International Science and Technology Journal
المجلة الدولية للعلوم والتقنية
Volume 37 العدد
Part 2 المجلد
ISTJ
http://www.doi.org/10.62341/dbfe1068

Received	**2025/11/28**	**تم استلام الورقة العلمية في**
Accepted	**2025/12/24**	**تم قبول الورقة العلمية في**
Published	**2025/12/25**	**تم نشر الورقة العلمية في**

Environmental Factors Influencing Acute *Toxoplasma gondii* Infection: The Role of Temperature, Humidity, and IgM Seropositivity in Benghazi, Libya

Hanan Abu Almajd Mohammed

Department of zoology, Faculty of Arts and Sciences Alabyar
University of Benghazi, Benghazi-Libya
hanan.abualmajd@uob.edu.ly

Abstract

The widespread zoonotic parasite Toxoplasma gondii has serious consequences for public health, especially for the health of mothers and newborns. The impact of climatic conditions on acute infection is yet unknown, despite numerous reports of high seroprevalence in Libya. 168 serum samples were obtained from Al-Saleem Laboratory in Benghazi, Libya, between November 2024 and November 2025 for this cross-sectional investigation, and they were tested for IgM antibodies. At the same time, serological results were combined with meteorological data on humidity and temperature. The total IgM prevalence was 5.95%, and there was clear seasonal clustering, with 80% of cases occurring between August and November. IgM positivity showed a positive correlation with humidity ($\rho = 0.18$, $P = 0.019$) and temperature ($\rho = 0.21$, $P = 0.007$).and logistic regression indicated that both are independent predictors, with each 1°C increase in temperature and 1% rise in humidity increasing the probabilities of IgM positive by 19% and 13%, respectively. These findings provide the first evidence from Libya relating acute toxoplasmosis to climate variability, emphasizing the importance of environmental factors in parasite transmission. This study contributes to addressing a significant research gap by providing a solid framework to guide public health interventions in the city of Benghazi, Libya**.**

Keywords: *Toxoplasma gondii*, Acute toxoplasmosis, IgM seropositivity ،Environmental factors , Benghazi, Libya

International Science and Technology Journal
المجلة الدولية للعلوم والتقنية
Volume 37 العدد
Part 2 المجلد
http://www.doi.org/10.62341/dbfe1068

العوامل البيئية المؤثرة في العدوى الحادة بطفيلي المقوسة الغوندية (*Toxoplasma gondii*): دور درجة الحرارة والرطوبة وإيجابية الأجسام المضادة IgM في مدينة بنغازي، ليبيا

حنان أبو المجد محمد

قسم علم الحيوان، كلية الآداب والعلوم الابيار، جامعة بنغازي. بنغازي – ليبيا

hanan.abualmajd@uob.edu.ly

الملخص

يُعدّ الطفيلي واسع الانتشار المقوسة الغوندية (Toxoplasma gondii) من الطفيليات المشتركة بين الإنسان والحيوان، وله تداعيات خطيرة على الصحة العامة، ولا سيما على صحة الأمهات وحديثي الولادة. وعلى الرغم من الدراسات العديدة التي تشير إلى ارتفاع معدلات الانتشار المصلي في ليبيا، لا يزال تأثير الظروف المناخية على العدوى الحادة غير واضح. في هذه الدراسة المقطعية، جُمعت 168 عينة مصلية من مختبر السليم بمدينة بنغازي، ليبيا، خلال الفترة من نوفمبر 2024 إلى نوفمبر 2025، وتم فحصها للكشف عن الأجسام المضادة من نوع IgM وبالتوازي مع ذلك، تم دمج النتائج المصلية مع بيانات الأرصاد الجوية المتعلقة بدرجتَي الحرارة والرطوبة. بلغ معدل الانتشار الكلي للأجسام المضادة من نوع IgM نسبة 5.95%، مع وجود تكتل موسمي واضح، حيث سُجِّل 80% من الحالات خلال الفترة الممتدة من أغسطس إلى نوفمبر. وأظهرت إيجابية IgM ارتباطًا موجبًا مع الرطوبة ($\rho = 0.18$، $P = 0.019$) ودرجة الحرارة ($\rho = 0.21$، $P = 0.007$). كما أظهر تحليل الانحدار اللوجستي أن كلا العاملين يُعدّان متنبئين مستقلين، إذ تؤدي زيادة قدرها 1°م في درجة الحرارة وارتفاع بنسبة 1% في الرطوبة إلى زيادة احتمالية إيجابية الأجسام المضادة من نوع IgM بنسبة 19% و13% على التوالي. توفر هذه النتائج أول دليل من ليبيا يربط داء المقوسات الحاد بالتقلبات المناخية، مما يؤكد الأهمية المحورية للعوامل البيئية في انتقال الطفيلي. وتسهم هذه الدراسة في سد فجوة بحثية مهمة من خلال توفير إطار علمي متين لتوجيه تدخلات الصحة العامة في مدينة بنغازي، ليبيا.

