RESEARCH REPORT

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PORK SAFETY

Title: Prevalence and Associated Risks in Areas Highly Endemic for *Toxoplasma gondii* in Swine – **NPB #98-207**

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I. Introduction

Human infection with the protozoan parasite *Toxoplasma gondii* is common in the U.S. and worldwide. Up to 40% of the U.S. population has antibodies to *T. gondii*, and even higher prevalence rates have been reported in other countries (Dubey, 1994). Infection in healthy adults is generally not serious. However, infection in pregnant women and subsequent transplacental transmission of the parasite can result in congenitally infected infants with birth defects or suffering chronic disease. Worldwide, congenital toxoplasmosis occurs in 0.1 to 0.3% of births (Smith, 1997). Acute infection or recrudescence of latent infection is important in adults whose immune system is compromised by immunosuppressive drugs or by retroviral infection. Toxoplasmic encephalitis is the second most common opportunistic infection of AIDS patients (Smith, 1997) and occurrence of this disease is proportional to the seroprevalence in the population. The annual health care costs of toxoplasmosis in the U.S. are estimated to be $0.4 - 8.8 billion (Roberts et al., 1994).

Human exposure to *T. gondii* has historically been associated with cats. Feline hosts are the only animals in which the parasite completes its entire life cycle and cats pass the infective and environmentally resistant oocyst stage in their feces. Inadvertent ingestion of oocysts by children or adults handling cats or litter boxes results in infection. Considerable public health efforts have been directed to educating pregnant women on the risks of exposure to *Toxoplasma* during pregnancy.

In recent years, it has been recognized that food animals play a role in the transmission of *Toxoplasma* to humans (Dubey, 1994). This realization is based on studies which have shown higher prevalence in segments of the population that eat undercooked meat, as compared with others who cook meat thoroughly (Kimball et al., 1974). Further, it has been observed that younger children do not become infected at the same rate as teenagers; this difference in exposure has been suggested to be a result of

eating habits (the age when children begin to eat solid meat), as cat exposure would not differ among children of different ages.

Of the meat animal species, cattle and poultry have not been shown to harbor significant numbers of *T. gondii*. Although sheep are known to have a high prevalence of infection with *T. gondii* little lamb is consumed in the U.S. on an annual basis. Based on the consumption of fresh pork in the U.S. and prevalence rates found for *T. gondii* in pigs, pork is likely a significant contributor to human exposure to this parasite. Studies of national and regional prevalence of *T. gondii* in pigs have shown variable rates of infection. Dubey et al. (1991), in a national prevalence study conducted in 1983-1984, reported *T. gondii* antibodies in 23.9% of 11,842 pigs; the infection rate was higher in breeding animals (41.4%), as compared with market-aged animals (23%). Infection rates were relatively consistent in different regions of the U.S. Zimmerman et al. (1990) found a prevalence rate of 5.96% for 2,616 pigs in Iowa; again, breeding animals (11.4%) were higher than market animals (5.4%). No differences in infection rate were found based on herd size. Infection did not differ according to management practices (confinement versus non-confinement). However, herds finishing swine in confinement had lower within herd prevalence. Patton et al. (1996) tested sera drawn for the 1990 NAHMS survey and found 679 of 3479 (20%) pigs positive. Regionally, prevalence ranged from 12% in Illinois to 36% in Wisconsin. In a study conducted on 179 farms in Illinois, Weigel et al. (1995a) found 1057 of 5080 (20.8%) of breeding animals to be positive and 59 of 1885 (3.1%) of market animals positive. Herds with no positive animals were found on 61 of 172 farms (35.5%) with breeding stock and 28 of 44 farms (63.6%) with grower/finisher animals. Recent studies in the New England states have found very high infection rates in pigs (Gamble et al., unpublished); using the modified agglutination test, 77 of 85 farms had seropositive pigs and overall prevalence was found to be 47.4%. Within positive herds, the mean prevalence rate was 48.4%.

Only a couple of studies have addressed the issue of risk factors associated with *T. gondii* infection in pigs. Assadi-Rad et al. (1995) found sows associated with cats to be 2.6 times more likely to be seropositive as compared with sows not associated with cats. Sows on small farms were 4.5 times more likely to be positive when compared with sows on large farms. Finally, sows kept outdoors were 23 times more likely to be infected as compared with sows kept indoors. Weigel et al. (1995b) conducted two epidemiologic studies on swine farms in Illinois. They found *T. gondii* infection in pigs to be associated with presence of cats on farms, particularly juvenile cats; in addition, the presence of infected house mice correlated with infection in pigs. No correlation was seen with infected pigs and management systems; confinement pigs were no less likely to be infected than pigs housed outdoors.

