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The Role of Parasites and Diseases in the Diseases in the Distribution and Abundance of Bobcats in New York

Jeanna S. Fox

Rainer H. Brocke

PART III

THE ROLE OF PARASITES AND DISEASES IN THE DISTRIBUTION AND ABUNDANCE OF BOBCATS IN NEW YORK

by

Jeanne Stone Fox
Graduate Research Assistant
Co-principal Investigator
Dept. of Environmental and Forest Biology
S.U.N.Y. College of Environmental Science
and Forestry
Syracuse, New York 13210

(Rainer H. Brocke
Principal Investigator
S.U.N.Y.C.E.S.F.)

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Prepared by: Jeanne Stone Fox

Jeanne S. Fox
Graduate Research Assistant

Principal Investigator: Rainer H. Brocke

Rainer H. Brocke
Senior Research Associate

Mar 18, 1983
Date

Approved by: William F. Porter 18 March 1983

William F. Porter — Date
Project Leader

Approved by: _____

Eugene Parks — Date
Wildlife Biologist

Approved by: _____

Stuart Free, Chief — Date
Bureau of Wildlife

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Job XII - 6

STUDY NUMBER AND TITLE: XII - Biology, Ecology and Range of the Bobcat, Felis rufus in New York and its Inferred Interactions with Potentially Reintroduced Lynx, Felis canadensis canadensis in Adirondack Park.

STUDY OBJECTIVES:

1. To determine and describe the predation ecology, movement patterns, territorial behavior and habitat of bobcats in New York.

2. To determine vital population characteristics and exploitation levels of bobcats in New York.

3. To recommend management alternatives for bobcats in New York on the basis of an information synthesis, range map and model of current bobcat exploitation levels in the region.

4. To make recommendations concerning the feasibility of lynx reintroduction in Adirondack Park based on the inferred level of lynx-bobcat competition and a survey of potential lynx range in the Park.

(1) JOB NUMBER AND TITLE: XII-6. The role of parasites and diseases in the distribution and abundance of bobcats in New York with special reference to the role of the domestic cat as a reservoir host.

JOB OBJECTIVES:

1. To identify and quantify selected parasites and diseases of bobcats and domestic cats in order to determine which species are shared by both cats. (This information will be used to assess the role of domestic cats as reservoir hosts for bobcat diseases and parasites.)

2. To identify and quantify endoparasites which are common to bobcats and other selected carnivores (e.g. red fox, gray fox, eastern coyote and raccoon. This information will be used to determine what endoparasites are feline host specific and to assess the role of selected predators as reservoir hosts of bobcat endoparasites).

3. To determine whether lagomorphs (cottontail rabbits and snowshoe hares) are the primary intermediate hosts of helminths in the bobcat.

4. To determine whether the regional distribution and abundance of bobcats in New York State may be affected by the incidence and mode of transmission of selected diseases and parasites. (This objective will be attained by analyzing all data in Job XII-5 as well as pertinent information in Jobs XII-1 and XII-2.)

Abstract: The diseases and parasites of bobcats Lynx rufus were investigated to determine their role in the distribution and abundance of bobcats in New York State in 1976-80. Antibodies for three viral diseases were detected in the serum. Statewide, 48 of 232 (21%) bobcats had feline panleukopenia antibodies, 36 of 224 (16%) had feline calicivirus antibodies, 112 of 224 (50%) had feline viral rhinotracheitis antibodies. Adult bobcats from the Catskills had a higher prevalence of feline panleukopenia antibodies than all other age classes in the Catskill or Adirondack regions of New York. In the Catskills, 28 of 37 (76%) adults had feline panleukopenia antibodies while in the Adirondacks only 5 of 58 (9%) adults had antibodies. Feline calcivirus and feline viral rhinotracheitis antibody prevalences showed no regional differences. Rural, unvaccinated domestic cats from both the Adirondacks and Catskills had higher antibody prevalences than bobcats for the same three viruses. Parasites were recovered from 215 of 218 (99%) intact bobcat carcasses. Helminths recovered included 10 nematodes, 5 cestodes, 2 trematodes and 1 acanthocephalan. The average infection was 3 helminth species with a mean burden of 38 worms per bobcat. Three nematode species were more prevalent in the Catskills while 2 tapeworm species were more common in the Adirondacks. Toxocara mystax worm burdens were higher in juveniles and yearlings than in adults. Toxoplasma gondii antibodies were present in 51 of 220 (23%) bobcat serums and in 24 of 44 (66%) domestic cat serums. Low parasite burdens minimized the impact of parasites on the bobcat population. Feline panleukopenia is probably an important cause of natural morality and may influence bobcat abundance in New York.

TABLE OF CONTENTS

PREFACE

The initial proposal outlined the collection of predators and snowshoe hares from three study areas in the state for comparisons of helminths with the bobcat. Instead predators and hares were only collected from the central Adirondacks. The logistics of organizing an equitable carcass collection from the other two areas proved to be too difficult and expensive.

It was originally planned to study the parasites and diseases of the domestic cat by collection of carcasses. However humane organizations and shelters refused to allow examination of domestic cats even after euthanasia. In addition for the disease testing only cats with known histories could be used to avoid sampling cats that had been vaccinated. Hence blood samples were collected from rural domestic cats, mainly from farms, with owner permission. Information on parasites was accomplished by a review of the literature from the Northeast. A fecal sample from the large intestine contents of each bobcat carcass was not examined for helminth eggs. It was decided that the process was too time consuming for the value of the information. Fecal samples from livetrapped bobcats were examined for parasites but were not included in the analysis since they did not show the total parasite load and could not be obtained on a consistent basis.

I would like to thank all hunters and trappers who turned in bobcat carcasses and all Department of Environmental Conservation personnel who collected them from around the state. Ward Stone, Mark Brown and Larry Meyers were especially helpful during this project. Dr. Rainer Brocke was instrumental in the formation, supervision and review of the project. I am grateful to Dr. Fredric Scott and the staff of the Cornell Feline Research Laboratory at the New York State College of Veterinary Medicine, Cornell University, Ithaca, N.Y. for their help and direction in the disease testing. Special thanks are given to Mrs. Eleanor Tompkins for her instructions on virological procedures. I would also like to thank Dr. Richard Jacobson of the Diagnostic Laboratory, Veterinary College, Cornell University, for his help and guidance in the toxoplasmosis testing. The assistance of the staff

and graduate students at the Adirondack Ecological Center, Huntington Wildlife Forest, Newcomb, N.Y. is gratefully acknowledged. I appreciate the advice provided by thesis committee members; Dr. Maurice Alexander, Dr. Daniel Dindal and Dr. Justus Mueller. I especially thank Lloyd Fox for his help throughout the project, particularly for his assistance in drawing blood samples from rural domestic cats.

BOBCAT DISEASES

Background

This project was undertaken to assess the role of diseases and parasites in the New York State bobcat population. A concurrent study on population dynamics (W-105-R, Job XII 1-4) provided information on distribution, age structure, home range, food habits, reproduction and behavior of the same study animals. The disease and parasite data were analyzed using this information.

In New York State several diseased bobcats have been recovered and examined by Department of Environmental Conservation pathologist Ward Stone. Feline panleukopenia was diagnosed in cases from both the Adirondacks and the Catskills (W. B. Stone, pers. commun.). A recent study by Watson et al. (1981) surveyed 153 bobcats from West Virginia and Georgia for current viral infections of feline calicivirus and feline herpesvirus. No current viral infections were found, however the enteric bacteria Salmonella spp. and Yersinia enterocolitica were isolated from six and one bobcats respectively.

Bobcat diseases were studied in this project by testing the serum for antibodies. The presence of antibodies in the serum indicates a past or current viral infection because antibodies form in response to viral invasion. The duration of antibodies varies considerably with different viruses. Thus a positive antibody result for an individual bobcat indicates that it has acquired a virus, survived and maintained a testable antibody level. Mortality estimates are based on domestic cat studies. The pathogenesis of these diseases is assumed to be fairly similar in all felines. Felines share many of the same diseases so the reservoir of infection for bobcats is dependent on the total density of susceptible felids. In New York State, domestic cats are the only other free roaming felids and they are frequently not vaccinated. These cats may influence disease transmission in the bobcat population by increasing the presence of the virus in the environment. They may facilitate transmission between bobcats which are widely dispersed. Disease transmission between felids does not depend solely on direct contact as many of the viruses are spread in feces or urine

and may remain viable for extended periods of time. Locally dense populations of farm cats provide possible sources of infection that can be spread rapidly. A small sample of domestic cats was tested in this project to estimate the relative infection levels of the two populations. Feline panleukopenia (FPL), feline calicivirus (FCV) and feline viral rhinotracheitis (FVR) were considered the most important viruses and both bobcats and domestic cats were tested for those antibodies. In addition, serums from live trapped bobcats were tested for feline infectious peritonitis (FIP) antibodies and feline leukemia (FeLV) virus. A brief introduction to these diseases is given here for background information.

Feline panleukopenia (feline distemper) is of major importance to all feline populations as it is highly contagious and mortality varies from 25 to 75% in different outbreaks among domestic cats (Scott and Gillespie 1973). Clinical signs of FPL are similar in domestic cats and wild animals and may include fever, lack of appetite, depression, vomiting and diarrhea (Bittle 1970). The infected animal is often dehydrated and shows an abnormal decrease in white blood cells (Scott and Gillespie 1973). FPL may cause abortions or muscular incoordination in kittens born to infected females (Scott and Gillespie 1973). The virus is transmitted directly in feces, urine, saliva, vomitus and by indirect contact with contaminated objects (Scott and Gillespie 1973). All wild felidae are susceptible to infection (Reif 1976) and FPL has been reported from captive bobcats (Povey and Davis 1977). Mustelids (fisher, marten, mink, otter) and raccoons are susceptible to both feline panleukopenia and canine distemper (Roberts and Carter 1976). FPL carriers may shed the virus for up to 43 days in feces or 22 days in urine (Csiza et al. 1971). The virus is highly resistant and may persist for one year in infected areas (Cszia et al. 1971). Lifetime immunity is acquired after exposure to the virus (Langheinrich and Nielsen 1971). Immunity to feline panleukopenia may be transferred by domestic cats to their kittens in the colostrum (Scott et al. 1970). However, this immunity disappears after 2 to 3 months and coincides with a rise in the distinct seasonal pattern of this virus which

is highest in July, August, and September (Reif 1976). Lanheinrich and Nielsen (1971) described the histological changes that occurred in 2 bay lynx, 3 ocelots, and 60 domestic cats due to naturally acquired panleukopenia. Pollack (1949) noted that it was very difficult to keep small cats alive in captivity in New England without prior vaccination for feline panleukopenia.

