

SEROPREVALENCE AND RISK FACTORS OF *TOXOPLASMA GONDII* INFECTION AMONG SLAUGHTERED PIGS AT IKPA SLAUGHTERHOUSE, NSUKKA, ENUGU STATE, NIGERIA

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ABSTRACT

Toxoplasmosis is a parasitic zoonotic disease found in both developed and less developed nations. The disease is associated with huge economic loss to the livestock industry, due to symptoms like infertility, miscarriage, and stillbirth. Despite being common in livestock, information on the disease in slaughtered pigs at Ikpa slaughterhouse in Nsukka Enugu State is scarce in the available literature. This study determined the seroprevalence and risk factors associated with toxoplasmosis among slaughtered pigs at Ikpa slaughterhouse, Nsukka, Enugu State. This is a cross-sectional study survey. Using the systematic random sampling technique of one in five, five hundred and fifteen (515) slaughtered pigs were selected over an eight-month period. The study population consisted mostly of 65% of adult pigs (>1year), 91% Large White breed of pigs; 49.3% males and 50.7% females. Data generated were analyzed with Chi-square statistics and p-values less than 0.05 were considered significant. The seroprevalence of *Toxoplasma gondii* infection was higher in adult pigs (35.2%; 118/335) than in young pigs (25.0%; 45/180). Seasonal variation showed a significant association with infection ($\chi^2 = 16.411$; $p < 0.001$), with pigs slaughtered during the dry season having a lower prevalence of 24.0% (67/279). No significant association was found between seropositivity and the other variables examined: gender ($\chi^2 = 0.329$; $p = 0.571$) and breed ($\chi^2 = 0.268$; $p = 0.625$). Regular screening of pigs slaughtered at the Ikpa slaughterhouse for toxoplasmosis, along with raising awareness on the significance of proper cooking of pork from the area of study, is highly recommended.

Keywords: Ikpa slaughterhouse, Nsukka; Risk factors, Seroprevalence; Slaughtered pigs; Toxoplasmosis.

INTRODUCTION

Toxoplasmosis remains one of the leading foodborne parasitic zoonosis, with far reaching effects on veterinary medicine, medical science, and public health globally (Stanić & Fureš, 2020; Adem & Ame, 2023). It is caused by the protozoan parasite *Toxoplasma gondii* (*T. gondii*), which is an obligate intracellular organism that can infect nearly all warm-blooded vertebrates, including humans (Pal *et al.*, 2021; Negesa & Kebedes, 2024). Felids from both domestic

and wild origins act as definitive hosts and pass on the resistant oocysts in the environment via their faeces (Hatam-Nahavandi *et al.*, 2021). In intermediate hosts like pigs, sheep, goats, birds, and man, infection is primarily acquired either by ingesting sporulated oocysts or eating tissue cysts found in meats of infected animals (Hill & Dubey, 2016).

Toxoplasmosis is prevalent among one-third of the world's human (Hosseini *et al.*, 2019; Molan *et al.*, 2019; Adem & Ame, 2023) yet, the prevalence of this disease greatly differs

from place to place because of varying factors such as climate, feeding habits, sanitary conditions, culture, and the animal husbandry system in a given region (Yan *et al.*, 2016). Toxoplasmosis is normally not symptomatic in healthy individuals but causes severe health complications to those that are immune-compromised as well as congenitally infected babies (Balcha *et al.*, 2020). Infected fetuses can suffer complications including abortion, hydrocephalus, chorioretinitis, neurologic disorders, and malformations (Fallahi *et al.*, 2018). It therefore follows that *T. gondii* has become an important neglected food borne disease of global significance.

Pigs are among the most significant intermediate hosts of *T. gondii* among food animals (Dong *et al.*, 2018) because of their intimate relationship with humans and the universal use of pork or pork products in human diets. Pork is among the major agents of human toxoplasmosis across the globe, especially when eaten unprocessed, half-cooked, smoked, cured, or raw (Alberto *et al.*, 2017). Once infected with *T. gondii*, pigs develop tissue cysts in their muscles and internal organs (Gisbert *et al.*, 2018). Thus, there is a significant association between porcine toxoplasmosis and public health due to food safety concerns.