http://www.doi.org/10.62341/dbfe1068

الكلمات المفتاحية: توكسوبلازما غوندي، داء التوكسوبلازما الحاد، إيجابية الأجسام المضادة IgM، العوامل البيئية، بنغازي، ليبيا

1 .Introduction

Toxoplasma gondii is an obligate intracellular protozoan parasite recognized as one of the most prevalent zoonotic pathogens worldwide, posing a significant public health challenge due to its broad clinical spectrum and complex epidemiology. Although most infections remain asymptomatic in immunocompetent individuals, toxoplasmosis can result in severe outcomes such as life-threatening encephalitis in immunocompromised patients and profound neurological and ocular complications in congenital cases (Dubey, 2010; Weiss & Kim, 2007) .The parasite infects virtually all warm-blooded animals; however, domestic cats serve as the exclusive definitive hosts capable of shedding environmentally resistant oocysts, thereby sustaining transmission cycles. This unique host specificity underscores the intricate interplay between Toxoplasma gondii epidemiology and environmental as well as climatic determinants (Zhu et al., 2023).The global seroprevalence of Toxoplasma gondii infection is estimated at 31–35%, with pronounced geographical heterogeneity. Seropositivity frequently exceeds 50% across several regions of Africa and South America, whereas it remains below 20% in countries characterized by arid or cold climates (Pappas et al., 2009; Robert-Gangneux & Dardé, 2012). These variations are largely attributed to differences in dietary habits, hygiene practices, environmental exposure, and—most critically—local climatic conditions that modulate oocyst survival, sporulation, and infectivity (Montoya & Liesenfeld, 2004). In North Africa, particularly in Libya, previous investigations have reported substantial seroprevalence rates. For instance, a study conducted in Benghazi identified seropositivity levels of approximately 44.8% among pregnant women, reflecting a considerable epidemiological burden within the population (Mousa et al., 2011). Comparable findings were documented in El-Beida, Libya (Elammari et al., 2021), and a recent systematic review corroborated persistently elevated prevalence across African countries (Gelaw et al., 2024).The persistence and infectivity of Toxoplasma gondii oocysts are strongly governed by climatic

http://www.doi.org/10.62341/dbfe1068

conditions. Oocysts may remain viable for several years under cool and moist environments, enduring temperatures as low as 4°C (Dubey, 1998). In contrast, elevated temperatures and desiccation drastically curtail oocyst survival, limiting viability to 32 days at 35°C and causing complete inactivation within one hour at 50°C (Frenkel & Dubey, 1973; Dubey,1998). Humidity and rainfall are equally pivotal for oocyst sporulation, and episodes of heavy rainfall have been associated with enhanced transmission through surface runoff that disseminates oocysts into water reservoirs and drinking water systems (López Ureña et al., 2022; Dubey & Jones, 2010; Silva et al., 2025).Despite the availability of several Libyan studies assessing toxoplasmosis seroprevalence, none have systematically investigated the correlation between acute infection—indicated by IgM seropositivity—and environmental parameters such as temperature and humidity. Given the established influence of climatic factors on oocyst persistence, elucidating their association with acute infection dynamics is imperative. The present environmental study therefore aims to bridge this knowledge gap by evaluating the relationship between acute IgM seroprevalence and key local climatic variables, thereby providing a robust framework

1.1 Objectives of the Study

1 .To estimate the seroprevalence of acute Toxoplasma gondii infection (IgM) through analysis of serum samples obtained from Al-Salim Medical Laboratory in Benghazi during the period from November 2024 to November 2025, and to investigate possible variations in infection prevalence among different age groups using the MAGLUMI TOXO IgM CLIA analytical system.