The two most important feline respiratory diseases are feline calicivirus (FCV) and feline viral rhinotracheitis (FVR) with similar incidence levels in domestic cats (Scott and Gillespie 1973). Together they cause 80 to 90 percent of the veterinary cases of feline upper respiratory disease (Palmer 1980). FVR is a more severe disease than FCV especially in young kittens (Scott and Gillespie 1973). A cat infected with either FCV or FVR may recover but remain a carrier of the virus and serve as a source of infection for other felines for many months (Scott and Gillespie 1973). The carriers may transmit the virus to their kittens or become reinfected themselves under stress (Scott and Gillespie 1973).

Strains of FCV differ in their pathogenicity (Povey 1976) so symptoms are varied. The disease may cause ocular and nasal discharges, ulcerative lesions on tongue and palate and occasionally bronchopneumonia (Scott and Gillespie 1973). The virus is shed in these discharges, in feces and sometimes in the urine (Povey 1976). FCV will survive up to two weeks at room temperature (Scott and Gillespie 1973). Carriers of FCV may shed the virus continuously for years (Povey 1976).

FVR is a herpesvirus that causes respiratory disease only in felids. Clinical signs vary but may include fever, ocular and nasal discharges, coughing and occasionally pharyngeal ulcerations (Povey 1976). Severe cases may cause pneumonia, abortion, systemic disease or other complications (Povey 1976). Clinical signs of FVR in clouded leopards are similar to those in domestic cats (Boever et al. 1977). FVR has been reported from bobcats and other felids in zoos (Povey and Davis 1977). The virus is transmitted in saliva, ocular and nasal discharges and by aerosel (Scott and Gillespie 1973). Transmission may be by direct contact or by indirect

contact with contaminated objects (Scott and Gillespie 1973).

Feline infectious peritonitis (FIP) is prevalent in domestic cat populations as a mild respiratory disease but is usually fatal to the small number that develop the secondary disease (Weiss 1978). FIP has been associated with reproductive problems and with the kitten mortality complex (Weiss 1978). In the general domestic cat population the incidence of FIP antibodies was 41% in Pullman, Washington (Loeffler et al. 1978) and 20% in Davis, California (Pedersen 1976). All felidae are susceptible and FIP antibodies have been detected in wild cheetahs from South Africa (Horzinek and Osterhause 1979). It is believed that FIP may be transmitted by direct contact urine and possibly feces although it is rapidly inactivated in the environment (Scott et al. 1978).

Feline leukemia virus (FeLV) may cause leukemia, anemia or lymphosarcomas in domestic cats and is associated with many other diseases (Post 1976). FeLV has an immunosuppressive effect so an infected animal is more susceptible to other diseases including FIP, toxoplasmosis and respiratory diseases (Post 1976). FeLV is transmitted in urine, saliva, milk and in utero (Hardy et al. 1976). A survey of 638 stray domestic cats for FeLV group specific antigen located 2 cats with current infections (Hardy et al. 1973).

Procedures

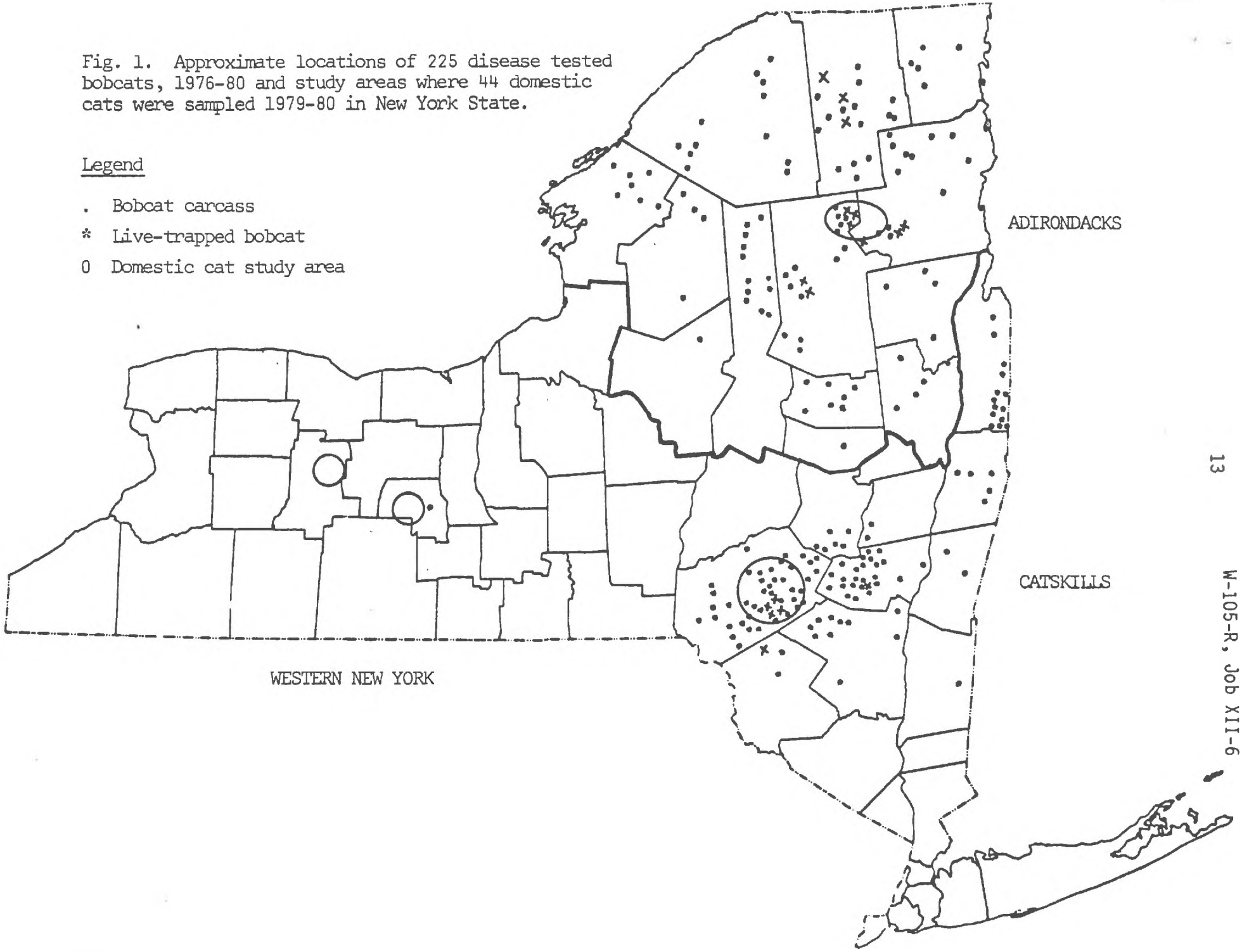
The Department of Environmental Conservation collected 245 skinned bobcat carcasses from trappers and hunters. Bobcats were taken from October to March from fall 1976 to spring 1980. Most carcasses were acquired frozen and examined at a later date. Bobcats were completely necropsied and all body organs slit open and thoroughly examined for gross physical injuries, parasites or abnormalities. A condition class was assigned to each animal based on a visual estimate of the amount of perirenal fat. The midventral abdominal fat was removed and weighed from each animal. This discrete fat body was located inside the abdominal cavity on the ventral wall. The broad anterior of the fat body covered the xiphoid process of the sternum.

Blood suitable for disease testing was drawn from the heart and thoracic cavity of 232 bobcats. In most cases the blood was hemolyzed due to the freezing and thawing of the tissues. Samples were centrifuged and the serum was refrozen for disease testing. Blood samples were drawn from the leg vein of 17 live-trapped bobcats and from 31 unvaccinated, rural, domestic cats. Blood was also collected from the thoracic cavity of 13 domestic cats supplied by the Department of Environmental Conservation.

Blood samples for disease analysis were collected from three study areas (Fig. 1), namely the central Adirondacks, the Catskills and western New York. Domestic cats occur in all three areas but are sparser in the Adirondacks than in the two other regions. Bobcats occur in the Adirondacks and Catskills but only rarely in western New York. These combinations of population levels were selected to shed light on disease transmission. The Adirondacks and the Catskills contain the major bobcat populations of the state (Fox 1982) and the majority of carcasses taken by sportsmen came from these two regions. The Taconic area in Washington County is ecologically similar to the Catskill region so it was included in that region. Domestic cat blood samples were collected in the town of Newcomb, Essex County, and the town of Long Lake, Hamilton County in the Adirondack region; towns of Andes, Bovina, Delhi and Middletown, Delaware County in the Catskill region; the town of Jerusalem, Yates County and the town of Livonia, Livingston County in western New York. Domestic cats were sampled during November to April 1979-80 in the Catskills and in western New York. Cats in the Adirondacks were sampled in August 1980. Blood samples could only be taken from cats with a known history to avoid testing any vaccinated cats.

All disease testing followed the established procedures of the Feline Research Laboratory and the Diagnostic Laboratory at the College of Veterinary Medicine, Cornell University, Ithaca, NY. Disease testing for FPL, FCV and FVR was done at the Feline Research Laboratory. Serum neutralization was used in most of the disease testing. The serum was combined with a laboratory grown virus and the mixture was inoculated into a specific cell culture. Cell destruction indicated growth of virus

Fig. 1. Approximate locations of 225 disease tested bobcats, 1976-80 and study areas where 44 domestic cats were sampled 1979-80 in New York State.



particles and the absence or insufficiency of antibodies. A cell culture that grew normally demonstrated that the presence of antibodies in the serum had neutralized the laboratory virus. Laboratory virus was grown from stock virus acquired from infected domestic cats. Stock virus was diluted to 100 $TCID_{50}$. All cell cultures used were grown from domestic cat tissues. Virus and cell control wells accompanied each test run. Serum was heat inactivated at 56^{o} C for 30 minutes. A thick paste resulted due to the hemolyzed condition of the serum. This was stirred, centrifuged and the red supernatant drawn off the top. Testing procedures had to be chosen that allowed accurate reading of results despite the presence of red blood cell particles. Antibody titer is expressed as the reciprocal of the highest dilution of serum that neutralized 50% of the laboratory virus. It describes the strength of the antibody in the serum. Viral isolation tests were done on small intestine sections from 5 emaciated bobcats and 2 colony deaths.

