

# The Prevalence of Antibodies Against *Toxoplasma gondii* Among Hospitalized Animals and Stray Dogs

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## ABSTRACT

Hospitalized animals and stray dogs were serologically tested for antibodies against *Toxoplasma gondii*. In addition, the data were examined for the possibility of toxoplasmosis infection being associated with the clinical diagnosis and with the discharge status (alive vs. dead).

Among 1056 hospitalized animals, 17 (20%) of 86 cats, 112 (14%) of 804 dogs, 34 (26%) of 133 horses and 6 (18%) of 33 cattle had serological evidence of infection with *T. gondii*. Only 22 (6%) of 342 young (median age = one year) stray dogs were seropositive. The difference in antibody prevalence between hospitalized and stray dogs was thought to be due to age and dietary factors.

Of 249 dogs grouped by clinical diagnosis, there was significantly ( $p < 0.01$ ) higher prevalence of seropositives among dogs with diseases of the kidney or with adrenocortical hyperfunction than among dogs hospitalized for other diseases. Of 19 dogs with diseases of the kidney and 12 with adrenocortical hyperfunction 37% and 42%, respectively, were seropositive. There was higher risk of being discharged from the hospital dead among seropositive dogs, cattle and horses than among seronegative animals of the same species. The exception was cats, where of 69 seronegative cats 29% were dead at discharge and where of 17 seropositive cats 18% were dead at discharge. The possible effects of stress due to hospitalization need further research.

## RÉSUMÉ

Les auteurs ont procédé à la recherche d'anticorps spécifiques à *Toxoplasma gondii*, dans le sérum d'animaux hospitalisés et de chiens errants. Ils analysèrent aussi leurs résultats dans le but de vérifier la possibilité d'une relation entre la toxoplasmose, leur diagnostic clinique et la survie ou la mort des animaux hospitalisés.

Parmi les 1056 animaux hospitalisés, 17 (20%) des 86 chats, 112 (14%) des 804 chiens, 34 (26%) des 133 chevaux et six (18%) des 33 bovins présentaient l'évidence sérologique d'une infection par *T. gondii*. Seulement 22 (6%) des chiens errants, dont l'âge n'excédait pas un an, donnèrent une réaction sérologique positive. La différence dans la prédominance des anticorps sériques décelés chez les chiens hospitalisés et les chiens errants sembla attribuable à l'âge et à des facteurs alimentaires.

Des 249 chiens regroupés selon le diagnostic clinique, ceux qui souffraient de maladies rénales ou d'un hyperfonctionnement du cortex surrénalien possédaient plus souvent ( $P < 0.01$ ) des anticorps sériques contre la toxoplasmose que ceux dont l'hospitalisation résultait d'autres maladies; 37% des 19 chiens qui souffraient de maladies rénales et 42% des 12 autres qui manifestaient un hyperfonctionnement du cortex surrénalien, possédaient des anticorps sériques contre *T. gondii*. Le risque de mortalité au cours de l'hospitalisation s'avéra plus grand chez les chiens, les bovins et les chevaux dont le sérum donnait une réaction positive à la toxoplasmose, que chez les sujets de ces espèces dont la réaction sérologique était négative. La situation se présentait cependant de façon différente, chez les chats; 29% des 69 sujets dont le sérum était dépourvu d'anticorps moururent au cours de leur hospitalisation, comparativement à seulement 18% des 17 sujets dont le

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sérum donnait une réaction positive. Les effets possibles du stress résultant de l'hospitalisation mériteraient une étude plus approfondie.

## INTRODUCTION

*Toxoplasma gondii*, the protozoan responsible for toxoplasmosis, is one of the most ubiquitous parasites in nature. Its indiscriminant host range includes pets and livestock as well as man and many species of wild birds and mammals (5, 9). Although exposure to the organism resulting in infection is common, clinically apparent disease is uncommon (3). When toxoplasmosis is clinically apparent, however, the signs vary considerably with the species affected and with the strain of organism involved (7). The capability of the organism to grow within the cells of the host's brain, eye, liver, lungs, kidney, fetal membranes and skeletal and cardiac muscles provides the opportunity for the disease to be manifested in a multitude of ways. Signs and syndromes that have been associated with toxoplasmosis in various animals include: apathy, fever, dyspnea, cough, jaundice, enteritis, emaciation and nervous system disturbances with incoordination, tremors and paralysis (1). Clinically apparent infections can occur in dogs whose resistance is decreased because of simultaneous distemper infection. In one study concomitant toxoplasmosis and distemper were found in 40% of the dogs studied (2). Furthermore, latent infection with *T. gondii* can proliferate into a fatal unrecognized disease among immunosuppressed or stressed animals (6).