A central question in transmission of toxoplasmosis to pigs is the point source of infection. It is clear that the major source of infection is the oocyst, which can only be passed by cats. Wildlife and rodents play only a minimal or bystander role in swine toxoplasmosis. Determining the distribution and prevalence of oocysts on the farm will aid tremendously in developing strategies to reduce pig exposure.

II: Objectives

1. Document the prevalence of *T. gondii* infection in sows and market pigs from the eastern United States, including New England, New Jersey, Pennsylvania, and

Ohio.

2. Identify risk associations on positive farms specifically related to the role of cats and differences in management systems. On a subset of *Toxoplasma* positive farms identified in serological studies, we will identify the location and prevalence of oocysts in the environment.

3. Identify "model" farms that are negative for *T. gondii* infection and document management systems that preclude infection.

III. Procedures

Serum or tissue fluids were obtained as convenience samples as part of an ongoing study on trichinae in New England, New Jersey, Pennsylvania, Ohio, Indiana, Illinois and Michigan. Additional samples were obtained from farms in northwest Iowa, southern Minnesota and southeastern South Dakota as part of a study under the USDA's Fund for Rural America. Samples included serum drawn on farms, serum or tissue samples obtained at slaughter, and banked sera drawn as part of other federal swine health programs. All samples were tested for antibodies to *Toxoplasma* gondii using the modified agglutination test (MAT) as described by Dubey (1997) and using a commercial ELISA (Safe-Path Laboratories, Inc, Carlsbad, CA) developed in the ARS laboratories. Information about farm management practices was obtained when possible and, in some cases, risk factors for transmission of *Toxoplasma* were evaluated.

Farms found to be positive for *Toxoplasma* infection were selected for further studies including environmental sampling. Farms were selected based on level of infection (>20% of pigs positive) and recency of infection (infection found in feeder/finisher pigs). Some farms with low-level infection rates were also included in the environmental sampling protocol. Another group of negative farms was selected to evaluate management practices that prevent *Toxoplasma* infection.

For environmental sampling, producers were contacted and their cooperation solicited for collection of samples of soil and feed. Samples collected consisted of approximately one liter of volume (the size of a coffee can) per sample site. The surface area sampled was approximately 100 sq. ft. for most samples. Multiple locations (5-10) were tested on each pork production site, including feed storage areas, feed delivery areas and non-concrete feed areas. Soil samples from dirt floor barns and pasture areas were also tested.

The presence of oocysts in samples was determined by bioassay in pigs. It is known that a single oocyst will cause infection in pigs (Dubey et al., 1996). Each sample was divided into 2 parts consisting of approximately 500 grams of material, mixed with corn mash and fed to pigs. Pigs were bled at 6 and 12 weeks following exposure and serum tested by MAT and ELISA for antibodies to *Toxoplasma*.

A group of intensively managed farms that had a low frequency of *Toxoplasma* infection was selected to evaluate management practices that preclude exposure of pigs. Each farm was visited and evaluated for risk and comparisons made of management practices on negative farms and those having low-level infections.

IV. Results

To determine regional prevalence of infection with *Toxoplasma gondii*, 1897 pigs from 85 farms in 5 New England states were tested using a modified direct agglutination test. Sera were diluted 1:25 and a titer at this dilution was indicative of *T. gondii* infection. Farm management questionnaires were completed at the time of blood collection and were used to develop descriptive statistics on farms tested and to determine measures of association for risk factors for the presence of *T. gondii*-seropositive pigs. A total of 900 seropositive pigs were identified for a prevalence rate of 47.4%. (see Table 1)

Table 1. *Toxoplasma gondii* MAT positive pigs by state.

State	Pos. pigs/total pigs	Prevalence	Pos./total herds	Prevalence
Connecticut	219/383	57.2%	15/15	100%
Massachusetts	398/817	48.7%	26/31	83.9%
New Hampshire	34/95	35.8%	6/8	75.0%
Rhode Island	90/157	57.3%	7/7	100%
Vermont	159/445	35.7%	23/24	95.8%
Total	**900/1897**	**47.4%**	**77/85**	**90.6%**

Of 85 herds tested, 77 had at least 1 positive pig for a herd prevalence rate of 90.6%. Within herd prevalence ranged from 4-100% (mean = 48.4%). All farms studied had one or more risk factors for exposure to *T. gondii*. However, statistical associations with individual risks could not be made, most likely due to the extremely high prevalence. The results obtained here suggest that education on farm management practices to reduce exposure to *T. gondii* should be targeted to include small producers. In addition to studies in New England, prevalence was determined on farms in New Jersey, Ohio, Pennsylvania, Indiana, Illinois and Iowa. Pigs included sows as well as finishers (Table 2).