Feline panleukopenia (FPL) antibodies were tested for by serum neutralization (Scott 1968) and fluorescent antibody techniques. The majority of serum samples were tested by the fluorescent antibody technique while early samples were screened with serum neutralization tests. Early samples with antibodies were rerun with the fluorescent antibody technique to establish comparability of the two methods and to acquire end points. First transfer kidney cells from domestic cat kittens were used for the cell cultures. Serum-virus mixtures were inoculated the same day the cells were transferred. Initial screens were made with serum dilutions of 1:5, 1:50, 1:100 and 1:500. Samples where antibodies were detected were rerun using 4 fold dilutions to acquire the end points. In the serum neutralization test the cell sheet was stained and examined for cytopathic effects. Growth of FPL virus in cells produced Cowdry Type A intranuclear inclusions. With the fluorescent antibody technique a slide with three or fewer fluoresing cells was considered positive for antibodies. A slide with over three fluoresing cells was called negative and a 50% end point was calculated.

The two respiratory viruses, feline calicivirus (FCV) and feline viral rhinotracheitis (FVR) were tested by plaque reduction and serum neutralization. Early tests using microtiter plates for the serum neutralization procedures were difficult to read as the hemolyzed blood blocked the cell sheets in the wells with low serum dilutions. Two fold serum dilutions were used and the serum-virus mixture grown on feline tongue cells. Plaque reduction tests were run with 4 fold serum dilutions using the Crandell feline kidney cell line. A 50% plaque reducing endpoint was calculated from the stained 6 well plates (Hoskins 1976).

Twenty-four serum samples were tested for FIP antibodies. These samples included 16 live-trapped bobcats, 1 unfrozen carcass, 5 emaciated bobcat carcasses and 2 colony deaths. In all, 20 different animals were surveyed as 4 live-trapped bobcats were retested at a later date after being found dead. The indirect fluorescent antibody test was used with base slides made from a canine fibrosarcoma cell line (A72) infected with transmissible gastroenteritis virus for an antigen (Osterhause et al. 1977). Each serum sample was screened at 4 fold serum dilutions from 1:5 to 1:1600 and with an undiluted serum sample.

Serums from sixteen live-trapped bobcats were tested for FeLV virus at the Diagnostic Laboratory. An enzyme-linked immunabsorbent assay (ELISA) Leukassay *F, manufactured by Pitman-Moore was used to detect the presence of FeLV group-specific antigens (Kahn 1980, Lutz 1980). The test interpretation depended on reading a color reaction so only non-hemolyzed serum was used.

Chi square tests were used to compare the presence of antibodies in bobcats and domestic cats between years, regions, sexes and ages. Antibody titers (means) were compared with t tests (Sokal and Rohlf 1969). Differences in sample sizes among comparisons were due to missing information on regions or ages of individual animals. Age classes of bobcats were juvenile (0.5 years), yearling (1.5 years), and adult (2.5 years or greater). Correlation analysis was used to estimate the association between condition class and midventral abdominal fat. Associations between disease antibodies were detected by chi square tests and measured by Cole's measure of association (Poole 1974).

Findings

Antibodies for three viral diseases were found in the serum of New York bobcats (Table 1). There was no evidence of FIP antibodies or FeLV virus in the small sample tested. Domestic cats had similar disease antibodies but at higher prevalence rates (Table 2). FVR was the most common antibody in both bobcats and domestic cats.

The proportion of bobcats with FPL antibodies remained fairly constant during the last three years (Table 3). In the first year, 1976-77, bobcats were collected only from the Adirondacks so the results cannot be directly compared with the statewide results. There were no differences between male and female bobcats in antibody prevalence statewide, by region or by age. Comparison of the Adirondack and Catskill regions (Table 4) showed a sharp difference in FPL antibodies ($P<.005$). A similar regional difference ($P<.05$) was also apparent in domestic cats (Table 5). In both cases FPL was more prevalent in the feline populations of the Catskills. Values for domestic cats from western New York were intermediary but not significantly

Table 1. Disease antibodies in New York bobcats, 1976-80.

Virus	Sample size	Number positive	% positive
Test for antibodies			
Feline panleukopenia	232	48	21
Feline calicivirus	224	36	16
Feline viral rhinotracheitis	224	112	50
Feline infectious peritonitis	24	0	0
Test for antigen			
Feline leukemia	16	0	0

Table 2. Disease antibodies in New York domestic cats, 1979-80.

Virus	Sample size	Number positive	% positive
Feline panleukopenia	44	16	36
Feline calicivirus	40	29	73
Feline viral rhinotracheitis	37	31	84

Table 3. Feline panleukopenia antibodies in New York bobcats by year, 1976-80.

Year	Sample size	Number positive	% positive
1976-77	18	1	6*
1977-78	37	10	27
1978-79	82	16	20
1979-80	95	21	22

* During 1976-77, only bobcats from the Adirondacks were tested.

Table 4. Feline panleukopenia antibodies in New York bobcats by region, 1976-80.

Region	Sample size	Number positive	% positive
Adirondacks	108	5	5
Catskills	120	42	35

Table 5. Feline panleukopenia antibodies in New York domestic cats by region, 1979-80.

Region	Sample size	Number positive	% positive
Adirondacks	11	1	9
Catskills	19	11	58
Western N.Y.	14	4	29

different from the Adirondack or Catskill regions. Domestic cats had a higher prevalence of FPL antibodies than bobcats statewide ($P<.05$). However, within each region bobcats and domestic cats had similar prevalence rates. In the Adirondacks 9% of the adult bobcats had FPL antibodies while in the Catskills 76% of the adults had FPL antibodies. There were no appreciable differences among Adirondack adults, yearlings, and juveniles and Catskill yearlings and juveniles. Thus the regional difference was due to the Catskill adults who had a much higher antibody prevalence than all other age classes both in the Adirondacks and Catskills ($P<.005$). A closer look at the relationship between age and antibodies in both regions showed sharp differences (Table 6). In the Adirondacks none of the 87 bobcats under 7½ years old had FPL antibodies. By contrast in the Catskills there was a gradual accumulation of antibodies in the population with age.

Feline panleukopenia produced high antibody titers in both bobcats and domestic cats. Antibody endpoints were determined for 45 of the 48 bobcats with FPL antibodies. Bobcats had an average FPL antibody titer ($x \pm$ S.E.) of 12373 $\pm$ 1946 with a wide range from 1024 to 49152 statewide. The average FPL antibody titer in the Catskills of 33 bobcats (13242 $\pm$ 2513) is 2.4 times higher than the average Adirondack antibody titer of 5 bobcats (5530 $\pm$ 893) but they are not significantly different. The range of FPL antibody titers is narrower in the Adirondacks (3072 to 8192) than in the Catskills (1024 to 49152) but this may be due to the small Adirondack sample size. The average age of bobcats in the Adirondacks with FPL titers (10.7 $\pm$ 1.7) was significantly higher ($P<.001$) than in the Catskills (4.4 $\pm$ 0.5). Bobcats with FPL antibodies ranged in age from 7.5 to 16.5 years in the Adirondacks and from 0.5 to 11.5 years in the Catskills. Within the Catskill sample there was no difference between males and females in FPL titer or age. The 6 yearlings and 26 adults had similar FPL antibody titers. The FPL antibody titers of domestic cats resembled those of the bobcat with an average of 19461 $\pm$ 8972 and a range of 100 to 131072. The number of domestic cats with FPL antibody titers in each region was too low to accurately compare antibody titers. The small sample size did not allow comparisons by region, age or sex.

Table 6. Feline panleukopenia antibodies in New York bobcats by age and region, 1976-80.

		Adirondack Region		Catskill Region	
		Number positive		Number positive	
Age Class	Age	Sample size	% positive	Sample size	% positive
Juveniles	0.5	0/26	0	1/24	4
Yearlings	1.5	0/21	0	6/46	13
Adults	2.5	0/18	0	6/11	55
	3.5	0/10	0	7/8	88
	4.5	0/5	0	3/6	50
	5.5	0/3	0	3/3	100
	6.5	0/4	0	1/1	100
	$\geq$ 7.5	5/18	28	8/8	100

Feline calicivirus antibodies were present in 14 to 18% of the statewide bobcat sample from 1977-80 (Table 7). In the Adirondacks there was no difference between males and females in FCV antibody prevalence. However in the Catskills more females than males had FCV antibodies ($P<.05$). Prevalence rates were not significantly different in the two regions (Table 8). A higher proportion of domestic cats had FCV antibodies in all three regions (Table 9). Statewide and in both the Adirondacks and Catskills, FCV antibodies were more prevalent in domestic cats than in bobcats ($P<.005$). There were no regional differences in FCV antibodies among domestic cats. A breakdown of the bobcat sample by age and region showed no differences in FCV prevalence (Table 10). In the Adirondacks 14% of the 58 adult bobcats had FCV antibodies while in the Catskills 20% of the 35 adult bobcats had FCV antibodies.

Feline calicivirus antibody titers of bobcats ranged from 4 to 48 with an average of 11.8 $\pm$ 1.8 statewide. The average FCV titer in the Adirondacks for 21 bobcats was 13.2 $\pm$ 2.6 with a range of 4 to 48. This was not significantly different from the average FCV titer in the Catskills which was 9.8 $\pm$ 2.0 with a range of 4 to 25 for 15 bobcats. The average age of bobcats with FCV antibodies was 3.6 $\pm$ 1.0 years (range 0.5 to 16.5) in the Adirondacks and 2.7 $\pm$ 0.7 years (range 0.5 to 10.5) in the Catskills. There were no differences in FCV antibody titers by year, region, age or sex. Domestic cats had an average FCV antibody titer statewide of 340.1 $\pm$ 77.2 with a range of 4 to 1024 for 29 cats. This was significantly higher than the average bobcat FCV titer ($P<.001$). Domestic cats had higher FCV titers than bobcats in both the Adirondacks ($P<.001$) and in the Catskills ($P<.01$). There were no differences in domestic cat FCV antibody titers among the three regions.

Feline viral rhinotracheitis antibodies were detected in bobcat serum more frequently each year than FPL or FCV antibodies. The proportion of bobcats with FVR antibodies was not significantly different among years (Table 11). Males and females had similar prevalence rates statewide and within each region; however when the sample was tested by age class, adult females had a higher proportion of FVR antibodies than adult males ($P<.05$). However, when adult females were tested against adult

Table 7. Feline calicivirus antibodies in New York bobcats by year, 1976-80.

