A Serological Survey of *Toxoplasma gondii* Infection in Zoo Animals and Other Animals

Koichi MURATA

Kobe Municipal Oji Zoo 3-1, Oji-cho, Nada-ku, Kobe 657, Japan

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ABSTRACT. A survey for *Toxoplasma gondii* (Tp) infection in the animals bred or caught in and around Kobe Municipal Oji Zoo was conducted by the Latex Agglutination (LA) test using plasma samples collected for the years from 1980 to 1988. Plasma antibody to Tp ($\geq 1:64$) was found in 5.0% (0 of 181) mammals belonging to 28 families of 10 orders and 6.7% (12 of 179) aves belonging to 22 families of 15 orders, respectively. Cats, rats and pigeons caught in and around the zoo lower positive rates than those reported in previous studies: 9.3% (4 of 43), 0% (0 of 55) and 4.9% (4 of 82), respectively. High antibody titers were obtained from a Caribbean flamingo, a chimpanzee and 7 other animals born in the zoo. These results suggest presence of some primary Tp infection in the animals bred in the zoo.—**KEY WORDS:** antibody detection, cat, rat, toxoplasma, zoo animal.

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Toxoplasma infection is widespread in nature of various species, and there are reports of isolation of *Toxoplasmas* from birds and mammals, including man [17]. *Toxoplasma* infections are also found in captive exotic animals [2, 4]. In the Philadelphia Zoological Garden, 13 mammals and 14 birds died of toxoplasmosis from 1940 to 1950 [13]. Riemann *et al.* [14] examined 109 sera from captive exotic animals and evidence of *toxoplasma* infection was found for 35 (32%) of them. A relationship between prevalence of *Toxoplasma gondii* (Tp) infection among animals and veterinarians was also suggested [19]. Thus of Tp infection in animals is considered a very important issue, concerning the health of both humans and animals. However, there has been few information about Tp prevalence in zoological parks in Japan.

In previous studies, antibodies to Tp were detected in wild animals, most frequently in wild boars (*Sus scrofa*), inhabiting in the suburbs of Kobe City [10–11]. In the present study, antibody prevalence among zoo animals and free-roaming animals caught in

and around a zoo was studied.

MATERIALS AND METHODS

Plasma samples: A total of 360 plasma samples were collected from zoo animals bred in Kobe Municipal Oji Zoo: 181 samples from 53 species of mammals belonging to 28 families of 10 orders and 179 from 61 species of birds belonging to 22 families of 15 orders (Table 1). These samples were collected for the purpose of antibody detection on clinical examinations or treatment or at the time of necropsy, over the years from 1980 to 1988 and stored at -20°C until tested. Plasma samples were also obtained from 43 cats (*Felis catus*), 55 rats (*Rattus norvegicus* and *R. rattus*), and 82 domestic pigeons (*Columba livia*) caught in and around the zoo with some injury, disease or other reasons and stored under the same condition.

Age constitution of animals examined: Zoo animals were roughly classified into three groups (infant or chick, juvenile and adult) with their ages suspected on the time

of puberty and life span of each species. The age was determined on the basis of the breeding history of the animals.

LA test: The detection of antibody to Tp was done by the Latex Agglutination (LA) test. The test was performed with Tox-check-MT (Eiken Chemical Co., Ltd., Japan) as described by Tsubota and Ozawa [20]. Plasma was regarded as positive when the titer was 1:64 or higher.

RESULTS

The results of antibody detection are shown in Table 1, and detailed information about individual animals that were positive is shown in Table 2.

In the zoo animals, antibody to Tp were found in 9 (5.0%) of 181 plasma samples from mammals and 12 (6.7%) of 179 samples from birds, respectively. The highest positive rates occurred in family Pongidae 2 of 6 (33.3%) among mammals and family Anatidae 4 of 26 (15.4%) among birds. The highest titer of 1:8192 was found in an adult female Caribbean flamingo (*Phoenicopterus r. ruber*) died of arthritis. As for the animals caught in and around the zoo, antibodies to Tp were detected 4 (9.3%) of 43 samples obtained from cats, 4 (4.9%) of 82 samples from domestic pigeons. Antibody to Tp was not detected from any of 55 samples from rats. Clinical diagnosis and post-mortem findings of seropositive animals are listed in the last column of Table 2. Of 6 animals with antibodies to Tp which underwent post-mortem examination, no evidence of Tp infection was found.