In the present study we were interested in determining: 1) the prevalence of antibodies against *T. gondii* among hospitalized animals, 2) if, among dogs, there was a possible association between their diagnosis and a history of infection with *T. gondii* and 3) if hospitalized animals were at higher risk of being discharged dead when infected with *T. gondii*.

## MATERIALS AND METHODS

### ANIMALS

Each year approximately 6,000 animals

from all areas of California are admitted to the Veterinary Medical Teaching Hospital (VMTH) at the School of Veterinary Medicine, University of California, Davis. The admissions to VMTH in recent years have consisted of approximately 60% canine, 18% feline, 15% equine, 4% bovine and 3% other large or small animals, many of which are exotic species. The samples used for this study were collected from animals for which blood chemistry tests were done for diagnostic purposes. During the period from January, 1973, through December, 1975, 1056 such serum samples collected at the VMTH were tested for antibodies against *T. gondii*. These included sera from 804 dogs, 86 cats, 133 horses and 33 cattle.

In addition, 342 serum samples from stray dogs from two county animal control centers were tested. The sera were collected in 1974 from healthy young (approximately one year of age or younger) dogs of mixed breeds.

### SEROTEST

The sera were tested by the indirect hemagglutination (IHA) test using commercial<sup>1</sup> antigen. Using a microtiter system, dilutions from 1:64 to 1:4096 were tested and agglutinating reactions of  $\geq 2+$  were considered positive for antibodies against *T. gondii*. Titers are reported as the reciprocal of the highest dilution showing the positive agglutination reaction.

### STATISTICAL ANALYSIS

The data were analyzed using standard chi-square tests for contingency tables. The variables tested for possible association with antibody prevalence included species, age, breed, clinical diagnosis and discharge status.

## RESULTS

### SPECIES

Serum samples from a total of 1398

<sup>1</sup>International Biological Laboratories Inc., P. O. Box 1247, Rockville, Maryland 20850.

**Table I. The Prevalence of Antibodies Against *Toxoplasma gondii* Among Hospitalized Livestock and Pets and Stray Dogs**

Species	Tested		Positive		Antibody titer <sup>a</sup>					
	No.	No.	%	64	128	256	512	1024	2048	≥4096
Hospitalized Livestock										
Horses.....	133	34	26	18	9	3	1	2	1	—
Cattle.....	33	6	18	2	3	1	—	—	—	—
Pets										
Cats.....	86	17	20	2	5	5	1	1	2	1
Dogs..... (domiciled)	804	112	14	60	23	14	4	4	3	4
Nonhospitalized										
Dogs (stray)	342	22	6	11	7	3	1	—	—	—
Total.....	1398	191	14	93	47	26	7	7	6	5

<sup>a</sup>Reciprocal of highest serum dilution reacting in the indirect hemagglutination test

domestic animals were tested for IHA antibodies against *T. gondii*. Of these, 14% (190) were seropositive (Table I). The highest prevalence of antibodies (26%) was among horses, followed by pet cats (20%), cattle (18%) and domiciled dogs (14%). The lowest prevalence of antibodies (6%) was among stray dogs. The differences in prevalence among species were highly significant ( $p < 0.0005$ ).

#### TITERS

The greatest proportion of "high" antibody titers was found among the cats. Of the 17 cats that were seropositive, four (24%) had titers  $\geq 1024$ . These high titers are indicative of a generally higher degree of chronic or recent infection among the hospitalized cats. Hospitalized seropositive dogs had the next highest proportion (10%) of antibodies in the higher range, followed closely by horses (9%). Cattle and stray dogs had relatively low titers, and, in fact, none were above 512.

#### AGE

Among cats there was a tendency for the prevalence of antibodies to increase with age of the host. For example, 9% of the cats less than two years of age were seropositive whereas 59% of the cats over ten years of age were seropositive (Table II). This indicates an approximate incidence rate of toxoplasmosis infection for cats to be 4% to 5% per year. There was no apparently consistent increased pre-

valence by age for hospitalized dogs, horses or cattle ( $p > 0.20$  for each of these species).

#### SEX

There was a slightly higher antibody prevalence among spayed female (25%) than among intact female cats (16%). The difference was not significant ( $p > 0.05$ ) and probably reflected an age difference inasmuch as spayed female cats tended to be older than unspayed females ( $p > 0.20$ ).