Year	Sample size	Number positive	% positive
1976-77	18	2	11*
1977-78	35	6	17
1978-79	79	11	14
1979-80	92	17	18

* During 1976-77, only bobcats from the Adirondacks were tested.

Table 8. Feline calicivirus antibodies in New York bobcats by region, 1976-80.

Region	Sample size	Number positive	% positive
Adirondacks	104	21	20
Catskills	116	15	13

Table 9. Feline calicivirus antibodies in New York domestic cats by region, 1979-80.

Region	Sample size	Number positive	% positive
Adirondacks	11	8	73
Catskills	16	14	88
Western N.Y.	13	7	54

Table 10. Feline calicivirus antibodies in New York bobcats by age and region, 1976-80.

		Adirondack Region		Catskill Region	
		Number positive		Number positive	
Age Class	Age	Sample size	% positive	sample size	% positive
Juveniles	0.5	7/23	30	3/22	14
Yearlings	1.5	5/20	25	4/46	9
Adults	2.5	3/18	17	3/10	30
	3.5	0/10	0	2/8	25
	$\geq$ 4.5	5/30	17	2/17	12

Table 11. Feline viral rhinotracheitis antibodies in New York bobcats by year, 1976-80.

Year	Sample size	Number positive	% positive
1976-77	18	11	61*
1977-78	35	21	60
1978-79	79	31	39
1979-80	92	49	53

* During 1976-77 only bobcats from the Adirondacks were tested.

males within each region, the results were not significant. There was no difference by sex among yearlings or juveniles. FVR antibodies were present in both Adirondack and Catskill bobcats at very similar prevalence rates (Table 12). There was also no regional differences among domestic cats (Table 13). Domestic cats had a higher proportion of FVR antibodies than bobcats statewide ($P<.005$), in the Adirondacks ($P<.05$), and in the Catskills ($P<.01$). FVR antibodies were present in 48% of the 58 Adirondack adult bobcats and in 66% of the Catskill adult bobcats (Table 14). Catskill yearling bobcats had a lower FVR antibody prevalence than Adirondack yearlings ($P<.05$) or Catskill adults ($P<.05$). Adult females statewide showed a higher FVR antibody prevalence than yearling females ($P<.05$). There was no difference among male age classes.

Antibody titers of FVR ranged from 4 to 235 with a statewide average of 20.7 $\pm$ 3.4. There were no significant differences in FVR antibody titers between the Adirondacks with an average of 25.8 $\pm$ 6.2 and a range from 4 to 235 and the Catskills with an average of 16.3 $\pm$ 3.2 and a range from 4 to 128. The average age of Adirondack bobcats with a FVR antibody titer was 3.4 $\pm$ .5 (range 0.5 - 16.5) which was similar to the average Catskill age of 3.0 $\pm$ .4 (range 0.5 - 11.5). Male and female bobcats had fairly equal titers statewide and in each region. FVR titers of bobcats in the Catskills were similar from fall 1977 to spring 1980. In the Adirondacks the FVR titers were low from fall 1976 to spring 1978 and then jumped significantly for the period from fall 1978 to spring 1980 ($P<.05$). There were no differences among bobcat age classes in FVR antibody titers. Domestic cats had a higher prevalence of FVR antibodies than bobcats statewide and in both the Adirondacks and Catskills ($P<.001$). Comparisons among regions showed no differences among domestic cat antibody titers which had a statewide average of 346.1 $\pm$ 61.4 and a range from 6 to 1024.

Antibodies of the two respiratory viruses, feline calicivirus and feline viral rhinotracheitis, were positively associated in bobcats ($P<.005$). Cole's measure of association was .67 indicating the degree of association on a scale from 0 to $\pm$ 1.

Table 12. Feline viral rhinotracheitis antibodies in New York bobcats by region, 1976-80.

Region	Sample size	Number positive	% positive
Adirondacks	104	54	52
Catskills	116	55	47

Table 13. Feline viral rhinotracheitis antibodies in New York domestic cats by region, 1979-80.

Region	Sample size	Number positive	% positive
Adirondacks	11	10	91
Catskills	15	13	87
Western N.Y.	11	8	73

Table 14. Feline viral rhinotracheitis antibodies in New York bobcats by age and region, 1976-80.

		Adirondack Region		Catskill Region	
		Number positive		Number positive	
Age Class	Age	Sample size	% positive	Sample size	% positive
Juveniles	0.5	11/23	48	10/22	45
Yearlings	1.5	14/20	70	16/46	35
Adults	2.5	11/18	61	6/10	60
	3.5	6/10	60	6/8	75
	$\geq$ 4.5	11/30	37	11/17	65

FCV and FVR were positively associated in both male ($P<.01$) and female ($P<.01$) bobcats and in both the Adirondacks ($P<.005$) and the Catskills ($P<.05$). Cole's measure of association was .88 for males, .48 for females, .65 for the Adirondacks and .67 for the Catskills. There was no association between feline panleukopenia and feline herpesvirus for the entire bobcat sample. However in females FPL and FVR were positively associated ($P<.05$) with a Cole's measure of .40. There was no association in males or in the Adirondacks. In the Catskills, FPL and FVR were positively associated ($P<.05$) with a Cole's measure of .35. Antibodies of feline panleukopenia and feline calicivirus were not associated in bobcats statewide or of either sex or region.

Physical condition classes were tabulated for 161 bobcats from the Adirondacks and Catskills from fall 1978 to spring 1980. A poor condition class was assigned to 4 emaciated bobcats without perirenal or any other body fat. A fair condition class was given 9 bobcats without perirenal fat but with no evident tissue wastage. Good condition class bobcats (62) had fat around the kidneys but not covering it. Very good condition class animals (68) had large amounts of perirenal fat that almost covered the kidneys. The kidneys of bobcats in excellent condition (18) were completely buried in fat. The condition classes of bobcats were not different between sexes, age classes, regions or years. Bobcats of each age class in the Catskills were in slightly better condition classes than those in the Adirondacks but this was not a significant difference. On the average, bobcats were judged to be in a good to very good condition class. The midventral abdominal fat was weighed from 214 bobcats. Since its weight is partially a factor of body size, bobcats were divided into age classes. The average weight of the midventral abdominal fat was 38.5 ± 4.6 grams for adults, 22.4 ± 2.3 grams for yearlings and 15.2 ± 1.9 grams for juveniles. The relationship between midventral abdominal fat and condition class was tested by correlation analysis. Correlation coefficients were .66 for adults, .79 for yearlings and .71 for juveniles.

Physical injuries were found in 11% of the 218 intact bobcats examined. These included healed broken bones, scars or infarcts on internal organs and adhesions of the mesenteric fat to the abdominal wall. None of the tissue damage was considered important and most injuries had healed. One exception was a 13½ year old bobcat with an abnormal head on the right femur. Porcupine quills were recovered from another four bobcats but they were only numerous in one animal with facial quills. Other bobcats had only a few quills in the intestine, liver, tongue or legs. Numerous thorns were found in the feet and lower legs of one bobcat. Pneumonia in the lungs is discussed in the parasite section of this report.

A total of 7 emaciated bobcats were examined in this project. One of the emaciated bobcats taken in January 1978 had a broken jaw which had healed in a skewed position preventing the animal from feeding normally. There had also been extensive internal injuries. Another bobcat which was found dead had a muzzle full of porcupine quills and it could not be determined if the animal was in poor condition and then attacked a porcupine or if the quills were the direct cause of the bobcat's physical condition. The remaining 5 emaciated bobcats had no physical injuries or evidence of gross disease on necropsy. Viral isolation tests were run on small intestine sections from 4 of these bobcats. No viruses were isolated. Two of the bobcats had feline calicivirus antibodies at low titers. It was concluded that these 4 bobcats had probably starved to death. The last emaciated bobcat examined was taken in January 1981 after the other disease testing was completed. This animal was taken to the necropsy services at the Veterinary College at Cornell University. Their diagnosis was starvation.

Analysis

Low antibody prevalence may be interpreted in two ways. It can be concluded that the virus infects a small number of animals and is relatively harmless to the population. Or one can conclude that the low antibody prevalence is due to high mortality. Many animals acquire the disease but only a small percent survive and

hence have antibodies. The interpretation has to be based on a consideration of the characteristics of each virus and its known mortality rates in susceptible species. The bobcat testing results may be of lower prevalence or lower titer than those of the domestic cat due to a higher proportion tested with hemolyzed serum from carcasses in poor condition.

The presence of feline panleukopenia antibodies in the bobcat population in New York indicates a potentially important mortality factor due to the properties of this virus. Considering the vigor, durability and high contagiousness of FPL virus, it is probable that FPL is responsible for a high percentage of the annual natural bobcat mortality in the Catskill region of New York State. The lower prevalence of FPL antibodies in the Adirondacks may be due to the wider dispersion of bobcats and to a lower domestic cat population than in the Catskills. The population density of bobcats is lower in the Adirondacks than in the Catskills (L. Fox pers. commun.). In the Catskills there are numerous farms with unvaccinated domestic cats that represent potential infection centers. Once an animal becomes infected then all other susceptible animals usually become rapidly infected. FPL serves as a population control measure for domestic cats as it regularly decreases farm populations. One Catskill landowner estimated that only 4 out of 25 domestic cat kittens survived on his farm each year due to FPL (L. Kovba, pers. commun.). The domestic cat samples were collected in the summer in the Adirondacks so the antibody prevalences should be at a maximum due to the seasonal pattern of the virus. However the prevalence rate is so low that it can be compared without adjustment to the FPL prevalences of bobcats and other domestic cats. Comparisons between bobcats and domestic cats have to be interpreted carefully due to the large difference in sample sizes. The domestic cats sampled in this study merely give an indication of the relative infection rates of the two felines. The similar feline prevalences in each region suggest that there is a difference in the actual presence of the virus between the two regions. The prevalence of feline viral rhinotracheitis antibodies in half of the bobcats in each region indicates that disease transmission is occurring among felines in both regions offering an opportu-

nity for FPL transmission as well. FPL persists in the environment much longer than FVR and is considered highly contagious (Scott and Gillespie 1973). So the low feline densities in the Adirondacks are not the only reason for a lower FPL antibody prevalence there. An increase or decrease in FPL virus or virulence in the last 7 years could explain the absence of FPL antibodies in bobcats under 7½ years old. There is no evidence of this and absence of FPL antibodies in the younger bobcats may just indicate that the virus exists at low levels in the Adirondacks and they have not yet encountered it. In domestic cats FPL antibodies are much more common in animals over one year old (Scott and Gillespie 1973). FPL antibodies were present in 77% of 78 farm cats surveyed in the Ithaca, New York area (Scott 1968).