In comparison between different age groups, antibody was detected from none of 18 infant mammals (0%), 1 of 34 juvenile mammals (2.9%) and 8 of 129 adult mammals (6.2%), and none of 10 chicks (0%), 1 of 18 juvenile birds (5.6%) and 11 of 151 adult birds (7.3%), respectively.

DISCUSSION

The positive rate of Tp infection among the zoo mammals (5.0%) was lower than the figures obtained in previous reports of surveys of free-roaming animals and captive exotic animals [4, 8, 15–17]. High frequency of antibody to Tp as well as high mortality for Tp infection is recognized in captive Felidae and marsupials in Europe and U.S.A. [2, 7, 9, 12, 14]. In this study, antibody to Tp was detected from 2 (8.0%) of 25 red kangaroos (*Macropus rufus*) of order Marsupialia, but not from any of 13 samples from family Felidae. The positive rate for zoo aves was 6.7%, and this rate seemed to be low as compared to high rates of parasitic infection of various bird species [18]. In Japan, the prevalence of Tp infection in cats and rats has been studied by several authors [1, 3]. The Tp antibody detection rates from cats and rats in our survey were lower than expected considering the results of those previous studies. However, the detection of Tp antibody from free-roaming cats in the zoo suggests a need for the control of such cats as well as close attention to contamination of the soil and water with their feces. In some previous studies describe that 10 to 12% of the pigeon population in the U.S. had antibodies to Tp [5, 18], but the detection rate (4.9%) of antibodies to Tp in the species in our survey was not so high as observed in those studies.

In our survey, the low rate of detection of antibodies to Tp in zoo animals may be attributed to the decrease of the number of exotic animals caught and transported from their native habitats to zoological parks by dealers, which is the reflection of the worldwide mood for wild animal conservation. It should also be noted that a lot of zoo species have come to be bred in zoos for many generations. In this study, 116 of 181 mam-

Table 1. Orders, families, number of animals examined and number of positive samples among the zoo animals

Order	Family	No. of Species	No. of Samples	No. of Positive Samples (%)
Mammals				
Marsupialia	Macropodidae	1	25	2(8.0)
Edentata	Dasyopodidae	1	3	0
Scandentia	Tupaiaidae	1	2	0
Chiroptera	Pteropodidae	1	5	0
Primates	Lemuridae	2	3	0
	Lorisidae	1	1	0
	Cebidae	3	9	0
	Cercopithecidae	8	30	0
	Hylobatidae	2	7	1(14.3)
	Pongidae	2	6	2(33.3)
Carnivora	Canidae	4	24	1(4.2)
	Ursidae	4	7	0
	Procyonidae	2	2	0
	Mustelidae	1	5	0
	Felidae	5	13	0
	Otariidae	1	1	0
Perissodactyla	Equidae	3	5	0
Artiodactyla	Hippopotamidae	1	1	0
	Camelidae	1	2	0
	Cervidae	1	2	0
	Giraffidae	1	4	0
	Bovidae	1	7	2(28.6)
Rodentia	Sciuridae	1	1	0
	Muridae	1	1	0
	Hystriidae	1	2	0
	Caviidae	1	4	0
	Myocastoridae	1	2	0
Lagomorpha	Leporidae	1	7	1(14.3)
Total		53	181	9(5.0)
Aves				
Struthioniformes	Struthionidae	1	4	0
	Rheidae	1	2	0
	Casuariidae	1	1	0
	Dromaiidae	1	5	0
Sphenisciformes	Spheniscidae	5	8	1(12.5)
Ciconiiformes	Ardeidae	2	2	0
	Ciconiidae	2	7	0
	Threskiornithidae	1	4	0
Phoenicopteriformes	Phoenicopteridae	4	27	4(14.8)
Falconiformes	Cathartidae	1	1	0
	Accipitridae	2	7	0
Anseriformes	Anatidae	9	26	4(15.4)
Galliformes	Phasianidae	12	42	3(7.1)
Gruiformes	Gruidae	2	15	0
Charadriiformes	Laridae	2	3	0
Columbiformes	Columbidae	1	1	0
Psittaciformes	Cacatuidae	3	7	0
	Psittacidae	7	11	0
Cuculiformes	Musophagidae	1	1	0
Coraciiformes	Bucerotidae	1	1	0
Piciformes	Ramphastidae	1	3	0
Passeriformes	Ploceidae	1	1	0
Total		61	179	12(6.7)
Sum total		114	360	21(5.8)