The epidemiology of *T. gondii* infections in pigs is heavily dependent on husbandry and environmental issues (Yan *et al.*, 2016). In an intensive housing system with strong biosecurity measures, pigs are less likely to be exposed to infective oocysts than those raised in extensive or semi-extensive systems (Hernández-cortazar *et al.*, 2015). Many developing countries such as Nigeria have poor housing systems, weak biosecurity, improper waste disposal, lack of restricted movements of pigs, presence of rodents, and close interactions between pigs and cats (Ojabo & Enya, 2020).

Tropical environments also play an integral role in the transmission and persistence of the parasite. The tropical climate provides favourable conditions for the prolonged survival of sporulated oocysts in the soil and water, and hence the parasite's persistent transmission all year round (Yan *et al.*, 2016). Poor meat inspections and lack of awareness among humans about toxoplasmosis also contribute to the prevalence of this disease in many parts of Africa (Adem & Ame, 2023). In Nigeria, serological surveys conducted in various areas indicate that there is a prevalence of toxoplasmosis in humans and livestock, such as pigs, sheep, goats, and poultry (Ayinmode & Abiola, 2016; Ohiolei & Isaac, 2016; Ishaku *et al.*, 2018). Nevertheless, the epidemiology of porcine toxoplasmosis in some areas in south eastern Nigeria remains unknown.

The Nsukka region of Enugu State is a critical agricultural and economic centre that has been experiencing growth in terms of pig farming and pork consumption. The Ikpa Slaughterhouse acts as a key centre where pigs raised in

various production systems and neighbouring areas are slaughtered for human consumption. Slaughterhouses offer ideal locations for conducting epidemiological studies, as they enable the evaluation of infection status in animals that come from diverse geographic regions and production methods. Although toxoplasmosis is vital in public health, there are no records concerning the sero-prevalence and epidemiological factors of *T. gondii* infection in slaughtered pigs in the Nsukka region.

Understanding the prevalence of porcine toxoplasmosis and its risk factors will play a key role in determining the potential health risks posed by the consumption of pork (tainted pork). The identification of the different risk factors related to porcine toxoplasmosis, such as age, sex, breed, season, husbandry, and environment, can help implement appropriate control methods that reduce the spread of the disease among animals and minimize human exposure.

Consequently, the current study was undertaken to establish the prevalence and risk factors for *T. gondii* infection among slaughtered pigs at the Ikpa Slaughterhouse in Nsukka, Enugu State, Nigeria. The information generated from the present study will not only form important baseline information regarding the epidemiology of toxoplasmosis but will also contribute immensely to existing literature concerning the epidemiology of toxoplasmosis in sub-Saharan Africa.

MATERIALS AND METHODS

STUDY AREA

This study was conducted at Ikpa slaughterhouse in Nsukka, Enugu State, Nigeria. Nsukka Town is situated at 6.8429° N and 7.3733° E (Ezeh *et al.*, 2023), and has a population of 111,017 (Ezeh *et al.*, 2025). The Ikpa slaughterhouse is the sole slaughter facility in Nsukka town; thus, it functions as a major hub for meat processing and trade in the region. Also, it is the primary slaughterhouse within the Nsukka local government area (LGA), catering to the needs of Nsukka and its surrounding areas. The municipal slaughterhouse at Ikpa, Nsukka, Enugu State, is a sizable facility with a daily slaughter capacity of roughly 30 cattle, 40 pigs, 15 goats, and 5 sheep. It lacks the basic facilities required to maintain basic hygienic slaughter and prevent environmental pollution. The small ruminants, and likewise the piggeries and poultry slaughtered in this facility are reared in households within the communities; however, most cattle consumed in the area are sourced from northern parts of the country. Figure I shows the LGA, where the selected health facility and slaughterhouse are located.

ETHICAL APPROVAL AND STUDY POPULATION

Ethical clearance for the research was sought from the Institutional Animal Care and Use Committee (IACUC), Faculty of Veterinary Medicine, University of Nigeria, Nsukka, with approval number: FVM-UNN-IACUC-2025-12/282. All animal subjects (pigs) slaughtered for human consumption within the period of this survey constituted the study population.