The FPL antibody titers of New York bobcats and domestic cats are as high or higher than FPL antibody titers produced in captive wild felids after repeated vaccinations. FPL antibody titers from 12 felid species averaged 8643 (Range 16 - 32768) after the vaccinations (Povey and Davis 1977). These high titers were attributed to a boosting effect of the vaccinations. This suggests the bobcats and domestic cats in New York are acquiring high titers on initial exposure to the virus or are reexposed to the virus periodically. The average antibody titer of the farm cats surveyed in Ithaca, NY was much lower (Scott 1968).

The FPL mortality rates in domestic cats are extremely varied depending on the virus virulence, host resistance and the density or contact of susceptible animals. Mortality rates for domestic cats are 25 to 75% (Scott and Gillespie 1973), 60 to 90% (Bittle 1970), and in young kittens from 75 to 90% (Reif 1976). The higher mortality rates may have occurred in catteries, research colonies or in other dense populations. Mortality rates are probably much lower in bobcats because they are more dispersed and contact with other bobcats or domestic cats is not as great. A conservative estimate of FPL mortality in bobcats would be 10%.

The respiratory virus antibodies of FCV and FVR were both present in a higher proportion of domestic cats than bobcats in all regions. There were no regional differences in prevalence among domestic cats. It is not known how much the summer sampling of domestic cats in the Adirondacks influenced the regional comparisons. However the presence of these antibodies in domestic cats demonstrates that the potential sources of infection for the bobcat are widespread. Sources of infection include carriers that act as reservoirs of respiratory disease (Kahn and Walton 1971). FVR and FCV only survive 18 to 24 hours and 1 to 2 weeks respectively at room temperature (Scott and Gillespie 1973). The existence of a carrier state could help explain the prevalence of FVR antibodies in 50% of the bobcats despite its low survival in the environment. The large difference between FCV and FVR antibody prevalences in bobcats suggests that either the transmission of FVR is greater or that bobcats are more resistant to FCV infections. The respiratory antibodies are present together in bobcats more often than expected. FCV and FVR virus were each isolated from 8% of 65 domestic cats examined in Louisiana (Bech-Nielsen et al. 1980). FVR is regarded as the most common and serious of the respiratory diseases in cats (Boever et al. 1977). Another virus infection or severe stress may cause an FVR recovered cat to shed FVR virus again (Scott and Gillespie 1973). Adult female bobcats had higher FVR prevalence rates than adult males but this was not a strong difference since it was not detected in either region. Male and female domestic cats of all ages are equally susceptible to natural FVR infection (Boever et al. 1977).

The pathogenicity of FCV varies considerably in disease outbreaks so bobcat or domestic cat mortality would be difficult to predict. Povey (1976) states "In spite of the often severe nature of FVR, mortality is not high except in kittens, old or debilitated animals...". The high prevalence of FVR antibodies in the bobcat population indicates that it may be a widespread respiratory disease in bobcats with low mortality.

The majority of bobcats were in good physical condition but the presence of several emaciated bobcats shows that starvation is possible. Diseases, especially

feline panleukopenia, apparently influence the abundance of bobcats in New York State. The mortality rates are not known but the nature of the disease viruses present in the population would probably eliminate a proportion of the bobcats. There is no indication that diseases are limiting the distribution of the bobcat in New York State.

BOBCAT PARASITES

Background

The impact of parasitism on any wild population depends on the collective influence of all parasites on the individual host and the proportion of the population they infect. Mitchell and Beason (1971) in South Texas, found heavy hookworm infestations in young bobcats and suggested that hookworms could account for some of the natural mortality in wild bobcat populations. In the Northeast records of bobcat parasites are few. Hamilton (1939) recovered Physaloptera sp. from more than half of the 140 bobcat stomachs that he examined for food habits in Vermont. Pollack (1949) investigated the bobcat in New England and identified 6 helminths from the gastrointestinal tracts of 100 bobcats from New Hampshire and Massachusetts. In other areas of the country, bobcat parasites have been reported from West Virginia and Georgia (Watson et al. 1981), Texas (Stone and Pence 1978), North and South Carolina (Miller and Harkema 1968), Virginia (Progulske 1952), Colorado (Lejby 1961) and Minnesota (Rollings 1945). Toxoplasmosis is a widespread zoonotic disease in the United States (Franti et al. 1976) but its effect on wildlife populations is unknown. Miller et al. (1972) confirmed that bobcats, like the domestic cat, are capable of producing oocysts after ingestion of cysts. This indicates that the parasite undergoes sexual reproduction in the bobcat which may be an important method of increasing the disease in the environment.

Parasitism was studied in New York bobcats to determine which species were present, their abundance and their possible impact on individuals and on the population as a

whole. Published records of domestic cat parasites were examined to see which parasite species infected both felids. Domestic cats could be serving as a reservoir of infection for certain parasite species and facilitating their transmission to bobcats. This could be done by increasing the density of infective eggs or larvae in the environment or by increasing the number of infective intermediate hosts. Other predators may share some parasites with the bobcat by ingesting the same intermediate stages of a parasite or a transport host. Selected animals from the Adirondacks were necropsied and examined to determine if they shared any of the same parasites with the bobcat. They might also be serving as reservoirs of infection for the bobcat. Snowshoe hares are a common bobcat food item in the Adirondacks and could potentially be acting as intermediate or transport hosts to the bobcat. To determine their role snowshoe hares were collected and necropsied from the Adirondacks. The objective of this study was to assess bobcat parasitism with a community approach to the source and distribution of potential bobcat parasites.

Procedures

Bobcat carcasses collected by the Department of Environmental Conservation from fall 1977 to spring 1980 were necropsied at the Adirondack Ecological Center. A complete necropsy was done on each bobcat and all body organs were opened and examined. The gastrointestinal tract was slit lengthwise and the contents washed through a sieve to recover all possible parasites. Lungs were cut open along the bronchioles and then teased apart to examine the parenchyma. Nematodes were stored in 70% ethyl alcohol plus 5% glycerin. They were cleared in either glacial acetic acid before fixation or in lactophenol after fixation. Trematodes, cestodes and acanthocephalans were fixed in AFA (Alcohol-Formalin-Acetic acid) and stored in 70% ethyl alcohol. Heads of acanthocephalans were everted before fixation. Tapeworms were stained in Celestine blue B, passed through a graded alcohol series and then cleared in methyl salicylate. Segments with mature or gravid proglottids were mounted to examine the position of the cirrus pouch, number of uterine branches and

other reproductive characteristics. Scolices were also mounted to determine the number and size of the hooks. Testing for Toxoplasma gondii antibodies was done at the Diagnostic Laboratory, College of Veterinary Medicine, Cornell University, Ithaca, N.Y. A commercial kit, TPM-Test, manufactured by Wampole Laboratories, was used to test serum samples. This was an indirect hemagglutination test using stabilized sheep erythrocytes sensitized with Toxoplasma gondii antigen. If T. gondii antibodies were present in the bobcat serum they agglutinated the erythrocytes and caused the formation of a distinctive pattern in the test wells. The dilution 1:64 was considered the lowest significant dilution.

A list of domestic cat parasites in New York and New Jersey was compiled from the literature. This was used to compare the parasites found in bobcats and domestic cats. Bobcat parasites were also compared to parasites found in other potential definitive hosts and to intermediate stages of parasites found in snowshoe hares from the same locality. Selected wildlife species from the Adirondacks were collected by local trappers and occasionally by road kills from summer 1977 to summer 1980. Species examined were 27 fishers, 24 coyotes, 21 red foxes, 8 raccoons, 7 porcupines, 5 otters and 1 gray fox. Snowshoe hares were collected from road kills and from a research project on Huntington Wildlife Forest. Twenty snowshoe hares were necropsied and examined in depth. The abdominal cavity and musculature of 67 additional hares was searched for tapeworm larvae. The 67 snowshoe hares included 42 hares from the Adjidaumo hare research area on Huntington Wildlife Forest. Identification of tapeworm larvae was based primarily on hook measurements and on the number of hooks.

Comparisons of parasites by year, region, sex and age were done with chi square Yates correction and t tests. Associations between pairs of helminth species were detected by chi square tests with Yates correction and measured by Cole's measure of association (Poole 1974). T tests were used to compare the mean abundance of each helminth species in the presence and absence of other helminth species.

Findings

Parasites were recovered from 99% of the 218 intact bobcat carcasses. Three bobcats did not have any endoparasites. Helminths recovered included 5 cestodes, 2 trematodes, 1 acanthocephalan and 10 nematodes (Table 15). Each bobcat had from 1 to 9 parasite species totalling from 1 to 514 parasites. An average of 3 helminth species with a mean burden of 38 worms infected each bobcat. Parasite counts included all stages of parasites so immature tapeworm scolices were counted with mature tapeworms. The mean worm burden of juveniles (52) and of yearlings (43) was higher ($P<.01$) than that of adults (24). Worm burdens for all age classes were higher in the Catskills than in the Adirondacks but the difference was only significant for juveniles ($P<.05$). Mean worm burdens ranged from a low of 22 in Adirondack adults to a high of 68 in Catskill juveniles. Adult bobcats were also infected with a lower number of helminth species than juveniles or yearlings ($P<.05$). No regional differences were apparent. Parasites were recovered from the lungs, stomach, small and large intestine and urinary bladder. All cestodes, trematodes, acanthocephalans and 4 of the nematode species were found in the small intestine. Postmortem migration of ascarids into the stomach or large intestine was common.

Three species of lungworms were located in the bronchioles and secondary bronchioles of the lung. The most common lungworm, Troglostrongylus wilsoni, was associated with lung pneumonia. The analysis of the prevalence and density of T. wilsoni was based solely on the presence of adult lungworms. The distribution of T. wilsoni showed a sharp regional difference as 10/102 (10%) bobcats from the Adirondacks and 53/112 (47%) bobcats from the Catskills were infected ($P<.005$). This regional difference was apparent in all three age classes. Within each region the incidence of T. wilsoni was similar among the age classes. The mean worm burden of Adirondack bobcats (10) was not significantly different from that of Catskill bobcats (21). There were no detectable differences in worm density among infected bobcats by sex or age class.

Table 15. Helminths from 218 bobcats in New York State, 1976-80.

