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# *Toxoplasma gondii* ANTIBODIES IN FREE-LIVING AFRICAN MAMMALS

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*Abstract:* Twelve species of free-living African mammals from Kenya, Tanzania, Uganda and Zambia were tested for antibodies to *Toxoplasma gondii* using the indirect hemagglutination test. Of 157 animals sampled, 20 (13%) were seropositive. *T. gondii* antibodies were detected in Burchell's zebra, (*Equus burchelli*), hippopotamus (*Hippopotamus amphibius*), African elephant (*Loxodonta africana*), defassa waterbuck (*Kobus defassa*), lion (*Panthera leo*), and rock hyrax (*Procavia capensis*). The highest titers were found in elephants, two having titers of 1:4096 and one of 1:8192. These results are discussed in relation to the maintenance of *T. gondii* among African wildlife.

## INTRODUCTION

In a recent study in California, 32% (35 of 109) of the captive exotic animals tested had serologic evidence of exposure to *Toxoplasma gondii*. However, it was not possible to determine if some of these animals had been infected prior to importation into America. It was important, therefore, to examine free-living animals and, in the present study, sera collected from African mammals in their native habitat were tested for antibodies to *T. gondii*.

## MATERIALS AND METHODS

### Animals

One hundred and fifty-seven serum samples were collected from 12 species of wild mammals in four areas of Africa (Table 1). These areas were as follows: a cattle ranch at Elmenteita in the Rift Valley of Kenya; the northern shore of Lake Victoria in the Busoga District of Uganda;[7] the Serengeti National Park and the adjacent area of Loliondo, both in Tanzania; and the Southern Luangwa Valley Game Reserve in Zambia. All animals were shot and then bled immediately for serum collection. Aqueous merthiolate (1:10,000) was added to each serum sample and all sera were stored at —20 C. The sera were heated at 56 C for 1 h prior to shipment to this laboratory.

The ages of the elephant and hippopotamus sampled were recorded as adult, juvenile, or calf, and the sex of every animal tested was noted.

### Serology

The serum samples were tested by the microtiter method of the indirect hemagglutination (IHA) test,[6] using a commercially available antigen.[1] Sera giving a 2+ reaction at a 1:64 dilution were considered positive and were titrated to their endpoints. The 1:32 dilution of serum was used as a nonsensitized cell control and any serum that reacted nonspecifically was omitted from the study.

[1] Industrial Biological Laboratories, Inc., 481 South Ave., Rockville, Maryland 20851, USA.

TABLE 1. Wild mammals studied, by area of capture.

| Order | Species | Number sampled by area | | | | | |
|---|---|---|---|---|---|---|---|
| | | Kenya | Uganda | Serengeti | Loliondo | Zambia | All areas |
| Carnivora | Lion (*Panthera leo*) | | | 1 | | | 1 |
| Proboscidea | African elephant (*Loxodonta africana*) | | 1 | | | 62 | 63 |
| Hyracoidea | Rock hyrax (*Procavia capensis*) | | | 1 | | | 1 |
| Perissodactyla | Burchell's zebra (*Equus burchelli*) | | | | 29 | | 29 |
| | Bushpig (*Potamochoerus porcus*) | | 1 | | | | 1 |
| | Warthog (*Phacochoerus aethiopicus*) | | | 2 | | | 2 |
| | Hippopotamus (*Hippopotamus amphibius*) | | | | | 49 | 49 |
| Artiodactyla | Defassa waterbuck (*Kobus defassa*) | | 2 | | | | 2 |
| | Impala (*Aepyceros melampus*) | 1 | | | | 2 | 3 |
| | Grant's gazelle (*Gazella granti*) | 1 | | | | | 1 |
| | Thomson's gazelle (*Gazella thomsoni*) | | | 4 | | | 4 |
| | Duiker (undetermined sp.) | 1 | | | | | 1 |
| Totals | | 3 | 4 | 8 | 29 | 113 | 157 |

## RESULTS

Of 157 serum samples tested, 20 (13%) had *T. gondii* antibodies (Table II). The highest prevalence of antibodies was detected among zebra where eight of 29 samples were seropositive. Other species showing *T. gondii* antibodies were hippopotamus (4 of 49), elephant (4 of 63), defassa waterbuck (2 of 2), and lion and rock hyrax (both 1 of 1). The highest titers were found in elephants, two having titers of 1:4096 and one of 1:8192. There was no evidence of *T. gondii* antibodies in either the wild pig or the small antelope species tested.