2 .To investigate the impact of key climatic parametersspecifically monthly mean temperature and relative humidityon the occurrence of acute toxoplasmosis, aiming to identify potential environmental determinants that may influence the transmission dynamics of the parasite.

3 .To analyze the seasonal fluctuations in Toxoplasma gondii IgM seropositivity by comparing infection patterns across the four climatic seasons, with the objective of detecting any seasonally driven peaks in infection rates.

4 .To explore the relationship between age distribution and climatic conditions in order to determine whether certain age groups are

http://www.doi.org/10.62341/dbfe1068

more vulnerable to infection under specific seasonal or meteorological circumstances.

5. To develop an ecological interpretation of Toxoplasma gondii transmission within the urban context of Benghazi, elucidating how local environmental factors may shape exposure risk and contribute to evidence-based public health strategies for toxoplasmosis prevention and control.

2.Materials & Methods

2.1 Study Design and Sample Collection

Serum samples from 168 individuals in this cross-sectional study were obtained between November 2024 and November 2025 at Al-Saleem Medical Laboratory in Benghazi, Libya. Every participant's patient age was noted.

2.2 Serological Analysis

To assess acute Toxoplasma gondii infection, IgM antibodies were measured using a chemiluminescent immunoassay (CLIA) on the MAGLUMI 800 analyzer (Snibe Co., Ltd., China) with the MAGLUMI Toxo IgM CLIA kit, as directed by the manufacturer.

2.3 Climatic Data

TimeandDate.com, which gathers information from the Benina Airport meteorological station, provided the monthly mean temperature and relative humidity for Benghazi (https://www.timeanddate.com/weather/libya/benghazi/climate). These climate-related factors.

2.4 Data Analysis

For age, IgM positivity, and climatic variables, descriptive statistics such as mean, standard deviation (SD), minimum, maximum, and median were computed. The associations between climatic conditions and IgM seroprevalence were evaluated using Pearson correlation and linear regression analyses. Additionally, seasonal fluctuation was assessed. With significance set at $p < 0.05$, statistical analyses were carried out using SPSS version 26.

3.Results

Between November 2024 and November 2025, 168 serum samples from Benghazi's Saleem Laboratory were examined for acute Toxoplasma gondii infection. With a median age of 31, the participants' ages varied from 1 to 78. The range of IgM antibody levels was 0.01–7.89 IU/mL, with a median of 0.14 IU/mL. Ten

http://www.doi.org/10.62341/dbfe1068

people tested positive using a threshold of >2.0 IU/mL to indicate recent or ongoing infection, resulting in an total seroprevalence of 5.95%.

The average monthly temperature was 22.8 ± 4.6°C, with a range of 16°C to 29°C, while average relative humidity was 64.8 ± 5.8%, with a range of 54% to 75%. Table 1 displays the descriptive features of the climatic parameters.

Table 1. Descriptive Characteristics of Climatic Parameters

Parameter	Mean ± SD	Range	Maximum (Month)	Minimum (Month)
Temperature (°C)	22.8 ± 4.6	16–29	29 (Aug 2025)	16 (Dec 2024, Jan–Feb 2025)
Relative Humidity (%)	64.8 ± 5.8	54–75	75 (Jun 2025)	54 (Mar 2025)

The chi-square test (χ^2=0.80, df=4, p=0.94) found no significant differences in the distribution among age groups. The association between age and acute Toxoplasma gondii infection (as detected by IgM antibodies) was not statistically significant. Table 2 displays an overall IgM positivity rate of 5.95% (10/168). The rate ranged from 0% in teenagers (6-17 years) and the elderly (≥60 years) to 7.32% in middle-aged adults (40-59 years).Table 2 and Figure 1 graphically depict the lack of correlation, where the positivity curve does not increase with age.