Helminth	Number infected	Percent infected	Number of helminths	
			Mean	Range
CESTODES				
Taenia rileyi	139	64	17	1-375
Taenia macrocystis	41	19	12	1-75
Mesocestoides corti	30	14	11	1-62
Spirometra mansonoides	25	11	4	1-18
Taenia spp.	5	3	5	1-18
TREMATODES				
Alaria spp.	17	7	12	1-66
Unknown	2	1	4	3-4
ACANTHOCEPHALANS				
Oncicola canis	10	5	3	1-9
NEMATODES				
Toxocara mystax	190	87	16	1-115
Troglostrongylus wilsoni	65	30	19	1-171
Capillaria plica	44*	29	2	1-9
Physaloptera rara	27	12	9	1-119
Cylicospirura felineus	23	11	4	1-9
Capillaria aerophila	18	8	2	1-9
Ancylostoma tubaeforme	16	7	2	1-5
Trichostrongylus spp.	13	6	3	1-9
Capillaria spp. (Intestine)	10	5	2	1-4
Aelurostrongylus abstrustus	2	1	6	2-10

* Only 153 urinary bladders were examined.

Pneumonia was detected in the lungs of 41/218 (19%) bobcats. Raised brown or yellow nodules were present on the surface of the lung lobes and areas of consolidation could sometimes be felt inside the lung. Lung sections from 7 bobcats with pneumonia were examined at Cornell University. Histological sections revealed lungworm eggs and larvae in all. E. Riley (pers. commun.) reported that "ribbon-like lesions on the surface of the lung represent migratory tracts left behind by the adults, and in which the eggs may be found". Eggs and larvae could also be squeezed from the areas of pneumonia and examined under a compound microscope.

Pneumonia was present in 1 to 7 lobes of the lungs. A mean of 4 lung lobes were involved in the 41 cases of pneumonia. However the distribution of lung lobe involvement was bimodal with the largest number of pneumonia cases involving either only 1 lung lobe or all 7 lung lobes. A subjective rating of the apparent severity of the pneumonia showed a range from mild pneumonia with scattered areas of infection (1) to massive pneumonia in all lung lobes (5). The mean rating was 2.5 indicating an infection that was locally intensive with some mild extension over other lung surfaces.

Adult lungworms, Troglostrongylus wilsoni, were recovered from 30/41 (73%) bobcats with pneumonia. The remaining 11 bobcats with pneumonia were not infected with adult T. wilsoni. However a close examination of lung sections preserved in 10% formalin from 8 of these bobcats revealed the presence of lungworm eggs or larvae in all. No sections were preserved on the other 3 bobcat lungs. Measurements of eggs and larvae from pneumonia areas were similar to those taken in utero from adult female T. wilsoni. This was additional evidence that T. wilsoni was the species responsible for the lungworm pneumonia. An additional 35 bobcats harbored adult T. wilsoni without apparent pneumonia. Histological examination of lung tissue might uncover pneumonia that was not detectable on gross examination. No significant differences in worm burden could be detected between bobcats with adult T. wilsoni and pneumonia and those with adult T. wilsoni without pneumonia. In fact bobcats

without apparent pneumonia harbored an average of 24 T. wilsoni while bobcats with pneumonia had a mean worm burden of 14 T. wilsoni (P>.05). Neither the severity of the pneumonia or the number of lung lobes involved was related to the number of adult T. wilsoni.

There was a significantly higher number of pneumonia cases in bobcats from the Catskills than in the Adirondacks (P<.005). Catskill adults and Catskill yearlings had a higher incidence of pneumonia than Adirondack adults and Adirondack yearlings respectively (P<.005) (Table 16). There were no significant differences in the incidence of pneumonia in juveniles from both regions. Statewide more pneumonia was present in yearlings than in adults (P<.05). Females had a greater occurrence of pneumonia than males (P<.05). However there were no significant differences between sexes or between age classes within each region. Pneumonia was detected in bobcats taken during the 1977-1978 season through the 1979-1980 season (Table 17). Pneumonia remained at a low level in the Adirondack bobcats throughout the 4 year period. In contrast the incidence of pneumonia in Catskill bobcats increased significantly from 1977-1978 to 1978-1979 (P<.05) and from 1977-1978 to 1979-1980 (P<.005). The level of femur marrow fat (Fox 1982) was similar in bobcats with pneumonia and in bobcats without pneumonia.

The prevalence and abundance of Capillaria aerophila in the lungs was similar in the Adirondacks and the Catskills. Age of the hosts ranged from 0.5 to 11.5 years with infection rates of 14% in juveniles, 8% in yearlings and 6% in adults. The third species of lungworm had been tentatively identified as Aelurostrongylus abstrusus based on the description given by Blaisdell (1952).

The chi square test for association indicated that T. wilsoni and C. aerophila were distributed independently. In addition the abundance of one lungworm species did not influence the abundance of the other.

Table 16. Incidence of lungworm pneumonia in New York bobcats, 1976-80, by region and ageclass.

	Adirondack Region		Catskill Region	
	Number infected		Number infected	
Age Class	Sample size	% infected	Sample size	% infected
Juveniles	2/26	8	6/23	26
Yearlings	1/22	5	18/42	43
Adults	1/51	2	8/33	24

Table 17. Incidence of lungworm pneumonia in New York bobcats, 1976-80, by region and year.

	Adirondack Region		Catskill Region	
	Number infected		Number infected	
Year	Sample size	% infected	Sample size	% infected
1976-77	0/20	0	-----	-----
1977-78	1/18	6	0/17	0
1978-79	0/30	0	12/43	28
1979-80	3/34	9	24/52	46

Two nematode species were occasionally found in the stomach. Cylicospirura felineus was embedded in stomach nodules on the inside of the stomach. These dome shaped nodules had an opening to the stomach lumen and contained from 1 to 9 worms apiece. The average sized nodule measured 10x8 mm and contained 4 worms. The nodules ranged in size from 3x3 to 15x11 and all nodules were located in the central body of the stomach. Larger nodules (>80 sq. mm) had an average of 4.4 worms but this was not significantly different from smaller nodules (≤ 80 sq. mm) with an average of 2.6 worms. Some nematodes were recovered from the lumen perhaps due to post-mortem migration. Empty nodules were found in an additional 7 bobcats and appeared to be old Cylicospirura nodules.. C. felineus was present in 6 juveniles, 5 yearlings and 12 adult bobcats. There were no regional differences in occurrence or density of C. felineus infections.

Physaloptera rara occurred much more frequently in the stomach lumen of Catskill bobcats (21%) than in Adirondack bobcats (2%) ($P<.005$). It was present in both sexes and in all three age classes at similar frequencies. The majority of specimens were small including the 119 worms recovered from the stomach of 1 bobcat.

Nematodes recovered from the small intestine included Toxocara mystax, Ancylostoma tubaeforme, Trichostrongylus spp. and Capillaria spp. Toxocara mystax (T. cati) was the most common bobcat parasite as it was recovered from 87% of the animals. Prevalence was fairly similar in the Adirondacks and Catskill regions but it decreased ($P<.005$) from a high of 94% in juveniles and 95% in yearlings to 79% in adult bobcats. Male bobcats from the Catskills had a higher prevalence (98%) of T. mystax than females from the Catskills ($P<.05$) or males ($P<.01$) and females ($P<.05$) from the Adirondacks. This difference was primarily because all of the adult males from the Catskills were infected. Bobcats in the Catskills had a significantly higher ascarid burden than those in the Adirondacks ($P<.05$). All three age classes of bobcats had higher worm burdens in the Catskills but only the adult bobcats were significantly different ($P<.05$). The worm burdens of juveniles and yearlings were similar statewide and

both were much higher than adult worm burdens (P<.001). Average worm burdens were 7.9, 20.8 and 21.9 for adults, yearlings and juveniles respectively. Thirteen juveniles and yearlings had over 50 ascarids in the small intestine. Only one adult bobcat from the Catskills had over 50 ascarids.

Hookworms, Ancylostoma tubaeforme, were uncommon in bobcats and present only at low densities. The small nematodes, Trichostrongylus spp. and Capillaria spp. also occurred in a low proportion of the bobcats. All three species were found in male and female bobcats of different ages from both regions.

Another species of Capillaria was located in the urinary bladder. Nearly one-third of the bobcats were infected with Capillaria plica. The nematode was predominantly located in Catskill rather than Adirondack bobcats (P<.005). Yearling and adult bobcats were more frequently infected than juveniles (P<.05). The mean worm burden was 1 in the Adirondacks and 2.5 in the Catskills.

Flukes were occasionally found in the small intestine. Alaria spp., probably Alaria marcianae, were found in bobcats from the Adirondacks, Catskills and in the 1 bobcat from western New York. Bobcats from the Catskills had a greater abundance of flukes but this was not statistically significant. Seven bobcats from the Adirondacks had a mean burden of 4 flukes while 9 bobcats from the Catskills harbored an average of 12 flukes each. Another trematode species found in 2 bobcats was not identified.

Oncicola canis was the only representative of the Phylum Acanthocephala found in the bobcat. The proboscis of 22 of the thorny-headed worms was still attached to the intestinal wall while 7 were recovered from the small intestine contents. Most of the attached worms were located in the central half of the small intestine. O. canis occurred in 5 juveniles, 3 yearlings, 1 adult and 1 bobcat of unknown age, from both the Adirondacks and the Catskills. It was identified from descriptions by Schmidt (1972) and Van Cleave (1953).

Four tapeworm species reach maturity in the small intestine of the bobcat. Tapeworms were present in 172 of 218 (79%) bobcats. The majority of infected bobcats (118) harbored a single tapeworm species but multiple species infections were common (54). Only 1 bobcat was infected with all 4 tapeworm species. Tapeworm burdens ranged from 1 to 397 with a mean of 19 tapeworms per bobcat.

Taenia rileyi was the most common tapeworm found in the bobcats and it occurred at similar frequencies in the Adirondacks and Catskills (Table 18). Worm burdens were higher in the Adirondacks but not significantly different from those in the Catskills. T. rileyi occurred much more frequently in female bobcats than in males ($P<.005$). Males had a similar frequency of the tapeworm in all age classes but the prevalence in females declined from yearlings to adults ($P<.05$). The greatest difference between the sexes occurred in the yearling age class ($P<.01$). Worm burdens of juvenile males, yearling males and yearling females were similar to that of adult females. However adult males had a lower worm burden than all other age classes of either sex.

