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Review Article

Toxoplasmosis-A Food borne Zoonotic Parasitic Disease of Human

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ABSTRACT: Toxoplasmosis is a food borne, protozoan disease of warm-blooded animals including human, caused by the unicellular parasite *Toxoplasma gondii.* After entering into host cells, *T. gondii* establishes acute infection through stage conversion into fast replicating tachyzoite. However, *T. gondii* tachyzoite undergoes developmental switching into slow replicating, dormant bradyzoite tissue cyst preferentially in the skeletal muscle and brain which causes life-long persistent infection on the host. *T. gondii* infection could be benign for immune competent host but it can cause fatal life threatening complication in immunocompromised individual and fetus bearing pregnant women. This mini-review highlights the major transmission routes of *T. gondii* infection into human. *T. gondii* uses fecal-oral route for transmission into human though eating oocyst contaminated foods, vegetables and water. In addition, infected meats of major livestock animals and birds have been identified as major route of *T. gondii* transmission into human. However, pork, sheep and backyard chicken have been shown as the predominate reservoir of *T. gondii* due to their higher rate of susceptibility to infection and growing in free housing condition. Public awareness on the transmission strategy of *T. gondii* might help on reducing overall Toxoplasmosis incidence world-wide.

Keywords: Toxoplasmosis, Foods and Vegetables, Livestock meats, Parasite transmission, Human

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INTRODUCTION

Toxoplasmosis is one of the major public health problems world-wide, caused by the Apicomplexan parasite *Toxoplasma gondii* (*T. gondii*) [1]. Approximately 30-50 percent of human populations are infected by this parasite internationally [2]. *T. gondii* not only causes disease in human but also can infect other mammalian and avian species including livestock animals and birds [3]. *T. gondii* infection can be asymptomatic or with a mild flu-like symptoms mostly in immune competent host [4], but they can causes severe, life threatening complication in immunocompromised patients for instance AIDS [5], cancer [6,7] and organ transplantation [8,9], people taking immune suppressive drugs for any disease treatment [10,11] and on fetus bearing pregnant women [12,13]. Severe complications include eye infection and blindness [14,15], macrocephaly (enlarged head), microcephaly (too small head), brain damage, hydrocephalus (water in brain), epilepsy, abnormal brain development of the fetus, enlargement of liver and spleen etc [16].

Two types of host animals are essential for *T. gondii* life cycle (Figure 1). Firstly, the feline "Cat" is the definitive host where *T. gondii* accomplishes their sexual reproduction. 2ndly, Intermediate host " Rabbit, livestock animals and human" where the parasite completes their life cycle through asexual stages [17–19]. After sexual reproduction in cat intestine, *T. gondii* oocyst are released into the environment through

faeces where they can contaminate foods, vegetables and water [20–22]. These oocyst contaminated foods, vegetables and water can act as a primary source of *T. gondii* infection to other animals and human[23]. More importantly, after acute infection, few parasite escape the immune system and undergoes stage differentiation from fast replicating tachyzoite to slow replicating dormant bradyziote/tissue cyst particularly in brain and skeletal muscle [24–26]. Therefore, skeletal muscle/ meat containing bradyzoite tissue cysts can act as an another important source of *T. gondii* infection to human [27]. In addition, the parasite can transmit from pregnant women to developing fetus through placenta [28,29] and to other human through blood transfusion of unscreened infected person[30,31]. In this study, routes of *T. gondii* transmission into human has been identified and classified as major and minor route. By considering the major routes of *T. gondii* transmission, Toxoplasmosis has been identified as the second leading cause of food-borne illness in human at the United States [32].

1. Major Routes of *T. gondii* Transmission into human:

T. gondii has three infective stages in their life cycle. These include oocyst, tachyzoite and bradyzoites. Among these stages, oocyst and bradyzoite tissue cyst use the major routs of transmission. For example, oocyst transmits into human through eating contaminating foods, water and vegetables. Bradyzoite tissue cyst enters into human by eating undercooked meats or meats products.