Table2. Distribution of *Toxoplasma gondii* IgM Positivity by Age Group.

Age Group (years)	Total Samples	IgM-Positive	IgM Positivity Rate (%)
≤ 5 years	28	2	7.14
6–17 years	2	0	0
18–39 years	90	5	5.56
40–59 years	41	3	7.32
≥ 60 years	7	0	0
Total	168	10	5.95

http://www.doi.org/10.62341/dbfe1068

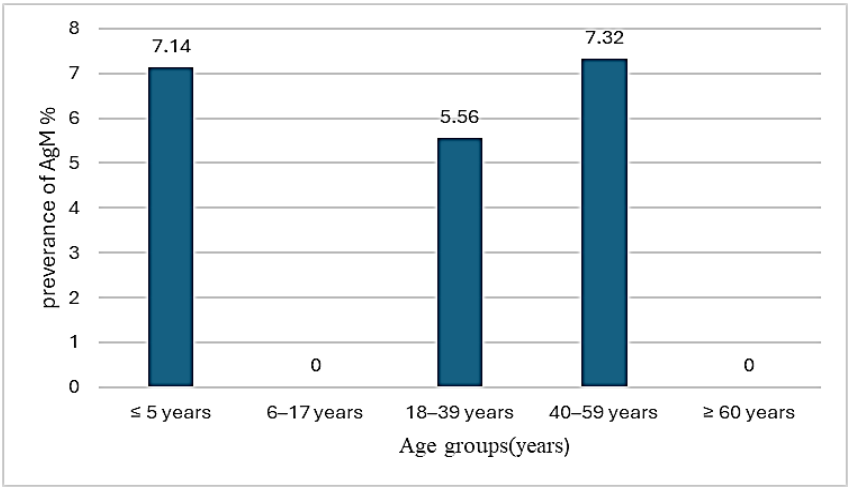

Figure 1. Prevalence of Toxoplasma gondii IgM by Age Group

Acute infections exhibited a clear seasonal pattern. Eight out of ten seropositive cases (80%) occurred between August and November 2025, with peaks in September (33.3%) and November (33.3%). Only two sporadic cases were detected during February and July 2025.The monthly distribution of IgM seropositivity along with temperature and humidity is summarized in Table3, and the trends are visualized in Figure 2 monthly temperature and humidity and Figure 3temperature, humidity, and seropositivity**.**

Table3. Monthly Distribution of Toxoplasma gondii IgM Seropositivity and Corresponding Climatic Conditions

Month	Tests (n)	Positive (n)	Seropositivity Rate (%)	Temperature (°C)	Humidity (%)
Dec 2024	21	0	0.0	16	66
Jan 2025	10	0	0.0	16	67
Feb 2025	13	1	7.7	16	64
Mar 2025	8	0	0.0	20	54
Apr 2025	12	0	0.0	20	67
May 2025	7	0	0.0	24	63
Jun 2025	17	0	0.0	25	75
Jul 2025	11	1	9.1	28	73
Aug 2025	23	3	13.0	29	70
Sep 2025	9	3	33.3	27	69
Oct 2025	11	1	9.1	25	63
Nov 2025	3	1	33.3	21	59

http://www.doi.org/10.62341/dbfe1068

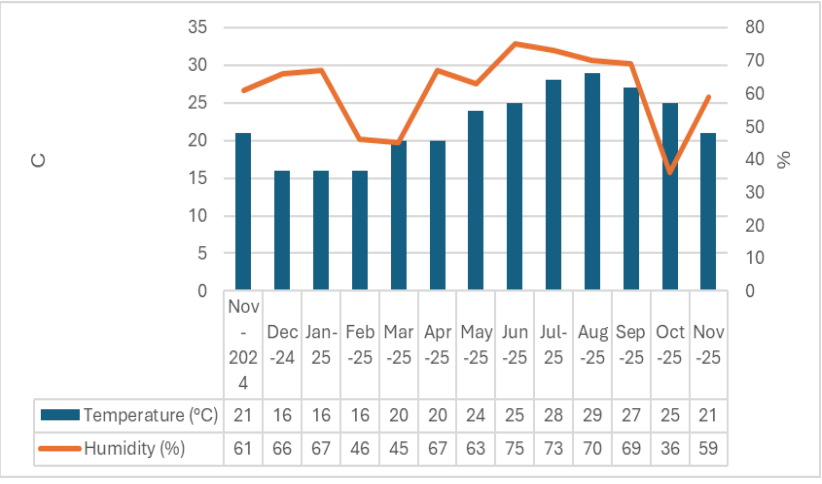

Figure2. Monthly variations in temperature and humidity parameters during the study period (November 2024 – October 2025)