Table 2. Detailed information about seropositive zoo animals

Order	Species	Sex	Age	Origin	LA-titer	Clinical diagnosis or Post-mortem findings
MAMMALIA						
Marsupials	Red kangaroo (<i>Macropus rufus</i>)	M	A	W	1:128	Cerebral Bleeding ^{a)}
	—	F	A	Z	1:128	Pneumonia ^{a)}
Primates	White-handed gibbon (<i>Hylobates lar</i>)	M	A	C	1:128	Normal
	Chimpanzee (<i>Pan troglodytes</i>)	F	A	U	1:1024	Normal
Carnivora	Lowland gorilla (<i>Gorilla g. gorilla</i>)	M	A	W	1:128	Pancreatitis ^{a)}
	Japanese fox (<i>Vulpes V. japonica</i>)	F	A	W	1:64	Trauma
Artiodactyla	Japanese serow (<i>Capricornis crispus</i>)	F	A	W	1:512	Trauma
	—	F	Y	Z	1:128	Uremia
Lagomorpha	House rabbit (<i>Oryctolagus cuniculus domesticus</i>)	M	A	Z	1:64	Nephrolithiasis ^{a)}
AVES						
Shenisciformes	Magellanic penguin	F	A	W	1:128	Egg Peritonitis ^{a)}
Phoenicopteriformes	Caribbean flamingo (<i>Phoenicopterus ruber ruber</i>)	F	A	W	1:8192	Arthritis
	European flamingo (<i>P. r. roseus</i>)	F	A	W	1:64	Fracture
	Chilian flamingo (<i>P. chilensis</i>)	M	A	W	1:512	Asphyxia
	—	F	A	Z	1:64	Staphylococosis
Anseriformes	Domestic duck (<i>Anas platyrhynchos domesticus</i>)	F	A	C	1:256	Normal
	—	F	A	C	1:256	Perosis
	Mandarin duck (<i>Aix galericulata</i>)	M	A	C	1:64	Normal

The symbols mean as follows: M: male, F: female, U: unknown, A: adult, Y: young, W: wild caught, C: captive born out of the zoo, Z: zoo born and a):post-mortem findings at necropsy.

imals (64.1%) and 98 of 179 birds (54.7%) were captive born, and considering the spread of toxoplasmosis in many species of wild animals [17–19], these factors may have led to the low detection rate of antibodies to Tp in the zoo animals. The hygienic situation of the zoo facilities has been improved much more than before. This will be supported by the low seropositivity among the zoo keepers and veterinarians (1(8.3%) of 12: unpublished data). Konishi *et al.* [6] indicated that the recent decrease of Tp infection among slaughtered animals for food can be attributed to the improvement of the hygienic environment.

In spite of the low frequency of antibodies against Tp in zoo animals, there were a few exotic animals which showed high antibody titer, for example, the titer of 1:8192 in an adult female Caribbean flamingo and 1:1024 in an adult female chimpanzee (*Pan troglodytes*). Seven animals born in the zoo had antibodies to Tp (Table 2), and the positive rate increased with the aging of the animals. These results indicate the presence of some primary infection of Tp in the zoo, and are to give an alarm for the need of careful handling of these animals, especially at the time of necropsy.

