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Source: Journal of Wildlife Diseases, 12(3) : 322-325

Published By: Wildlife Disease Association

URL: <https://doi.org/10.7589/0090-3558-12.3.322>

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THE PREVALENCE OF ANTIBODIES AGAINST *Toxoplasma gondii* IN SOME ONTARIO MAMMALS

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Abstract: A survey of serum samples from mammals trapped in Central Ontario showed that many contained antibodies to *Toxoplasma gondii*. The prevalence of infection as reflected by positive reactions in the Sabin-Feldman Dye Test appeared to be related to the type of diet of each species examined, and specifically, to the proportion of rodents in the diet. Of the fox blood samples tested, 84% were positive. The percentage of positive samples diminished through, coyote, mink, bear, fisher skunk, raccoon, marten and rabbit. Blood samples from squirrel, deer, hare and groundhog were negative.

INTRODUCTION

Toxoplasmosis is endemic in man and domestic mammals in the densely populated areas of Southern Ontario.² In this communication are reported the results of a serologic survey for toxoplasmosis conducted among wild mammals in the counties of Bruce and Huron, and in the Muskoka, Algonquin Park and Kawartha areas of Central Ontario. Insofar as these areas form the northern boundary of the populated Ontario lowlands, infectious diseases found in mammals in these areas represent potential sources of infection for domestic animals and man further south. In addition, the rapid development of these areas for tourism implies that domestic pets will be introduced into these areas in increasing numbers, with greater opportunities for the interchange of infection between wild and domestic species. It was an objective of this survey, therefore, to ascertain the prevalence of antibodies to toxoplasmosis in wild mammals in this region.

In addition, it was hoped that a knowledge of this prevalence in different species might provide some evidence as to the relative importance of infection obtained through carnivorousism and by oocyst

derived infection. *Toxoplasma* oocysts are derived only from felids¹ and it is desirable to know whether spread of toxoplasmosis in this manner contributed significantly to disease prevalence in the population tested.

MATERIALS AND METHODS

Between 1971 and 1974, blood samples of trapped mammals were collected by trappers operating in Central Ontario and forwarded, when convenient, to the nearest office of the Ontario Ministry of Natural Resources.

These samples consisted of 1 cm diameter filter paper discs³ which were saturated in the heart blood of each dead animal. The discs were allowed to dry and, while in this laboratory, stored at -20 C until used. The offices to which these samples were sent were Parry Sound, Muskoka, Bracebridge, Bancroft, Kirkland Lake, Minden, Pembroke, Whitney and Lambton. In addition, samples were obtained from animals trapped in Huron and Bruce Counties and from animals submitted to the Wildlife Pathology Laboratory, Ontario Veterinary College, for autopsy.

³ Schleicher and Schuell Co., Keene, New Hampshire.

Prior to testing, the blood in each disk was eluted by soaking in 1.6 ml normal saline for 24 to 48 hrs. at 5 C. Disks were gently squeezed by pressing them against the tube bottom with a glass rod. The eluate obtained represented approximately 1/20 dilution of the original sample and was tested at this dilution only. Immediately prior to testing, samples were heated at 56 C for 30 min. and centrifuged at 5,000 g for 10 min to remove particulate debris.

Samples were tested for the presence of antibodies against *T. gondii* by means of the Sabin-Feldman Dye Test (SFDT)¹⁰ utilizing human "accessory factor" and the RH strain of *T. gondii*. The test was considered to be positive when more than 50% of the organisms in the test system were unstained. Appropriate positive and negative controls were used at all times.

RESULTS

Nine hundred and eighty samples from 13 different species were tested. The percentage of samples giving a positive reaction varied significantly among species (Table 1). Samples from Foxes (*Vulpes vulpes*) were 84.4% positive. Coyotes (*Canis latrans*) were 64.3% posi-

tive and mink (*Mustela vison*) were 55% positive. The percentage of positive reactions gradually declined through bear (*Ursus americanus*), fisher (*Martes pennanti*), skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*), marten (*Martes martes*) and rabbit (*Sylvilagus floridanus*) in that order. No positive samples were obtained from deer (*Odocoileus virginianus*), squirrel (*Sciurus carolinensis*), hare (*Lepus americanus*) and groundhog (*Marmota monax*).

No statistically significant differences were observed in the prevalence of antibodies between male and female animals. The numbers of skunk and marten tested enabled an estimate to be made of the annual incidence of *T. gondii* infection in these species. Immature skunk trapped during their first winter were 25% positive while "adult" animals were 33% positive. This suggested that, during the first year of life, the incidence of *T. gondii* infection in this species reached 25%. Similarly the incidence in fisher for this same period was 40%.

Analysis of the sera of animals trapped in the winters of 1971-72, 72-73 and 73-74 gave no indication of significant changes in the prevalence of antibodies during that time.

TABLE 1. The prevalence of antibodies against *Toxoplasma gondii* in 13 species of wild mammals.

Species	Number Tested	Number Positive	Percentage Positive
Fox	96	81	84.4
Coyote	28	18	64.3
Mink	100	55	55.0
Bear	16	7	43.8
Fisher	379	157	41.4
Skunk	62	19	30.6
Raccoon	105	19	18.1
Marten	139	15	10.8
Rabbit	18	1	5.6
Squirrel	8	0	0
Deer	22	0	0
Hare	12	0	0
Groundhog	5	0	0

DISCUSSION

In general, these results tend to suggest that the prevalence of antibodies to *T. gondii* (and hence infection by this organism) may be related to the food habits of the species in question. Herbivores, such as deer and groundhog, are apparently free from this infection. Confirmed omnivores, such as bear and raccoon, have intermediate values while fox and coyote have an extremely high prevalence of antibodies to *Toxoplasma*. It is possible to relate these prevalence rates to the number of rodents consumed.

It has long been assumed that rodents act as carriers of *Toxoplasma* although the epidemiological evidence for this is not great.⁸ Toxoplasmosis can be maintained in rodents through cannibalism and consequently these animals will provide a significant source of infection for animals utilising them for food. The proportion of rodents in the diet of red foxes varies seasonally but can reach 97.8% of the diet at times.⁹ Coyotes probably eat fewer rodents. Sperry¹¹ reported that they constitute 15-17% of the diet of these animals in the western United States; carrion and rabbits probably represent more significant sources of protein. About 20% of the skunk's diet consists of small mammals although they also ingest carrion and birds, especially in winter when insects are scarce.⁵ Black bears and raccoons do eat mice and squir-

rels, but these constitute only a small percentage of the diet.^{1,11}

In Southern Ontario approximately 25% of cats possess antibodies to *T. gondii* (I. R. Tizard: Unpublished observations). It is possible that bobcats (*Lynx rufus*) in the region under study are similarly infected although no figures for this species are presently available. Felids shed oocysts for a short period of time after infection. These oocysts can remain infective for a relatively long period of time when conditions are optimal. Scats are of considerable interest to canids and foxes³ who are liable to paw and mouth them. They therefore represent a potentially significant source of infection especially for the fox and coyote. In spite of this, it is possible on the basis of the results reported here, that ingestion of infected rodents may represent a major source of *Toxoplasma* infection in wild carnivores in Central Ontario.

Another factor which may be considered in relation to these results is the role of *Toxoplasma* in controlling animal populations. In humans this infection has a relatively low morbidity and a very low mortality.⁹ Nevertheless, the extremely high prevalence rate in foxes suggests, even with a relatively low mortality rate, that this infection may contribute to the control of fox populations, and to a lesser extent the control of coyote and mink populations.

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Received for publication 29 September 1975