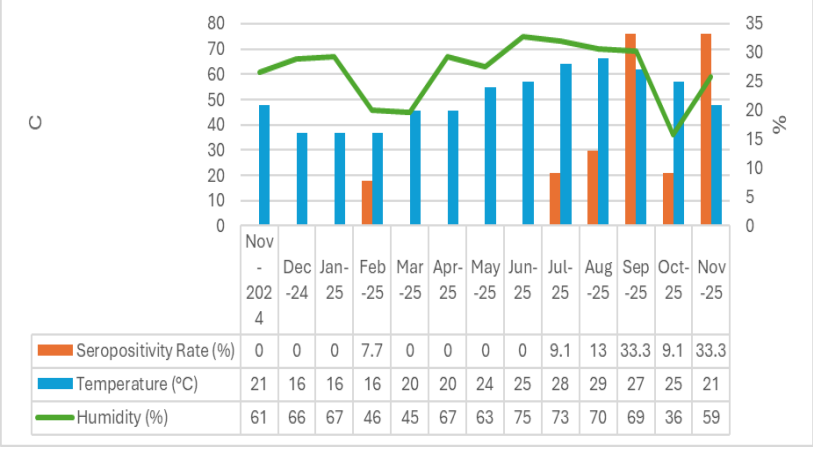

Figure3. Environmental Factors Influencing Acute Toxoplasmosis: Monthly Patterns of Toxoplasma gondii IgM Seropositivity and Climatic Variability

4. Discussion

The present study demonstrated statistically significant positive correlations between climatic factors and anti Toxoplasma gondii IgM seropositivity.In particular, higher antibody titers were linked

http://www.doi.org/10.62341/dbfe1068

to mean monthly temperature (ρ = 0.21, P = 0.007) and mean monthly humidity (ρ = 0.18, P = 0.019). These results make biological sense because both temperature and Humidity is known to affect T. gondii oocyst survival and sporulation in the environment, increasing transmission chances (Dubey, 2010; Lindsay & Dubey, 2007). The study found no statistically significant difference in IgM seropositivity among age groups (χ^2=0.80, df=4, p=0.94), suggesting that age was not a factor in acute Toxoplasma gondii infection in this population. The epidemiological character of IgM, which indicates current exposure rather than accumulated risk, is consistent with this finding. Abdel Gawad et al. (2017 observed similar findings in Egypt, where pregnant women's IgM positive remained low and did not significantly correlate with age. Ben Abdallah et al. (2024) discovered that acute infection identified by ICT IgG/IgM® was uncommon and not age-dependent in Tunisia. Similarly, Sebaa et al. (2024) found that IgM prevalence was less than 10% in Algeria, with no discernible difference between age groups. The conclusion that acute toxoplasmosis is relatively rare and that age does not seem to be a significant risk factor is supported by all of these investigations. Rather, IgM dynamics are probably more significantly shaped by behavioral and environmental exposures, such as eating undercooked meat and coming into contact with contaminated soil. Small sample sizes in some age groups, which restrict statistical power in Mediterranean contexts, may possibly contribute to the lack of statistical significance in our data. Nonetheless, the consistency of our findings with regional literature supports the conclusion that age is not a major predictor of acute infection in Mediterranean settings.