Table 2. *Toxoplasma gondii* ELISA/MAT positive pigs by state.

State	Sample	Pos. pigs/total pigs	Prevalence
New Jersey	Sows	498/1504	33.1%
Illinois	Sows	723/3498	20.7%
Indiana	Sows	1574/3646	43.2%
Pennsylvania	Finishers – 1	122/2755	4.4%
	Finishers – 2	54/3900	1.4%
Ohio	Finishers	3/567	0.5%
Iowa	Finishers (hoops)	88/1319	6.7%
	Finishers (confinement)	31/15657	0.19%

There were obvious differences in prevalence between market hogs versus breeding animals. In addition, prevalence rates from hogs finished in hoops, was higher than hogs finished in confinement. The herd prevalence rate for confinement finished pigs was 4/56,

or 1.8%, contrasted with a herd prevalence rate of 90.6% for pigs raised outdoors.

Environmental samples were collected from farms with high and low within herd prevalence of *Toxoplasma* in New England states (6 farms) and Iowa (6 farms). A total of 5 samples were collected from each farm and included samples from entry and load-out areas, feed areas, and other locations outside barns where oocysts might be expected. Results of all bioassays of these samples in pigs were negative. Although a comprehensive survey of cats from these farms was not undertaken, a single blood sample taken from one domestic cat on a *Toxoplasma* positive farm was positive by MAT. The results obtained here suggest that widespread contamination with *Toxoplasma* oocysts in the environment cannot be measured even using sensitive methods of bioassay. However, the fact that a single oocyst can cause infection makes even low-level contamination a risk for pig exposure.

A group of confinement farms with low level of *Toxoplasma* infection in pigs were evaluated for risk factors associated with infection as well as management factors that preclude exposure of pigs. The following table summarizes management factors associated with positive pigs:

Table 3. Risk factors identified on *Toxplasma*-positive and negative farms in Iowa.

	Positive farms	Negative farms
Total	6	22
Confinement	4	22
Non-confinement	2	0
Active mouse population	6	18
Minimal rodent activity	0	4
Cats observed	5	7
Cat not observed	1	15
Farms with boot changes	0	0
Farms without boot changes	6	22

There are notable risk associations with negative versus positive farms. Of the *Toxoplasma* positive farms, 2/6 (33.3%) were not confinement, whereas all (100%) negative farms were confinement. This is consistent with our previous observation of a herd prevalence of 90.6% in pigs raised outdoors, versus a herd prevalence of 1.8% in confinement systems. A high incidence of active mouse infestations made it difficult to determine a risk association; however, active mouse populations were observed on all positive farms, while a few negative farms had minimal rodent activity. Cats were observed on 5/6 (83.3%) positive farms, but only on 7/22 (31.8%) of negative farms. In one case, cats were not reported in the vicinity of the production site; however, further questioning of the producer revealed that cats were kept around the farm house approximately ½ mile from the site and that the same boots were worn from the house to the site and into pig areas.

Based on the results obtained here, the following conclusions might be drawn:

1. Pigs raised outdoors have a high risk of exposure to *Toxoplasma* and it is unlikely that outdoor management systems can be used to raise pigs free from this parasite. This is in contrast to *Trichinella*, which has a different pattern of transmission (no stages which pose a risk for environmental contamination).

2. Cats are an important risk factor for exposure of pigs to *Toxoplasma*; however, mice likely serve as a bystander population and the presence or absence of mice is no an important risk unless coupled with the presence of cats.

3. Environmental contamination to difficult to detect even on sites with high within herd prevalence of infection.

4. Boot hygiene is of paramount importance in reducing the risk of exposure of pigs to infection. Oocysts can be transported into production sites from distant locations. Barn specific boots should be used when entering any pork production site.

V. Publications

Gamble, H.R., Brady, R.C. and Dubey, J.P. 1999. Prevalence of *Toxoplasma gondii* infection in domestic pigs in the New England states. Veterinary Parasitology 82: 129-136.

Gamble, H.R. 2000. Toxoplasma gondii: The role of swine as a source of human infection. In, Food Safety and Zoonoses, Proc., Am. Assoc. Swine Prac., p 7-14.

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Gamble, H.R. 2000. *Toxoplasma gondii*: prevalence and transmission. Proc. Pork Quality and Safety Summit. .