Taenia macrocystis was more common in bobcats of all age classes from the Adirondacks than the Catskills ($P<.005$). Only 6% (7/112) of the Catskill bobcats were infected with T. macrocystis in comparison to 32% (33/102) of the Adirondack bobcats. Yearling bobcats from the Adirondacks had the highest prevalence of T. macrocystis (59%) which was significantly different ($P<.01$) than the 24% of Adirondack adults. Mean infection levels of the tapeworm were not significantly different in any comparison.

Mesocestoides corti is distributed in both regions at similar frequencies and densities. Female bobcats harbor M. corti more frequently than males ($P<.05$) and at greater densities ($P<.05$). The greatest difference between the sexes occurs in the juvenile age class where 7% (2/29) of the males and 45% (9/20) of the females are infected ($P<.01$). Males of all age classes have a similar prevalence and abundance of M. corti but juvenile females have a greater frequency of infection

Table 18. Prevalence and abundance of bobcat tapeworms in New York, 1976-80, by region, sex and age class.

	Region		Sex		Age Class		
	Adirondacks	Catskills	Males	Females	Juveniles	Yearlings	Adults
Taenia rileyi	60% [1]	67%	54% ***	75%	69%	73%	58%
	22 [2]	13	20	14	18	14	12
Taenia macrocystis	32% ***	6%	22%	15%	20%	23%	16%
	13	5	11	11	14	13	10
Mesocestoides corti	15%	13%	9% *	19%	22%	11%	11%
	13	6	1 *	16	13	12	11
Spirometra mansonoides	23% ***	2%	13%	10%	15%	14%	31%
	4	1	3	5	2	2	5

[1]Prevalence is the percent of infected bobcats

[2]Abundance is the mean worm burden

* P<.05

*** P<.005

than yearling females ($P<.01$) or adult females ($P<.05$). Worm burdens of all females are similar.

Spirometra mansonoides was predominantly recovered from Adirondack bobcats. Bobcats from the Catskills had a significantly lower incidence of infection ($P<.005$). An average of 4 tapeworms were found in 23 Adirondack bobcats while only single tapeworms were recovered from 2 Catskill bobcats. In the Adirondacks adult bobcats (31%) had a greater incidence of S. mansonoides than yearlings (14%) or juveniles (15%) but this was not a significant difference. Males and females appear to be equally susceptible to infection and at similar densities.

Five bobcats had very small tapeworm scolices of a Taenia species distinctly different from the other Taenia species present in the small intestine. Hook measurements and the number of hooks indicate that it may be Taenia serialis serialis (Multiceps serialis). Adult tapeworm of this species were not found in the bobcat.

A single adult Taenia species was recovered from the small intestine. This tapeworm was extremely contracted even though it was collected from a carcass that had been frozen. The scolex had 2 rows of hooks with a total of 30 hooks. Large hooks measured 391μ and small hooks were 253μ. These hook measurements fall in the size ranges given by Verster (1969) for Taenia taeniaeformis.

Chi-square tests demonstrated that 3 pairs of tapeworm species were not independently distributed. T. rileyi was associated with T. macrocystis ($P<.01$), S. mansonoides ($P<.05$) and M. corti ($P<.005$). Cole's measure of association indicated that there was a small negative association between T. rileyi and each of the other three tapeworm species. The levels of infection of T. rileyi and M. corti were significantly higher when T. macrocystis was also present in the host ($P<.05$).

Antibodies of Toxoplasma gondii were detected in 23% of the 220 bobcat serums tested. The Adirondacks and the Catskills had the same prevalence rate. Fewer

juveniles had antibodies than yearlings ($P<.01$) or adults ($P<.05$). Only 7% (3/44) of the juveniles had antibodies while 30% (20/66) of the yearlings and 28% (26/93) of the adults had antibodies to T. gondii. Antibody prevalences were fairly similar in males (21%) and females (26%) as were the mean antibody titers in males (1:125) and females (1:143). Mean regional titers were close and the average antibody titer statewide was 1:134. Bobcat titers ranged from 1:64 to 1:512.

Domestic cats had a significantly higher prevalence of T. gondii antibodies than bobcats ($P<.005$). Toxoplasma antibodies were present in 66% of the 44 domestic cats tested. There was a sharp difference in prevalence between bobcats and domestic cats in both the Adirondack and Catskill regions. In the third region in western New York the prevalence (43%) in domestic cats was considerably lower than that of domestic cats in the Adirondacks (73%) or in the Catskills (79%). The mean antibody titer of all domestic cats tested was also higher at 1:468 than in bobcats ($P<.001$). Within the regions domestic cats had a higher antibody titer ($P<.001$) than bobcats in the Catskills but not in the Adirondacks. Domestic cat titers ranged from 1:64 to 1:2048. Mean domestic cat titers were higher in the Catskills (620) and in western New York (640) than in the Adirondacks (176). So domestic cats in the Adirondacks were similar to bobcats from both regions in mean titer but higher in antibody prevalence.

Domestic cats in New York and New Jersey shared 7 helminths with the New York bobcat (Table 19). This included 5 nematodes, 1 tapeworm and 1 trematode. Toxocara mystax was the most frequently reported parasite from domestic cats. A minimum of 21 helminths were shared by bobcats and domestic cats in the United States. The lynx, Lynx canadensis (Felis canadensis), is another feline in North America that may share parasites with the bobcat and domestic cat. Species in common with the bobcat in New York include Taenia rileyi, Alaria spp., Toxocara mystax, Cylicospirura spp. and Troglostrongylus wilsoni (Van Zyll de Jong 1966).

Table 19. Helminths shared by bobcats and domestic cats.

Parasites reported from domestic cats in New York and New Jersey that were present in New York bobcats.

Species	Literature source*
Aelurostrongylus abstrusus	2,3,5
Alaria spp.	3
Ancylostoma spp.	2,4,5,6
Capillaria aerophila	2,3,5
Physaloptera rara	3,5
Spirometra spp.	7
Toxocara	1-6

Additional parasites reported from both bobcats and domestic cats in the United States.

Anafilaroides rostratus	11	Taenia taeniaformis	2,3,4,6,9
Capillaria plica	9	Toxascaris leonina	3,4,6,8,9
Dirofilania spp.	8,9	Toxocara canis	8
Heterobilharzia americana	10	Trichinella spiralis	9
Paragonimus spp.	2,9	Trichostrongylus spp.	9
Phvsaloptera preputialis	9	Trichuris felis	2,3,8
Taenia pisiformis	1,3,9	Uncinaria stenocephala	3,8,9

* Literature sources for domestic cat parasites

1 Styles and Evans 1971
2 Lillis 1967
3 Burrows and Lillis 1960
4 Mann 1955
5 Baughn and Bliznick 1954
6 Mann and Fratta 1952
7 Mueller 1974
8 Flick 1973
9 Burrows 1965
10 Becklund 1964
11 Levine 1968

Tapeworm larvae of 3 Taenia species were recovered from 10 of 87 (9%) snowshoe hares. Taenia macrocystis and Taenia pisiformes were located in the abdominal cavity of 5 and 4 hares respectively. Infection levels ranged from 2 to 7 larvae of T. macrocystis and from 4 to 9 larvae of T. pisiformes in each snowshoe hare. The majority were attached to the mesentary of the stomach and intestines. An additional hare had large numbers of Taenia serialis serialis (Multiceps serialis) in the muscles of the hind legs. All infected hares harbored only one species. All other parasites found in the snowshoe hare were in their definitive host and not in a larval form.

Examination of other predators yielded 5 helminth species that were shared with the bobcat. Capillaria plica, a common bladderworm of carnivores was found in red foxes, fishers, raccoons and in 1 coyote. Capillaria aerophila was common in the lungs of red foxes and occasionally found in the lungs of coyotes and fishers. The fluke, Alaria spp., was recovered from a few coyotes and 1 red fox. These appeared to be the same species as those in the bobcat. Tapeworms of the genus Mesocestoides were frequently found in the fisher and sporadically in the coyote. Specimens from the fisher appeared to be M. corti based on the description by Voge (1955). Two of the 24 coyotes examined has small Mesocestoides scolices. No developing or mature tapeworms were present so the tapeworms could not be identified to species. In addition 1 coyote harbored the nematode, Physaloptera rara. Porcupines, otters and the single gray fox did not have any parasites in common with the bobcat.

Analysis

Bobcats in New York were lightly parasitized in comparison to bobcats in West Virginia (Watson et al. 1981) and Texas (Stone and Pence 1978). Many of the same parasites were present in all three states and ascarids were the most common parasites. The helminths from New York bobcats are discussed separately and then collectively.

Troglostrongylus wilsoni was described from bobcats in Virginia and North Carolina where 25% of 64 bobcats were infected (Sarmiento and Stough 1956).

Additional reported prevalences of T. wilsoni are 92% in 24 Virginia bobcats (Klewer 1958), 42% of 42 Virginia bobcats (Klewer 1965), 22% in 9 Texas bobcats (Little et al. 1971) and in 73% of 143 West Virginia and 10% of 10 Georgia bobcats (Watson et al. 1981).

The presence of T. wilsoni occasionally caused the formation of a mucous substance in the bronchioles as previously noted by Watson et al. (1981). Life cycle studies have shown that slugs may act as intermediate hosts and laboratory white mice can serve as transport hosts to the definite host (Klewer 1965).

Capillaria aerophila infects the lungs of several carnivores but it is most frequently recovered from red foxes. In New York, Zeh et al. (1977) found 41% of 211 red foxes to be infected with C. aerophila. In contrast only 8% of the New York bobcats were infected indicating that they are not the principal host. Zeh et al. found a mean burden of 87 worms in red foxes and concluded that this lungworm was an important factor in the mortality of foxes. Heavy burdens of C. aerophila may cause bronchitis, bronchopneumonia, secondary bacterial pneumonitis and death (Beck et al. 1968, Levine 1968). Young animals are more susceptible to and more affected by C. aerophila infections (Beck et al. 1968, Levine 1968). Juvenile bobcats also have a higher prevalence rate than older bobcats but the worm burdens (1 to 9) in bobcats of all ages are too low to normally cause severe problems. Bobcats in West Virginia had a prevalence of 35% but the average worm burden was the same as in New York (Watson et al. 1981). The life cycle is direct and earthworms may act as transport hosts (Levine 1968). Bobcats probably acquire an infection directly or through an additional transport host since earthworms are not a part of the diet unless ingested in their prey's gastrointestinal tract.