A. Oocyst contaminated foods, vegetables and water mediated transmission of *T. gondii*:

During sexual reproduction in cat intestine, millions of oocyst is produced through fusing male and female gametes [33]. *T. gondii* oocyst are sheded and spread into environment through cat feaces [17]. The unsporulated oocsyst undergo meiosis to produces eight haploid sporozoites containing infectious oocyst. The oocyst possesses a bilayer and hard wall around them to protect from adverse environmental condition [34]. These oocsyt are dormant and resistant to unfavorable conditions (e.g. temperature, desiccation, toxic chemicals etc) and therefore can survive long time even more than 1.5 years into the environment [35]. Infectious oocyst in the environment can easily contaminate foods, vegetables, water in soil [21,22]. These contaminated food stuff can act as one of the major source of *T. gondii* transmission [23]. Human and other animals can be infected by the ingestion of these unwashed contaminated foods and water [21]. This also provides attention on processing of contaminated foods and washing hands properly. Otherwise, after food preparation unwashed hands might act as risk of parasite transmission into human (Figure 1).

Previously several studies have showed that the outbreaks of toxoplasmosis has been reported world-wide due to ingestion of oocyst contaminated water or soil [36–39]. In 2012, for the first time, Lass and colleagues detected *T. gondii* DNA in fruits and vegetables at northern Poland using real-time polymerase chain reaction [40]. Another study further showed the higher prevalence of *T. gondii* oocyst in fruits, vegetables, soil and water of urban areas as compared to rural areas [41]. The probable explanation could be due to increase possibility of cat faces contamination with human in urban area. In this study, the authors also identified *T. gondii* in different water source including drinking water [41].