STUDY DESIGN, AND SAMPLE SIZE

DETERMINATION

This cross-sectional survey was conducted between August 2022 and April 2023. The minimum sample size (MSS) of the study population was computed using the Raosoft® sample size calculator available at https://www.raosoft.com/sample_size.htm (assessed on April 16, 2022). The determination of the sample size was based on the expected target population size of 20,000 (as the number for each of the populations is not known), a 0.5% margin of error, and a 95% confidence level. The MSS computation was based on 69% (pigs) prevalence/expected response distribution (Ohiolei & Isaac, 2016). Consequently, the minimum sample size (MSS) of 324 was determined. However, a total of 515 blood samples were collected and screened for *T. gondii* antibodies.

SAMPLING AND SAMPLE COLLECTION

The study involved multiple visits to the slaughterhouse for 8 months between August 2022 and April 2023. Slaughter pigs were selected on each visit via the systematic random sampling method, whereby one pig per five pigs slaughtered was sampled. About 5 ml of blood was collected from each pig on slaughter in plain test tubes kept tilted to facilitate coagulation. The collected samples were appropriately labeled alongside information about the sex, age, breed, and season recorded. The samples were labeled properly, and information about the gender, age, season, and breeds of the sampled animals was recorded. Following this, the blood samples were transported in ice packs to the Fleming Fund-Supported Animal Health Laboratory at the University of Nigeria, Nsukka, where the sera were decanted. Serum samples were stored in a freezer at -20 °C until used for testing *T. gondii* antibodies.

SEROLOGICAL TEST

The serological test was conducted in the Fleming Fund Supported Animal Health Laboratory at the University of Nigeria Nsukka. Serum samples were subjected to an in-house ELISA (National Institutes of Health), following the instructions as detailed on the protocol. The optical density (OD) values were measured at a wavelength of 405 nm using a Bio-Rad ELISA microplate reader. The OD readings

obtained were used to determine the serological status of the samples for *T. gondii* IgG antibodies. Thus, OD value equal to or greater than the cut-off point (as detailed on the protocol) were considered positive, whereas values less than the cut-off point were considered negative.

STATISTICAL ANALYSIS

Data generated were entered into Microsoft Excel® 2016 and then categorized, filtered, and coded. Data bothering on prevalence were analyzed descriptively (frequencies and percentages) and presented in tables. The Chi-square (χ^2) statistic was used to test for associations between the seroprevalence of *T. gondii* infection and the demographics (such as sex, age, breed, season) of the slaughtered pigs. All statistical analyses were performed with SPSS version 25, and p-values less than 0.05 were considered significant.

RESULTS

DEMOGRAPHIC CHARACTERISTICS OF THE PIGS SAMPLED

A total of five hundred and fifteen (515) pigs were tested for the presence of *T. gondii* antibodies in the current study. The pig population consisted mostly (65%) of adult pigs (>1 year old) and a very large proportion (91%) of Large White breed of pigs. Although both males and females had a good representation (49.7% and 50.3%, respectively), more samples were collected during the dry season (Table I).

SEROPREVALENCE OF *T. GONDII* INFECTION IN SLAUGHTERED PIGS IN NSUKKA, ENUGU STATE, NIGERIA, ACCORDING TO VARIOUS EPIDEMIOLOGICAL FACTORS

The seroprevalence of *T. gondii* infection in slaughter pigs within Nsukka, Enugu State, Nigeria, was assessed with respect to age, sex, breed, and seasonal variations (Table II). Out of the five-hundred and fifteen (515) slaughtered pigs sampled, the overall seroprevalence of 31.7% (163/515) was documented. The age of the slaughtered pigs was significantly associated with their infection status. The prevalence of *T. gondii* infection was higher in adult pigs (35.2%; 118/335) than in young pigs (25.0%; 45/180). Seasonal variation showed a significant association with infection ($\chi^2 = 16.411$; $p < 0.001$), with pigs slaughtered during the dry season having a lower prevalence of 24.0% (67/279). No significant association was found between the prevalence of *T. gondii* antibodies and the other variables examined, which included sex ($\chi^2 = 0.329$; $p = 0.571$) and breed ($\chi^2 = 0.268$; $p = 0.625$). The prevalence in male pigs was 30.5% (78/256), while in female pigs it was 32.8% (85/259). Large White breed exhibited a prevalence of 32.0% (150/469), whereas the Duroc had a prevalence of 28.3% (13/46).

