (L)	6	3 (1-5)	-	-
Molineus barbatus (I) (75825)	63	26 (1-320)	10	115 (115)
Oesophagostomum sp. (S)	3	2 (1-3)	-	-
Oslerus rostratus (L) (75817)	45	10 (1-76)	10	4 (4)
Oxyuriidae (S)	1	7 (7)	-	-
Physaloptera rara (S) (75821)	27	9 (1-69)	30	7 (1-15)
Rictularia sp. (S)	2	1 (1)	-	-
Trichostrongylus affinis (S)	-	-	10	24 (24)
Trichostrongylus axei (I) (75824)	28	127 (1-746)	-	-
Toxascaris leonina (I)	61	21 (1-197)	-	-
Toxocara mystax (I)	89	44 (1-1258)	80	13 (1-39)
Troglostrongylus wilsoni (L) (75819)	73	16 (1-350)	10	2 (2)
Uncinaria sp. (I) (75767-69)	68	15 (1-157)	-	-
Vigisospirura potekhina (L)	20	2 (1-10)	-	-

*Location in host: (I) Intestines, (L) Lungs, (S) Stomach.
†Numbers in parenthesis indicate USNM Helminthological Collection accession numbers.

glycerine-alcohol or alcohol-phenol for identification.

Two rectal swabs were made. One was added to saline for isolation of *Yersinia enterocolitica* while the second was stored in selenite broth to facilitate isolation of *Salmonella* spp. Liver and spleen tissues were ground for inoculation into Crandall feline kidney cell culture for isolation of feline calcivirus and feline herpesvirus.

Basic descriptive statistics ($\bar{x}$, s^2, S.D.) were applied to the data,[15] and detailed tests (Chi^2, ANOVA, t tests) were performed on a computer utilizing the Statistical Analysis System (SAS).[1] Since only 10 animals were collected from Georgia, statistical analyses were conducted only on data from West Virginia bobcats. All statements regarding statistical significance refer to $P \leq 0.05$.

RESULTS

Parasitologic Findings. Twenty-nine species of parasites (1 protozoan, 1 trematode, 4 cestodes, 1 acanthocephalan, and 22 nematodes) were recovered from bobcats from West Virginia (Table 1). Individual animals harbored 1 to 13 species of helminths. Animals from Georgia were infected with 14 species of helminths including 1 trematode, 4 cestodes and 9 nematodes (Table 1).

Comparisons among age classes indicated significant associations between parasite prevalence and host age (Table 2). Young bobcats were infected significantly more often with *Sarcocystis* sp., *Taenia rileyi, Angiostrongylus gubernaculatus, Capillaria putorii, Molineus barbatus,* and *Physaloptera rara* than old bobcats. Significantly more adults (≥2 yrs.) harbored *Paragonimus kellicotti* and *Oslerus rostratus.* Intensities of infections were not significantly different among age classes. No significant differences in prevalence or intensity of individual species of parasites were noted between host sexes.

Significant relationships also were found between host density and the prevalence of certain species of parasites (Table 2). The prevalences of *Sarcocystis* sp., *O. rostratus, Toxascaris leonina,* and *Uncinaria* sp. increased with host density, whereas the prevalences of *A. gubernaculatus, C. aerophila* and *Toxocara mystax* decreased as host density increased. Relationships between parasite intensity and host density were not statistically significant. Species diversity was equivalent in bobcats from all three host density categories.

Lesions were associated with only a few species of parasites. *Paragonimus kellicotti* produced firm, slightly raised cysts up to 2 cm in diameter in the lung parenchyma. The cysts were filled with viscous dark brown fluid. In some cases there also were excessive amounts of brown mucus in bronchioles and bronchi. Mixed infections of pulmonary nematodes, primarily *Troglostrongylus wilsoni* but also including *A. gubernaculatus, C. aerophila, Metathelazia* sp., and *O. rostratus,* were infrequently associated with a verminous bronchitis characterized by bronchiolar obstruction and mucus exudate. Gastric nodules due to *Cylicospirura felineus* as described by Pence *et al.*[11] were noted infrequently.

Microbiologic Findings. *Salmonella* sp. was cultured from 1 of 143 bobcats from West Virginia and 5 of 10 from Georgia. *Yersinia enterocolitica* was isolated from the feces of one bobcat from Georgia. Feline calicivirus and feline herpesvirus were not isolated by cell culture inoculation.

DISCUSSION

Most species of parasites recovered during the present study have been reported from bobcats, although four species *(Sarcocystis* sp., *A. guber-*

TABLE 2. Species of parasites showing significant differences in prevalence when stratified by host age or host density.