Acute infections showed a distinct seasonal pattern, as seen in Figures 1 and 2, with peaks matching times of higher humidity and warmth, which is consistent with the positive associations that were found. Comparable results have been reported in diverse ecological contexts. Toxoplasma gondii has been found to be more prevalent in warmer and wetter seasons in humans (Hubálek, 2005), rabbits (Almería et al., 2004), and wild ruminants (Gamarra et al., 2008). Domestic cats (Afonso et al., 2010). According to Smith and Frenkel (1995), forest cover and relative humidity can extend oocyst viability and increase exposure risk. Seropositivity in neotropical

http://www.doi.org/10.62341/dbfe1068

monkeys in Costa Rica was shown to be favorably associated to forest cover and inversely related to rainfall, indicating a complex relationship between climatic variables and host ecology (Niehaus et al., 2020). Our study's weak correlation coefficients ($\rho = 0.21$ and $\rho = 0.18$) are in line with ecological epidemiology, which diffuses the direct climatic signal due to a variety of factors such animal contact, water quality, and food preferences. However, the statistical significance highlights how crucial seasonal weather patterns are in determining acute toxoplasmosis exposure. These findings support the concept that seasonal climate fluctuations play a crucial role in Toxoplasma gondii transmission dynamics. They underline the importance of integrating meteorological data into predictive epidemiological models, especially in Regions with high humidity and temperatures. This integration can guide targeted public health efforts, such as increased surveillance and preventive measures during periods of elevated risk.

5. Conclusion

This study provides new information about the epidemiology of Toxoplasma gondii in Benghazi, Libya, by connecting acute IgM seropositivity with environmental factors. Notably. Despite the low total frequency (5.95%), most cases clustered seasonally between August and November. Furthermore, temperature and humidity strongly predicted IgM positivity, highlighting the impact of environmental variables on transmission. These findings further emphasize how important contaminated water sources and climate variability are in shaping illness patterns. Thus, by addressing a research need in Libya, this work offers a basis for targeted public health actions. To further enhance Future study should expand regionally, incorporate molecular diagnostics, and examine additional environmental factors in order to enhance epidemiological knowledge and guide evidence-based preventive interventions.

References

Abdel Gawad, S. S., Ghieth, M. A., Kamel, N. M., & Shawkey, S. M. (2017). Sero-prevalence of toxoplasmosis among multiparous pregnant women attending antenatal care at Beni-Suef University's Hospital, Egypt. Journal of the Egyptian Society of

http://www.doi.org/10.62341/dbfe1068

Parasitology, 47(3), 689–694 .
.

Afonso, E., Thulliez, P., & Gilot-Fromont, E. (2010). Local meteorological conditions and dynamics of seroconversion in cats. Epidemiology and Infection, 138(8), 1105–1113 .
.

Almería, S., Moré, G., Pérez, J., & Dubey, J. P. (2004). Factors affecting the seroprevalence of Toxoplasma gondii infection in wild rabbits from Spain. Veterinary Parasitology, 123(3–4), 265–270 .

Ben Abdallah, R., Kalboussi, Y., Bellali, H., Issaoui, N., Souissi, O., Maatoug, R., Aoun, K., & Bouratbine, A. (2024). Contribution of the Toxoplasma ICT IgG/IgM® test in determining the immune status of pregnant women against toxoplasmosis in Tunisia. Journal of Clinical Laboratory Analysis, 38(5), e23749. https://doi.org/10.1002/jcla.23749

Dubey, J. P. (1998). Toxoplasma gondii oocyst survival under defined temperatures. The Journal of Parasitology, 84(4), 862–865. https://doi.org/10.2307/3284606 .

Dubey, J. P. (2010). Toxoplasmosis of animals and humans (2nd ed.). Boca Raton, FL: CRC Press .

Dubey, J. P., & Jones, J. L. (2008). Toxoplasma gondii infection in humans and animals in the United States. International Journal for Parasitology, 38(11), 1257–1278 . .

Elammari, N. E., Sariti, S. R., Miftah, H. H. A., & Al Abbar, M. Y. (2021). Seroprevalence of IgG and IgM of Toxoplasma gondii among pregnant women at El-Beida city, Libya. International Journal of Medical Science in Clinical Research and Review, 4(5), 7–13. https://ijmscrr.in/index.php/ijmscrr/article/view/165

Frenkel, J. K., & Dubey, J. P. (1973). Effects of temperature on the viability of Toxoplasma gondii oocysts. Journal of Parasitology, 59(3), 531–533 . .