The presence of Cylicospirura felineus in stomach granulomas of bobcats and lynx has been described in detail by Pence et al. (1978). C. felineus in New York bobcats occurred at a lower prevalence and density and produced smaller nodules in a different

location than C. felineus in Texas bobcats or Canadian lynx. In bobcats from Texas and lynx from Alberta, Canada the viable nodules were all located in the pyloric region (Pence et al. 1978) while in New York bobcats the nodules were in the central body of the stomach. The life cycle of C. felineus is unknown but Levine (1968) presumes that arthropods are the intermediate hosts.

Physaloptera rara was recovered more frequently in bobcats from West Virginia (27%) and Georgia (30%) but at similar densities (Watson et al. 1981). P. rara has also been reported from bobcats in Virginia and North Carolina (Progulske 1952). Baughn and Bliznick (1954) found P. rara in 3/126 (2.4%) of domestic cats from upper New York State. It is common in coyotes of Kansas and other hosts include dogs, raccoons, wolves and foxes (Levine 1968). Insects such as the field cricket, flour beetle, German cockroach and ground beetle are intermediate hosts for P. rara (Levine 1968).

Toxocara mystax, also called T. cati, has a direct life cycle. Eggs passed in the feces may directly infect another feline if they are accidentally ingested. Mice may serve as transport hosts for if they ingest infective eggs, the larvae encapsulates in the tissues (Levine 1968). When a bobcat eats the mouse the larvae are released to infect the bobcat. The greater density of felines in the Catskills may explain the heavier worm burdens of the adult bobcats in that region. Ascarid burdens are usually greater in young animals and may cause unthriftiness in domestic kittens (Levine 1968). Ascarid infections are less prevalent in domestic cats over 6 months old (Visco 1978). Heavy ascarid infections could potentially be damaging to young bobcats but the 13 juveniles and yearlings with over 50 worms apiece were in good to very good condition classes. The one exception was a bobcat with a broken jaw that had healed in a skewed position. This emaciated bobcat had large numbers of immature parasites in the small intestine, perhaps due to an increased susceptibility or decreased immunity from poor nutrition. There were 115 ascarids and 375 Taenia rileyi in the small intestine compared to the average bobcat burdens of 16 and 17 helminths respectively.

The potentially harmful hookworm, Ancylostoma tubaeforme, was only present at low numbers in 7% of the bobcats. An earlier survey in New York reported 36.5% of 126 domestic cats infected with Ancylostoma spp. (Baughn and Bliznick 1954). Hookworms cause loss of blood that can lead to anemia, weakness, emaciation and death especially in young animals who are most susceptible (Levine 1968). The prevalence of hookworms in New York bobcats was too low to find host differences in infection by age or region. The life cycle is direct and the infective larvae enter by ingestion, or through the skin, colostrum or placenta (Levine 1968).

Capillaria plica infections were light and caused no apparent harm to the bobcat. C. plica has previously been reported from 13% of 16 bobcats from North and South Carolina (Miller and Harkema 1968). Heavy capillarid infections may retard growth in young foxes and is associated with secondary bacterial complications (Beck and Beverley-Burton 1968). However in dogs the infection is only slightly pathogenic (Levine 1968). The life cycle is indirect with earthworms as intermediate hosts (Levine 1968).

Oncicola canis is an infrequent parasite of bobcats. Light infections have been reported from Virginia (Progulske 1952), Arizona (Van Cleave 1953), and Texas (Stone and Pence 1978). Other hosts include lynx (Schmidt 1968), domestic cats and dogs and coyotes (Van Cleave 1953). The life cycle is unknown but an arthropod intermediate host is involved (Holloway 1964).

The tapeworms in the small intestine of the bobcat were acquired by ingestion of intermediate or transport hosts infected with the larval stages of the tapeworms. Thus the presence of tapeworms is a direct reflection of the food habits of the bobcat which may vary with the age, sex or locality of the individual bobcat. Snowshoe hares are one of the intermediate hosts of T. macrocystis (Bursey and Burt 1970). Snowshoe hares are also the principal prey of bobcats in the Adirondacks followed in importance by deer (Fox 1982). In the Catskills deer become more important than lagomorphs in the

diet. This difference in food habits is also reflected in the presence and abundance of adult T. macrocystis which are more common in Adirondack bobcats than in Catskill bobcats.

Female bobcats are more frequently infected with T. rileyi than males. The fall and winter food habits of males and females show no significant differences in consumption of small mammals (Fox 1982). However there may be an appreciable difference during the summer months when small mammals are more available. Other studies in West Virginia (Fox and Fox 1983) and Arkansas (Fritts and Sealander 1978) have shown that females utilize small mammals more than males. This may be one possible explanation of the increased prevalence of T. rileyi in the female bobcats of New York. Watson et al. (1981) found a decrease in the prevalence of T. rileyi infections from juveniles and yearlings to adults. The New York data showed a similar decline from yearlings to adults but it was only significant at the 0.1 level rather than at 0.05. Small mammals are the intermediate hosts for T. rileyi and the host records have been summarized by Rausch (1981). Several of these small mammals occur in New York and may be serving as intermediate hosts for the bobcat. These include red squirrels, red-backed voles, white-footed mice and deer mice. All of these small mammals are used as food by New York bobcats (Fox 1982).

Mesocestoides corti is also more prevalent in females and also more abundant. The intermediate hosts are not known although Voge (1953) found tetrathyridia in California lizards which were thought to be M. corti. Voge (1955) synonomized M. variabilis and M. manteri with M. corti but M. variabilis is often used in the literature. This widespread species has been reported from many hosts including bobcats, coyotes, foxes and skunks (Voge 1955). M. corti can also multiply asexually in the small intestine of its host (Schmidt and Todd 1976) so parasite counts may be influenced.

Spirometra mansonoides has two intermediate stages, first in Cyclops spp. and then in a vertebrate host (water snake, mouse, frog) where it remains until it is

ingested by a feline. Mueller (1974) estimates that S. mansonoides is present in 3% of the domestic cats in Syracuse, N.Y. The difference in prevalence between Adirondack and Catskill bobcats may depend on a difference in the presence or abundance of the vertebrates that are actually serving as intermediate hosts.

Toxoplasma gondii antibodies occurred primarily in yearling and adult bobcats. This age difference was also noted in bobcats by Oertley and Walls (1980) in West Virginia and Georgia and by Riemann et al. (1978) in California. The low prevalence of antibodies in juveniles probably indicates low contact with the protozoan. New York bobcats showed no difference in prevalence between males and females unlike the two studies mentioned above. Higher titers in the Catskill and western New York domestic cats may mean more recent exposure or a booster effect on the titer due to repeated exposure. The denser population of felines in the Catskills would increase the probability of released oocysts infecting other animals and cycling the infection through carnivorism back to the bobcat.

Reported prevalences in bobcats with 1:64 as the lowest dilution were 18% in West Virginia and Georgia and 61% in California (Riemann et al. 1978). In Iowa and Missouri 58% of 157 stray domestic cats over 6 months of age were seropositive for T. gondii (Dubey 1973). Feral domestic cats tested in California by Riemann et al. (1978) had a lower prevalence (32%) of antibodies than bobcats (61%).

Animals may acquire an infection through ingestion of feline-produced oocysts, transplacental or congenital infection or through ingestion of cysts in prey species. Oocysts may remain infective in the environment for a year or longer depending on the soil conditions, temperature and exposure to direct sunlight (Yilmaz and Hopkins 1972). In wildlife, carnivorous eating habits are probably of greatest importance in transmission (Quinn et al. 1976). However Riemann et al. (1978) pointed out that infection through the food chain has limitations and that felids appear necessary to perpetuate the protozoan. The similar prevalence of T. gondii antibodies in the Adirondacks and Catskills with low and locally abundant domestic

cat populations respectively suggests the bobcat is important in oocyst production.

The condition of the serum may partially account for the difference in the results between bobcats and domestic cats. The majority of the bobcat serums (95%) were hemolyzed as the blood was collected from carcasses that had been frozen. In contrast only 30% of the domestic cat serums were hemolyzed. All serums were frozen before testing. However there was no significant difference in antibody prevalence or in the mean titers between hemolyzed serum (N=13) and fresh serum (N=31) of domestic cats. In addition 1 domestic cat sample was tested twice from the same blood sample. The first subsample of blood was spun down fresh and frozen. The second subsample was initially frozen to hemolyze the blood and then spun down and frozen. The titers from the two subsamples were identical. Oertley and Walls (1980) considered their T. gondii antibody testing results conservative due to hemolyzed serum and storage time.

The major bobcat parasites were the nematodes, T. mystax, T. wilsoni, C. plica and the cestodes, T. rileyi and T. macrocystis. They are all usually feline host specific with the exception of C. plica. Some of the less common bobcat parasites were shared with other hosts that may be the major reservoirs of infection. The domestic cat and the bobcat are the main sources of most of their major helminths. The domestic cat may serve as a reservoir of infection for A. tubaeforme and A. abstrustus. Several of the bobcat's major parasites have not been found in domestic cats in New York. These include T. macrocystis, T. rileyi, T. wilsoni and C. felineus. However this may be due to a scarcity of parasite studies on rural domestic cats. In addition the genus Taenia can not be identified to species by examining fecal samples.

The nematodes T. wilsoni, P. rara and C. plica were more prevalent in Catskill bobcats. All three have an indirect life cycle with invertebrates as intermediate hosts and probably utilize transport hosts to infect the bobcat. In contrast the tapeworms T. macrocystis and S. mansonoides with vertebrate intermediate hosts were

more prevalent in Adirondack bobcats. T. mystax was the only species that showed a significant regional difference in abundance. Since T. mystax has a direct life cycle the regional difference in abundance may be primarily due to the increased density of felines in the Catskills where there is a greater frequency of exposure. The decreased prevalence and decreased worm burden of T. mystax in adults suggests that partial immunity to reinfection develops in the bobcat.

Acquisition of parasites in the bobcat from other species that may be serving as reservoirs of infection does not appear to be important due to their overall low prevalence and/or abundance.

The snowshoe hare is clearly not a primary intermediate host of helminths in the bobcat. Only 1 species, T. macrocystis, appeared to cycle through the snowshoe hare (intermediate host) and the bobcat (definitive host). Bobcat helminths appear to utilize a wide variety of intermediate and transport hosts, particularly small mammals.

The majority of bobcats in New York State are in good physical condition and do not appear to be harmed by their parasites. Parasite burdens are fairly light and potentially dehabilitating parasites like the hookworm are present in very low numbers. The lungworm pneumonia may decrease fitness of individual animals. It is the conclusion of this study that parasites are not affecting the regional distribution and abundance of bobcats in New York State presently.

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