Although there was no difference in toxoplasmosis antibody prevalence according to sex, there were some revealing characteristics concerning animals whose owners sought veterinary services. For instance, although the sexes of cats were distributed almost uniformly (intact males 25%, intact females 22%, neutered males 29%, neutered females 23%), most (52%) of the hospitalized dogs were intact males and only 4% of the dogs were castrated males, a ratio of 13 to 1. On the other hand, 28% of the dogs were intact females compared to 19% spayed females, a ratio of 1.5 to 1. Among 109 horses and 33 cattle whose sex was recorded, none were neutered. Of these large animals, 81 (74%) of the horses and 24 (73%) of the cattle were females, yielding a ratio of three females to one male for both species.

#### BREED

There were no significant differences in the prevalence of antibodies against *T.*

**TABLE II. Prevalence of Toxoplasmosis Antibodies Among Hospitalized Animals, by Age, Davis, California 1973-75**

Age <sup>a</sup> (yrs)	Pets						Livestock					
	Cats			Dogs			Horses			Cattle		
	Tested	Positive	% <sup>b</sup>	Tested	Positive	%	Tested	Positive	%	Tested	Positive	% <sup>b</sup>
	No.	No.	% <sup>b</sup>	No.	No.	%	No.	No.	%	No.	No.	% <sup>b</sup>
<2	34	3	9	177	26	15	32	6	19	13	0	0
2-3	13	1	8	157	22	14	19	6	32	6	2	23
4-6	16	3	19	235	31	13	24	4	17	8	1	13
7-10	11	3	27	133	27	20	27	12	44	4	1	25
>10	12	7	58	85	6	7	30	6	20	1	1	—
Total	86	17	20	787	112	14	132	34	26	33	6	18

<sup>a</sup>Age was unknown for 17 dogs, one horse and one cow

<sup>b</sup>% = percentage seropositive, not expressed for groups of three or less

*gondii* by breed in any of the animal species tested. In many cases, too few animals of a certain breed were tested to give reliable percentages. However, in cats the prevalence of antibodies against *T. gondii* among Siamese was 24% and among mixed breeds 20%. In horses the prevalence ranged from 24% among Quarterhorses to 30% for Arabian and 32% for Thoroughbred horses. Among cows the prevalence was 13% for Holstein and 22% for Hereford. Among dogs the prevalence of antibodies was 18% for the larger breeds (> 29.7 kg), 13% for medium size dogs (10.2 to 29.7 kg) and 10% for small dogs (1.6 to 10.1 kg).

The distribution of breeds most common among dogs hospitalized at the VMTH and available for serotesting was: Poodle 18%, German Shepherd dog 17%, mixed breed 12%, Dachshund 10%, Collie and Doberman 5% each, Schnauzer 4% and Beagle, Saint Bernard and Great Dane 3% each.

#### ASSOCIATION WITH OTHER DISEASES

The clinical diagnosis of 249 dogs was categorized by systems and organs affected by the disease for which the animal had been hospitalized (Table III). The highest prevalence of seropositive animals was associated with problems of the kidney. Of 19 with kidney diseases that were tested, 7 (37%) were seropositive for *T. gondii* (Table III). Using the odds ratio, this association was statistically significant ( $p < 0.05$ ). A high percentage (42%) of seropositives also was found among dogs having adrenocortical hyperfunction and this as-

sociation between diagnosis and toxoplasmosis antibody prevalence also was significant ( $p < 0.05$ ).

Of the 81 dogs with neurologically related diagnoses, 14% were seropositive but this diagnostic category was not significantly associated with the prevalence of toxoplasma antibodies. Although acute toxoplasmosis in dogs is often associated with various neurological signs, there was insufficient evidence in this study to link chronic toxoplasmosis with the neurological disorders of hospitalized dogs. Similarly, there were no significant associations between possible chronic toxoplasmosis and intestinal, cutaneous or blood disorders.

#### TOXOPLASMOSIS DIAGNOSES

A primary or secondary diagnosis of toxoplasmosis was relatively uncommon among animals admitted to the VMTH. During an eight year period, January, 1968, to February, 1976, only 57 animals admitted to the VMTH were diagnosed as having toxoplasmosis. Of these, 30 were dogs, 25 were cats, one was an exotic feline (Pallas cat) and one was a bird (goshawk). In cases where a second diagnosis was listed, the most common were brain and spinal cord involvement (six dogs, four cats), visual involvement (five cats) and muscle involvement (three dogs, one cat). Two dogs had concomitant canine distemper and one dog and a cat each had concomitant *Coccidioides immitis* infection of the lungs. One dog with toxoplasmosis had kidney involvement and one cat had lymph node involvement and lymphosarcoma.