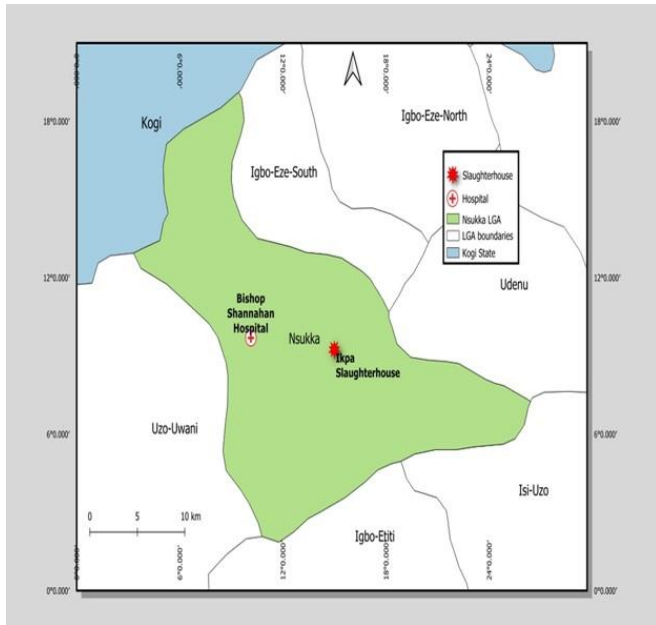


FIGURE I: NSUKKA LGA, ENUGU STATE, WHERE THE SELECTED HEALTH FACILITY AND SLAUGHTERHOUSE ARE LOCATED

TABLE I: DEMOGRAPHIC CHARACTERISTICS OF PIGS SAMPLED AT IKPA SLAUGHTERHOUSE IN NSUKKA, ENUGU STATE, NIGERIA.

Variables	Categories	Frequency	Percentage
Age	Young (<1yr)	180	34.95
	Adult (>1yr)	335	65.05
Sex	Male	256	49.71
	Female	259	50.29
Breed	Large White	469	91.07
	Duroc	46	08.93
Season	Dry	279	54.17
	Wet	236	45.83

TABLE II: SEROPREVALENCE OF *T. GONDII* INFECTION IN SLAUGHTERED PIGS IN NSUKKA, ENUGU STATE, NIGERIA

Epidemiological Variables	Categories	Number Sampled	Number Infected	Prevalence	X ² -value	Odds ratio	95% CI	p-value
Age	Young (<1yr)	180	45	25.0	5.658	0.608	0.401-0.921	0.022*
	Adult (>1yr)	335	118	35.2				
Gender	Male	256	78	30.5	0.329	0.894	0.609-1.313	0.571
	Female	259	85	32.8				

DISCUSSION

This study investigated the seroprevalence of *T. gondii* antibodies among slaughtered pigs at Ikpa slaughterhouse in Nsukka, Enugu State, Nigeria. An overall sero-prevalence of 31.7% was recorded among the slaughtered pigs. The overall

prevalence observed in this study corroborates the existing findings on the high rate of *T. gondii* infection among pigs in Nigeria and suggests that such pigs may serve as significant sources of zoonotic infection due to consumption of contaminated pork/pork products (Ohiolei & Isaac, 2016). The observed prevalence in pigs further suggests a high level of environmental contamination with *T. gondii* oocysts in the area (Thakur *et al.*, 2019). Again, the observed seropositivity raises serious concerns due to the associated symptoms of toxoplasmosis, such as infertility, abortion, miscarriage, and stillbirth, which can result in significant economic losses for livestock farmers, when there is an active infection (Adem & Ame, 2023). It is essential to note that being positive for *T. gondii* antibodies in livestock is not an accurate indicator of the risk of human infection. Nonetheless, it is highly probable that any sheep, goat, or pig that tests positive for *T. gondii* carries the infectious tissue cysts of the parasite (Hill & Dubey, 2016). Thus, consumption of undercooked meat from these animals will increase the risk of *T. gondii* infection in humans. The observed prevalence is higher than the 29.14% and 4.4% reported by Onyiche & Ademola (2015) and Obijiaku *et al.* (2017) in pigs from pig farms/abattoirs in Ibadan and two slaughterhouses in Makurdi Benue State, Nigeria, respectively. However, Okewole (2007), Ishaku *et al.* (2018) and Ayinmode & Abiola (2016) reported a higher seroprevalence of 41.5%, 40% and 45.2% in Ibadan and Ogun State, respectively. Geographical factors, potential differences in production systems, and the specificity/sensitivity of the serological test used could account for the difference in prevalence. The observed prevalence of toxoplasmosis was higher in the adult pigs than the young; this aligns with the findings of Onyiche & Ademola (2015) who reported a markedly higher prevalence in mature pigs than the younger ones. This observation may be attributed to the fact that elderly pigs experience greater cumulative exposure to infectious oocysts in the environment (Yan *et al.*, 2016). Such extended