*T. gondii* antibodies were detected in wild mammals from all areas studied, except the ranch in Kenya from which only three samples were collected.

All the elephant and hippopotamus sera containing *T. gondii* antibodies were collected from adult animals (for both species, 4 of 39 adults were seropositive). The prevalence of *T. gondii* antibodies was similar for each sex of elephant (1 of 13 males and 3 of 49 females were seropositive), hippopotamus (1 of 18 and 3 of 31), and zebra (6 of 20 and 2 of 9).

TABLE 2. Distribution of HI antibody titers to **Toxoplasma gondii** among African wildlife.

| Species | No. tested | No. positive | Reciprocal titer | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | <64 | 64 | 128 | 256 | 512 | 1024 | 2048 | 4096 | 8192 |
| Lion | 1 | 1 | 0 | 1 | | | | | | | |
| African elephant | 63 | 4 | 59 | | 1 | | | | | 2 | 1 |
| Rock hyrax | 1 | 1 | 0 | | | 1 | | | | | |
| Burchell's zebra | 29 | 8 | 21 | 3 | 2 | 2 | | | 1 | | |
| Bushpig | 1 | 0 | 1 | | | | | | | | |
| Warthog | 2 | 0 | 2 | | | | | | | | |
| Hippopotamus | 49 | 4 | 45 | 4 | | | | | | | |
| Defassa waterbuck | 2 | 2 | 0 | 2 | | | | | | | |
| Impala | 3 | 0 | 3 | | | | | | | | |
| Grant's gazelle | 1 | 0 | 1 | | | | | | | | |
| Thomson's gazelle | 4 | 0 | 4 | | | | | | | | |
| Duiker | 1 | 0 | 1 | | | | | | | | |
| Totals | 157 | 20 | 137 | 10 | 3 | 3 | 0 | 0 | 1 | 2 | 1 |

## DISCUSSION

Our results show that *T. gondii* is present in wild mammals in three different areas of Africa. Many of the captive exotic animals studied by Riemann *et al.*[8] were from species indigenous to Africa. Direct comparisons between the African and U.S. groups of animals cannot be made because different species were studied in each group. There were, however, certain similarities between the groups. For example, about 10% of the Artiodactyla in each group were seropositive. Since these are herbivores, exposure to *T. gondii* would likely be from ingestion of oocysts shed by Felidae rather than by ingestion of cyst-

infected meat.[2,3,5,10] If one can extend the observations that certain Felidae can serve as definitive hosts,[4,5] one might postulate that lions and genets could also serve as such hosts and oocyst shedders. The potential ability of wild Felidae to harbor *T. gondii* has been shown by the study of captive exotic animals in California where 75% of the 12 feline species tested were found to have *T. gondii* antibodies.[8]

Another similarity between the wild and the captive groups of animals was the high antibody titers found in some elephants. Three of the seropositive African elephants had titers of 1:4096 or 1:8192, and were the highest found among the 12 species tested. One of the three captive Indian elephants tested and reported in our earlier study,[8] had a titer of 1:524,288, which was the second highest titer among the 47 captive species studied.

In general, titers for seropositive captive animals were higher than seropositive animals in the present study, the conditional median antibody titer for the seropositive captive animals being 1:256 compared to a median titer of 1:64 for the seropositive African wildlife. High antibody titers are often an indication of active chronic infection. Many investigators have found that a high frequency of isolations can be made from animals with titers $\geq$ 1:256.[9] However, the parasites also can be present in animals with much lower antibody titers and, in some cases, particularly in birds, the organism can be isolated from individuals with no detectable antibodies.[5]

This study provides evidence that *T. gondii* is being maintained in free-living African wildlife. The organism appears to be maintained among chronically infected herbivores and carnivores, with various wild Felidae amplifying the infection chain among these free-living wild mammals. All of the necessary conditions for the perpetuation of *T. gondii* were present in the areas that were studied. Small species of Felidae such as genets (*Genetta genetta*) were found in all areas, while larger species such as lion were also present in Tanzania and Zambia. These cats probably act as the definitive hosts for the parasite, with herbivores becoming infected by ingestion of oocysts. In all probability, the complete cycle of *T. gondii* can be maintained in Africa by an infection chain that includes the lion and zebra, which have a common predator-prey relationship, as well as in domestic cat-rodent cycle as has been shown in less remote areas.[1]

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