**Table III. Antibodies Against Toxoplasma in Dogs According to Anatomical System Relating to Clinical Diagnosis**

System Clinical diagnosis	Tested	Positive	
	No.	No.	%
Nervous (total).....	81	11	14
Brain syndrome.....	3	0	0
Focal seizures.....	31	4	13
Myelopathy.....	4	2	50
Compressed spinal cord.....	39	4	10
Encephalopathy (due to distemper).....	4	1	25
Kidney (total).....	19	7	37 <sup>a</sup>
Kidney failure.....	5	1	20
Diseases of kidney.....	8	3	38
Pyelonephritis.....	6	3	50
Endocrine (total).....	32	6	19
Diabetes.....	13	0	0
Adrenocortical hyperfunction.....	12	5	42 <sup>b</sup>
Hypothyroid.....	7	1	14
Intestinal (total).....	43	4	9
Gastroenteritis.....	8	1	13
Enteritis.....	7	0	0
Pancreatitis.....	28	3	11
Cutaneous (total).....	39	3	8
Dermatitis.....	19	1	5
Seborrheic dermatitis.....	10	2	20
Dermatitis due to demodex.....	10	0	0
Blood and lymph (total).....	35	5	14
Lymphosarcoma.....	14	2	14
Lymphoma.....	15	1	7
Anemia.....	6	2	33
Total.....	249	36	13

<sup>a</sup>Odds ratio indicated significant ( $p < 0.05$ ) association between diagnosis and antibody prevalence; comparison group includes all dogs not in the diagnostic category specified

<sup>b</sup>Odds ratio significant ( $p < 0.05$ ), kidney disease cases excluded from comparison

#### DISCHARGE STATUS

The data were analyzed to see if there was a higher rate of deaths among animals that were seropositive for toxoplasmosis than among seronegative animals, the reason being that stress or immunosuppressants during hospitalization might activate a chronic infection, thereby causing unforeseen complications and death. Of 1036 animals for which the discharge status was known, 851 (82%) were discharged alive and 185 (18%) were dead (Table IV). Of the 870 seronegative animals, 723 (83%) were discharged alive and of the 166 seropositive animals, 128 (77%) were alive at discharge from the hospital. A chi-square

test indicated statistically significant differences among death rates ( $p < 0.01$ ) with significantly *high* death rates in seronegative cats and seropositive cattle and significantly *low* death rates in seronegative dogs. Thus, there were from 6% to 10% higher proportions of seronegative dogs, cattle and horses discharged alive than among animals of the same species who were seropositive at admission to the VMTH. The notable exception was cats for which 11% more of the seropositive cats were discharged alive (82%) than were the seronegative cats (71%). It is particularly interesting in this context that cats, the definitive host for *T. gondii*, should differ so strikingly in comparison to the other three species tested.

Table IV. The Distribution of Toxoplasma Antibodies Among Hospitalized Animals by Discharge Status

Discharge Status	Pets						Livestock							
	Cats		Dogs		Horses		Cattle		Total					
	Tested	Positive	Tested	Positive	Tested	Positive	Tested	Positive	Tested	Positive				
No.	%	No.	%	No.	%	No.	%	No.	%	No.	%			
Alive.....	63	14	22	89	13	23	21	23	24	4	17	851	128	15
Dead.....	23	3	13	123	23	34	10	34	9	2	22	185	38	21
Total <sup>a</sup> .....	86	17	20	795	112	20	31	25	33	6	18	1036	166	18

<sup>a</sup>Discharge status was not recorded for nine dogs and 11 horses

## DISCUSSION

In many respects, the animals hospitalized at a large teaching and research institution, such as the VMTH, may not be typical of the patients treated at other veterinary clinics. For example, surveys in Yolo County and in Alameda and Contra Costa counties in California indicate that mixed breeds may constitute more than 30% of the canine population in the area near the VMTH (4, 8). In particular, it is known that many of the animals admitted to the VMTH have been referred by practitioners from other veterinary clinics because the animals had unusual or undiagnosed conditions or needed specialized treatment. For instance, few patients at the VMTH were diagnosed as having toxoplasmosis. However, in the typical veterinary clinic, a larger part of the patient load may consist of cats or dogs with toxoplasmosis or with other diseases such as feline infectious peritonitis or distemper that have clinical signs similar to toxoplasmosis.