exposure to the infective oocyte in the environment may increase the probability of infection among old animals. Furthermore, the presence of *T. gondii* tissue cysts after infection is another reason for increased seroprevalence with age. Increased prevalence with age has also been observed in

Africa and other parts of the world, and thus reflects accumulated exposure to environmental contamination.

The prevalence of *T. gondii* antibodies amongst the slaughtered pigs showed a pattern influenced by seasons with a higher prevalence rate during the wet seasons than the dry season. Similar observations were noted in Spain (García-bocanegra *et al.*, 2010) and China (Wang *et al.*, 2019). The elevated seroprevalence in the rainy season may be due to rainfall, which creates a wet environment that enhances oocyst survival and distribution, leading to contamination of the pig house, feed, and water supplies. The rainy season creates favourable environmental conditions for the survival and sporulation of *T. gondii* oocytes due to moisture, increased humidity, and moderate temperatures (Yan *et al.*, 2016). Precipitation also promotes the leaching of oocysts from polluted soil into surface water bodies, drainage systems, and swine enclosures, resulting in the pollution of potable water, feed containers, and housing floors (Yan *et al.*, 2016; Dixit *et al.*, 2024). Pigs in intensive systems are therefore more likely to ingest oocysts through contaminated water or feed, especially under poor sanitary conditions.

Although higher prevalence was recorded in females than males, gender was not found to be associated with *T. gondii* infection in the current study. This finding aligns with the observations of Onyiche & Ademola, (2015) in Ibadan, who likewise reported a higher prevalence in female pigs relative to males. The above finding may be related to the longer production life span of females (Symeonidou *et al.*, 2020) and their exposure to additional stressors such as pregnancy and lactation (Fallahi *et al.*, 2018). Female animals have been reported to exhibit greater susceptibility to protozoan parasites in comparison to the males, due to hormonal variations (Elmajdoub *et al.*, 2026). Studies have shown that numerous hormones, including those associated with sex, exert a direct influence on the immune system (Bhatia *et al.*, 2014; Sciarra *et al.*, 2023). However, Ishaku *et al.* (2018) documented a higher prevalence among male pigs.

Similarly, breed was not identified as a risk factor for the prevalence of *T. gondii* antibodies in slaughtered pigs within the study area. This observation concurs with the report by Onyiche & Ademola (2015) in Ibadan, who similarly noted no significant differences between breed and seropositivity. In conclusion, the above findings suggest that *T. gondii* infection is common among slaughtered pigs in the study area and thereby underscore the zoonotic risks associated with pork consumption in the area. This is critical need for control measures such as enhanced husbandry practices, management of rodents and cats around pig enclosures, and public health education on safe meat handling and preparation procedures.

CONCLUSION

Findings from this study show that toxoplasmosis is endemic among slaughtered pigs in the study area. The seroprevalence of *T. gondii* infection was found to be significantly higher in adult pigs compared to the young pigs, while the positive cases were observed more during the rainy season than the dry season. The study provides preliminary information on *T. gondii* infection in pigs slaughtered for human consumption in the Nsukka metropolis. The work therefore highlights the need for public enlightenment on the importance of thorough cooking of pork sourced from the study area to prevent the risk of being exposed to *T. gondii* cysts.

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CONFLICTS OF INTEREST/COMPETING

INTERESTS:

The authors declare no conflict of interest.

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