Gamarra, J. A., Cabezón, O., Pabón, M., Arnal, M. C., Luco, D. F., Dubey, J. P., & Almería, S. (2008). Prevalence of antibodies against Toxoplasma gondii in roe deer from Spain. Veterinary Parasitology, 153(1–2), 152–156. https://doi.org/10.1016/j.vetpar.2008.01.028 .

http://www.doi.org/10.62341/dbfe1068

Gelaw, M., Dagnew, G. W., Alene, G. D., Gangneux, J.-P., & Robert-Gangneux, F. (2024). Toxoplasma gondii seroprevalence among pregnant women in Africa: A systematic review and meta-analysis. PLOS Neglected Tropical Diseases, 18(5), e0012198. https://doi.org/10.1371/journal.pntd.0012198

Hubálek, Z. (2005). North Atlantic weather oscillation and human infectious diseases in the Czech Republic, 1951–2003. European Journal of Epidemiology, 20(3), 263–270 . .

Jones, J. L., & Dubey, J. P. (2010). Waterborne toxoplasmosis – recent developments. Experimental Parasitology, 124(1), 10–25. https://doi.org/10.1016/j.exppara.2009.03.013

Lindsay, D. S., & Dubey, J. P. (2007). Toxoplasmosis in wild and domestic animals. In L. M. Weiss & K. Kim (Eds.), Toxoplasma gondii: The model Apicomplexan (pp. 133–152). London: Academic Press . .

López Ureña, E., Villalobos, C., & Vargas, M. (2022). Environmental factors influencing Toxoplasma gondii oocyst survival and transmission: A review. Veterinary Parasitology, 305, 109698 .

Montoya, J. G., & Liesenfeld, O. (2004). Toxoplasmosis. Lancet, 363(9425), 1965–1976 . .

Mousa, D. A., Mohammad, M. A., & Toboli, A. B. (2011). Toxoplasma gondii infection in pregnant women with previous adverse pregnancy outcome. Medical Journal of the Islamic World Academy of Sciences, 19(2), 95–102 . .

Niehaus, C., Spínola, M., Su, C., Rojas, N., Rico-Chávez, O., Ibarra-Cerdeña, C. N., Foley, J., Suzán, G., Gutiérrez-Espeleta, G. A., & Chaves, A. (2020). Environmental factors associated with

Frontiers in Veterinary Science, 7, 583032. https://doi.org/10.3389/fvets.2020.583032

Pappas, G., Roussos, N., & Falagas, M. E. (2009). Toxoplasmosis snapshots: global status of Toxoplasma gondii seroprevalence and implications for pregnancy and congenital toxoplasmosis. International Journal for Parasitology, 39(12), 1385–1394 . .

http://www.doi.org/10.62341/dbfe1068

Robert-Gangneux, F., & Dardé, M. L. (2012). Epidemiology of and diagnostic strategies for toxoplasmosis. Clinical Microbiology Reviews, 25(2), 264–296. .

Sebaa, S., Behnke, J. M., Labed, A., & Abu-Madi, M. A. (2024). Seroprevalence of Toxoplasma gondii and associated risk factors among pregnant women in Algeria. American Journal of Tropical Medicine and Hygiene, 110(6), 1137–1144 . .

Silva, R. J., Oliveira, L. F., & Costa, F. C. (2025). Climatic determinants of Toxoplasma gondii transmission: The role of rainfall and humidity in oocyst dissemination. Parasites & Vectors, 18(1), 54 . .

Smith, D. D., & Frenkel, J. K. (1995). Prevalence of antibodies to Toxoplasma gondii in wild mammals of Missouri and east central Kansas. Journal of Wildlife Diseases, 31(1), 15–21. .

Weiss, L. M., & Kim, K. (2007). Toxoplasma gondii: The model Apicomplexan. London: Academic Press . .

Zhu, S., VanWormer, E., & Shapiro, K. (2023). More people, more cats, more parasites: Human population density and temperature variation predict prevalence of Toxoplasma gondii oocyst shedding in free-ranging domestic and wild felids. PLOS ONE, 18(6), e0286808. https://doi.org/10.1371/journal.pone.0286808.