Among dogs, horses and cattle, the data are suggestive of a higher risk of death among hospitalized animals having serological evidence of latent toxoplasmosis. If hospitalized animals are under greater stress than is commonly recognized, it seems possible that in some cases a diagnosed disease, complicated by stress-reactivated toxoplasmosis, could be fatal. It is known that toxoplasma cysts (bradyzoites) occur in kidney tissue and a statistically significant association ( $p < 0.05$ ) between kidney disease and toxoplasmosis antibodies was found using the odds ratio. However, due to the nature of the sampling scheme used to obtain our serum samples, it is not known whether toxoplasmosis actually increases the risk of diseases of the kidney and adrenals as our findings may suggest.

Some of the accompanying syndromes, such as brain and spinal cord involvement, are recognized manifestations of *T. gondii* infection while other conditions, such as canine distemper and lymphosarcoma, could be stress conditions that activated latent cases of toxoplasmosis. Further study is needed concerning the effects that specific diseases (other than toxoplasmosis) may have on toxoplasma antibody prevalence. Further research is also needed to determine to what extent various treatment

procedures and the animal's response to treatment, as well as stresses due to hospitalization *per se*, may be contributing to reactivation of latent toxoplasmosis.

The lower antibody prevalence among stray dogs rather than among hospitalized dogs is thought to be due to differences in age and diet. It is known that dogs are often kept at home while they are pups. However, when the owner cannot find a home for them or they grow up, eat more and become sexually mature, they may often be sent to county animal shelters (pounds). It is this population of young, or recently matured, dogs that were raised on mother's milk and puppy chow that constituted a large part of the group of "stray" dogs tested in this study. On the other hand, in addition to being older and thus having a longer period of time to be exposed to *T. gondii*, domiciled mature dogs have often been pampered by feeding scraps of raw meat or have had the opportunity to eat carcasses of wild birds or mammals. It is known that uncooked meat or carnivorousness is an opportune way to transmit *T. gondii*, especially in wild animals (3, 6). Thus, in one study toxoplasmosis antibodies were found in 69% of 86 bobcats and 28% of 58 coyotes (5). This finding leads to speculation that rural dogs and cats that have occasion to prey on wild birds and mammals are at a higher risk of infection than their urban counterparts.

The other extreme of possible dietary influence on toxoplasmosis was shown by the domiciled (and hospitalized) dogs over ten years of age. These ages are the realm of "old age" for a dog and may imply a sheltered life with good care in order to reach those ages. Only 7% of these dogs

had evidence of toxoplasmosis and were probably sustained almost exclusively on canned or prepared dog foods.

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## REFERENCES

1. AVERILL, D.R. and A. DELAHUNTA. Toxoplasmosis of the canine nervous system: clinicopathologic findings in four cases. *J. Am. vet. med. Ass.* 159: 1184-1141. 1971.
2. CAPEN, C.C. and C.R. COLE. Pulmonary lesions in dogs with experimental and naturally occurring toxoplasmosis. *Pathologia vet.* 3: 40-63. 1966.
3. DUBEY, J.P. A review of *Sarcocystis* of domestic animals and of other Coccidia of cats and dogs. *J. Am. vet. med. Ass.* 169: 1061-1078. 1976.
4. FRANTI, C.E. and J.F. KRAUS. Aspects of pet ownership in Yolo County, California. *J. Am. vet. med. Ass.* 164: 166-171. 1974.
5. FRANTI, C. E., H.P. RIEMANN, D. E. BEHYMER, D. SUTHER, J.A. HOWARTH and R. RUPPANNER. Prevalence of *Toxoplasma gondii* antibodies in wild and domestic animals in northern California. *J. Am. vet. med. Ass.* 169: 901-906. 1976.
6. FRENKEL, J.K. Toxoplasmosis: Parasite life cycle, pathology, and immunology. In *The Coccidia*. D.M. Hammond and P.M. Long, Editors. pp. 343-410. Baltimore, Maryland: University Park Press. 1973.
7. QUINN, P. J. and B. M. McCRAW. Current status of *Toxoplasma* and toxoplasmosis: A review. *Can. vet. J.* 13: 247-262. 1972.
8. SCHNEIDER, R. and M.L. VAIDA. Survey of canine and feline populations: Alameda and Contra Costa Counties, California, 1970. *J. Am. vet. med. Ass.* 166: 481-486. 1975.
9. VANDERWAGEN, L.C., D.E. BEHYMER, H.P. RIEMANN and C.E. FRANTI. A survey for *Toxoplasma* antibodies in northern California livestock and dogs. *J. Am. vet. med. Ass.* 164: 1034-1037. 1974.