Parasite Species	Age Class*	Prevalence (%)	Density Class*	Prevalence (%)
Sarcocystis sp.	<1	47.1[a]†	L	13.6[a]
	1-2	38.7[b]	M	37.2[b]
	>2	24.4[b]	H	47.8[b]
Paragonimus kellicotti	<1	4.3[a]	L	
	1-2	18.7[b]	M	NS
	>2	34.1[b]	H	
Taenia rileyi	<1	75.7[a]	L	
	1-2	78.1[a]	M	NS
	>2	58.5[b]	H	
Angiostrongylus gubernaculatus	<1	31.4[a]	L	39.1[a]
	1-2	6.2[b]	M	20.7[b]
	>2	9.8[b]	H	11.9[b]
Capillaria aerophila	<1		L	34.8[a]
	1-2	NS[π]	M	39.6[a]
	>2		H	10.4[b]
Capillaria putorii	<1	42.9[a]	L	
	1-2	34.4[b]	M	NS
	>2	21.9[b]	H	
Molenius barbatus	<1	67.1[a]	L	
	1-2	71.9[b]	M	NS
	>2	48.8[b]	H	
Oslerus rostratus	<1	31.4[a]	L	17.4[a]
	1-2	59.4[b]	M	39.6[b]
	>2	56.1[b]	H	58.2[b]
Physaloptera rara	<1	37.1[a]	L	
	1-2	25.0[b]	M	NS
	>2	12.2[b]	H	
Toxocara mystax	<1		L	100.0[a]
	1-2	NS	M	94.3[b]
	>2		H	82.1[b]
Toxascaris leonina	<1		L	17.4[a]
	1-2	NS	M	69.9[b]
	>2		H	70.1[b]
Uncinaria sp.	<1		L	34.8[a]
	1-2	NS	M	75.5[b]
	>2		H	73.1[b]

*Age Class designations are in years and Density Classes are L = low, M = moderate, and H = high.

†Significantly different ($P \leq 0.05$) values are designated with different alphabetical subscripts.

πNS = significant difference ($P \leq 0.05$).

naculatus, *Trichostrongylus axei* and *Uncinaria* sp.) represent new host-parasite associations. Prevalences and intensities of infections also were generally comparable to previous reports.[8,9,12-14,16]

This study provided evidence that the bobcat is an important definitive host for two species of coccidian parasites, *Sarcocystis* sp. and *T. gondii*. The size (11.0-13.2 x 6.6-8.8 μm; N=129) and morphology of *Sarcocystis* sp. sporocysts

from bobcats in West Virginia were identical to that of sporocysts shed by domestic cats fed muscle of white-tailed deer *(Odocoileus virginianus)* from Virginia (James M. Crum; unpubl.). Similar sporocysts also were shed by domestic cats fed muscle of cottontail rabbits *(Sylvilagus floridanus)* from Virginia.[3] The above findings in conjunction with portions of carcasses of white-tailed deer and cottontail rabbits in stomach ingesta of our bobcats (L. Lloyd Fox; unpubl.) suggests deer and rabbits likely are intermediate hosts of the *Sarcocystis* sp. in bobcats.

Information pertaining to *T. gondii* has been presented in detail by Oertley and Walls.[10] These authors found that 27 of 150 (18%) bobcats had IHA antibody titers ≥1:16, but oocysts typical of *T. gondii* were not detected in fecal specimens. Based on the presence of serum antibodies, bobcats were concluded to be contributory to the maintenance of the sylvatic cycle of *T. gondii*.

In their study of helminth parasitism of bobcats, Stone and Pence[16] noted low concentrations of dominance and considerable variation in helminth faunas among bobcats from five different geographic areas in North America. These results were attributed to basic differences in food habits of bobcats throughout their range. Our findings generally support their conclusions. Inspection of information for areas within the Southeast presented by Stone and Pence,[16] in conjunction with data from our study, revealed a degree of uniformity in the regional helminth fauna and disclosed 13 species of helminths that should be considered typical components of the regional helminth fauna of bobcats. These species are *P. kellicotti, Spirometra mansonoides, T. macrocystis, T. rileyi, C. putorii, T. leonina, T. mystax, Ancylostoma braziliense, A. tubaeforme, O. rostratus, M. barbatus, P. rara,* and *T. wilsoni*.

In contrast, several species of helminths recovered in this study probably represented spurious infections, possibly being parasites of prey species. These include the single unidentified acanthocephalan, *Citellinema* sp., *G. pulchrum, Rictularia* sp., *Oesophagostomum* sp., an unidentified oxyurid, *Cyrnea* sp., and *Trichostrongylus affinis*. These parasites often were degenerate, usually few in number, and present in only a small proportion of bobcats examined. A case also could be made for accidental parasitism by *T. axei* with ruminant prey as a source of the parasite; however, the high prevalence and intensity of infection and the non-degenerate condition of the nematodes suggests the bobcat may be a suitable host for *T. axei*.

A point of interest during this study was evaluation of the relationship of parasitism to host density in a manner similar to the abomasal parasite count concept described for white-tailed deer.[5] Parasites useful as indicators of host density must meet certain criteria[5] including (1) a frequent and widespread occurrence, (2) a high degree of host specificity, (3) a statistically significant relationship between levels of parasitism and host density, and (4) a monoxenous life cycle. Only four species *(Sarcocystis* sp., *O. rostratus, T. leonina,* and *Uncinaria* sp.) meet the most significant criterion (statistically significant relationship to density); and of these, only *Uncinaria* sp. potentially could satisfy the remaining three criteria. However, until additional information is obtained relative to criteria 1, 2, and 4, the value of *Uncinaria* sp. as an indicator of bobcat density must be considered speculative.

Examinations for microbiologic pathogens were limited due to the condition of the specimens. The low prevalence of *Salmonella* spp. and *Y. enterocolitica* suggests that bobcats probably are not significant hosts for the maintenance of these organisms. Lesions were not associated with the presence of these bacteria.

An overview of data from this study indicates that these bobcat populations did not have overt, clinical parasitism or disease during the fall and winter.

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