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REFERENCES

1. Hagiwara, T. 1977. Toxoplasmosis of animals in Japan. *Int. J. Zoon.* 4: 56-70.
2. Hilgenfeld, M. 1965. Toxoplasmose bei Zootieren. *D. Zoolog. Garten.* 30: 262 (cited Jacobs and Frenkel 1982).
3. Iseki, M., Nishibayashi, M., Sano, R., Ogo, T., Inamoto, T., and Shibuya, J. 1972. Prevalence of *Toxoplasma* antibodies in rats in Osaka. *Jpn. J. Parasitol.* 21: 39-44.
4. Jacobs, L. and Frenkel, J. K. 1982. Toxoplasmosis. pp. 167-185. *In: CRC Handbook Series in Zoonoses, Parasitic Zoonoses Vol. I* (Steele, J. H. ed.), CRC Press, Florida.
5. Jacobs, L., Melton, M. L., and Jones, F. E. 1952. The prevalence of toxoplasmosis in wild pigeons. *J. Parasitol.* 38: 457-461.
6. Konishi, E., Sato, R., Takao, T., and Anada, S. 1987. Prevalence of antibodies to *Toxoplasma gondii* among meat animals slaughtered at an abattoir in Hyogo Prefecture, Japan. *Jpn. J. Parasitol.* 36: 347-351.
7. Klöss, H. G. and Lang, E. M. 1982. *Handbook of Zoo Medicine*, Van Nostrand Reinhold Co., New York.
8. Macconnell, E. E. Basson, P. A., Wolstenholme, B., De Vos, V., and Malherbe, H. H. 1973. Toxoplasmosis in free-ranging Chacma baboons (*Papio ursinus*) from the Kruger National Park. *Trans. Royal. Soc. Trop. Med. Hyg.* 67: 851-855.
9. Møller, T. 1962. Three casuistic reports of toxoplasmosis in zoo-animals (*Macropus bennetti*, *Marmota marmota*, *Lepus timidus*) *Nord. Vet. Med.* 14: 233-243.
10. Murata, K. 1987. Antibodies against *Toxoplasma gondii* in wild animals wounded or diseased and caught in the Kobe area. *J. Jpn. Vet. Med. Assoc.* 40: 846-849 (in Japanese with English Summary).
11. Murata, K. 1988. A serological survey of antibodies against *Toxoplasma gondii* in wild boars (*Sus scrofa*) in Kobe district. *J. Jpn. Vet. Med. Assoc.* 41: 811-813 (in Japanese with English Summary).
12. Potkay, S. 1977. Diseases of Australian Marsupials. pp. 456-497. *In: The Biology of Marsupials* (Hunsaker, D. II ed.), Academic Press, New York.
13. Ratcliffe, H. L. and Worth, C. B. 1951. Toxoplasmosis of captive wild birds and mammals. *Am. J. Pathol.* 27: 655-667.
14. Riemann, H. P., Behymer, D. E., Fowler, M. E., Schulz, T., Orthoefer, J. G., Silverman, S., and Franti, C. E. 1974. Prevalence of antibodies to *Toxoplasma gondii* in captive exotic mammals. *J. Am. Vet. Med. Assoc.* 165: 798-800.
15. Riemann, H. P., Burrige, M. J., Behymer, D. E., and Franti, C. E. 1975. *Toxoplasma gondii* antibodies in free-living african mammals. *J. Wildl. Dis.* 11: 529-533.
16. Riemann, H. P., Howarth, J. A., Ruppanner, R., Franti, C. E., and Behymer, D. E. 1975. Toxoplasma antibodies among bobcats and other carnivores of Northern California. *J. Wildl. Dis.* 11: 272-276.
17. Sanger, V. L. 1971. Toxoplasmosis. pp. 326-330. *In: Parasitic Diseases of Wild Mammals* (Davis, J. W. and Anderson, R. C. eds.), Univ. Iowa State Press, Iowa.
18. Sanger, V. L. 1971. Toxoplasmosis. pp. 313-316. *In: Infectious and Parasitic Diseases of Wild Birds* (Davis, J. W., Anderson, R. C., Karstad, L., and Trainer, D. O. eds.), Univ. Iowa State Press, Iowa.
19. Tizard, I. R. and Caoili, F. A. 1976. Toxoplasmosis in veterinarians: an investigation into possible sources of infection. *Can. Vet. J.* 17: 24-25.
20. Tsubota, N. and Ozawa, H. 1977. Studies on Latex Agglutination test for Toxoplasmosis (1) Preparative conditions and stability of the reagent. *Jpn. J. Parasitol.* 26: 276-285.

要 約

動物園飼育動物ならびにその他動物のトキソプラズマ抗体保有調査：村田浩一(神戸市立王子動物園)——動物園の飼育動物，ならびに動物園周辺で保護もしくは捕獲されたネコ，ネズミ，ドバトについて，ラテックス凝集反応によるトキソプラズマ(Tp)抗体保有調査を行った．調査対象である動物園動物360個体のうち Tp 抗体価64倍以上を示したものは，哺乳類10目28科中 5 % (9/181)，鳥類15目22科中6.7% (12/179)であった．ネコ43個体，ネズミ55個体，ハト82個体の陽性率は各々，9.3%，0%，4.9%であった．これらの他の報告に比べて低い抗体保有率は，動物園施設の衛生的改善や飼育動物中に占める野生捕獲動物数の減少によるものと考えられた．しかし，ペニイロフラミンゴやチンパンジーに認められた高い抗体価(1：8192と1：1024)と他の動物園内繁殖動物7個体にみられた64倍から512倍の抗体保有，さらに園内で捕獲されたネコ4個体における128倍から512倍の抗体価の存在から，低率ではあるが動物園内における Tp 感染の成立が疑われた．このことから，野生動物の取扱い，ならびにネコによる動物舎周辺の土壌汚染については，動物の健康管理面のみならず公衆衛生面からも更に注意を続ける必要が示唆された．