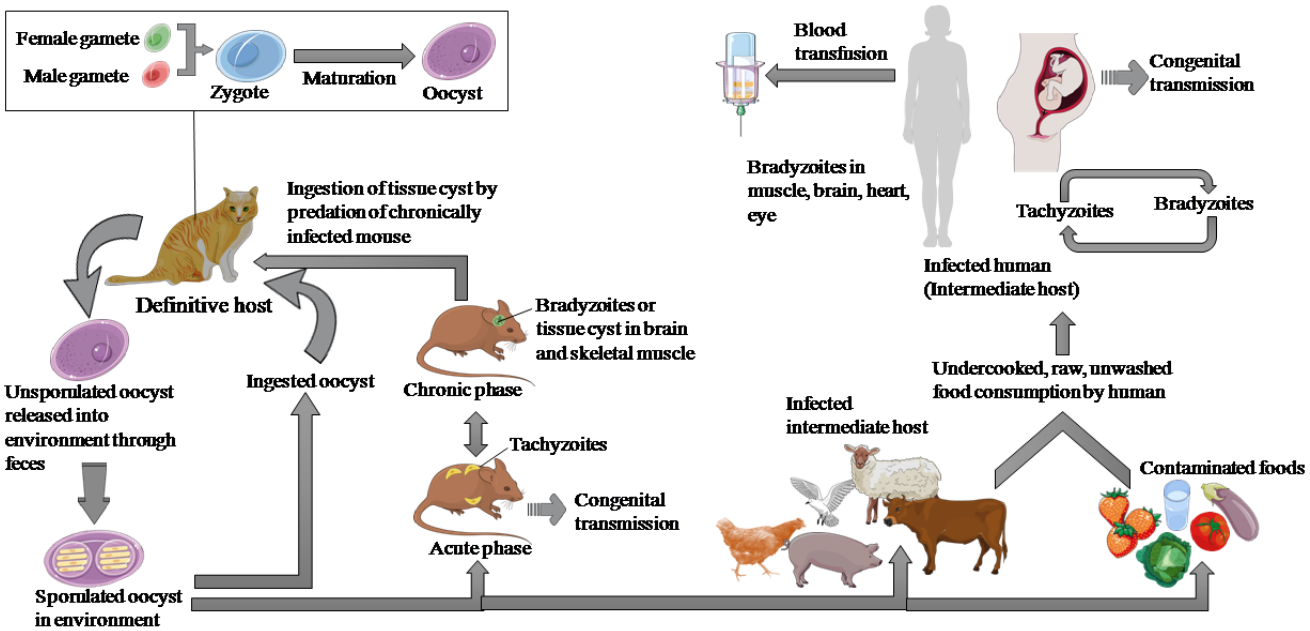

Figure 1. Life cycle and transmission of *Toxoplasma gondii*

B. Meat mediated transmission of *T. gondii*:

Meats of livestock animals for instance poultry, cattle, sheep, goat, pig act as a major source of animal protein for human. Therefore, people must consume meat as per demand on animal protein. In USA, the average meat consumption for an adult has been estimated as 90 Kg/year on 2014 according to the data of Organisation for Economic Co-operation and Development (OECD). More importantly, after acute infection, *T. gondii* accomplishes their asexual reproduction through stage conversion from metabolically active, replicating form tachyzoite to dormant cysts forming bradyzoite predominantly in skeletal muscle and brain [25], which allow the parasite to persist in skeletal muscle/meat of livestock animal for whole life time. Therefore consumption of eating raw or undercooked meat and meat products may act as an important source of *T. gondii* infection into human [3,42]. A case control study at European multicenter showed that up to 63 % of pregnant women are infected with *T .gondii* due to eating undercooked meats or meat products [43]. In USA, research on toxoplasma in meat identified a major route of *T.gondii* transmission into human [44,45]. These studies suggest the importance of meat mediated transmission of *T. gondii* into human.

It has to be stressed that meat consumption is extremely high in both developed and developing countries like Bangladesh. For example highest meat consumption is found in USA where people consume 124 kg/capita/year of meat [46]. In Germany approximately 57.2 kg meats are consumed per capita/ year [47]. The amount of consumption has been estimated as 52 kg pork, 18 kg poultry and 12 kg beef [47]. In Bangladesh the average meat consumption has been shown 3-5 kg/capita/year [46]. Unexpectedly Speedy et al has shown meat consumption rate limited to only 3 to 5 kg but the actual amount might be higher particularly in people of high socioeconomic group. In addition, meat processing is not hygienic in Bangladesh because of not using hand gloves. This further may increase the possibility of *T. gondii* transmission into human. Therefore, it is expected that high meat consumption may increase the transmission of the parasite and disease incidence.

Previous studies have confirmed that *T. gondii* is found in meats of nearly all major livestock animals and birds [48,49]. Recently, Rahman et al has summarized data of *T. gondii* prevalence in domestic animals of Bangladesh where 20% Pigs, 12-55% goats, 12-70% sheeps and 8-27% cattles were positive for *T. gondii* antibodies (Rahman et al, unpublished data). Another study conducted by Belluco and colleagues in Italy on meta analysis of *T. gondii* prevalence in domestic animals, has shown that *T. gondii* is prevelant in 12.3% Pigs, 14.7% sheep and 2.6% cattle [50]. In Germany, 31% sows Pigs carried *T. gondii* antibodies [51]. In USA, 16.4% pigs were positive for *T. gondii* whereas it was 26% in parts of South America including Brazil (Miao Guo 2015, Review). In this connection, a number of study has identified infected pork meat as one of the major source of *T. gondii* in human particularly in Europe and USA [45,49,52]. The possible reason has been identified as higher susceptibility of *T. gondii* infection in pigs than poultry and cattle[53].

Not only pigs but also poultry meats plays an important role on *T. gondii* transmission into human [54]. Aigner and colleagues conducted a seroprevalence study where they showed the presence of *T. gondii* antibodies in 60% chicken. Remarkably, in another study 100% chicken were found to be positive for *T. gondii* [55].The higher rate of infection was due to growing of the chicken in different housing condition known as backyard chicken. Similar to pigs and chicken, sheep, goats and horse also transmits *T. gondii* infection into human. However, the prevalence of this parasite in these animals varies with their age. For example, higher rate of *T. gondii* infection is found in 90% of adult sheeps as compared to 18% lambs [56]. Dubey and colleagues reported the seroprevalence rate of *T. gondii* in goats ranges from 4 to 77% [57] and relatively lower in horses [58]. These clearly point out the importance of meat mediated *T. gondii* transmission from livestock animals to human.

Another evidence of meat mediated *T. gondii* transmission was explained in a cross-sectional study at Germany. In this study, the authors identified *T. gondii* seropositive in 55% adults where the rate of infection was higher in adult male as compared to female. The higher rate of *T. gondii* infection in male has been considered due to increased consumption of meats [59]. This also further confirms the meat mediated transmission of *T. gondii* into human.

2. Minor route of *T. gondii* transmission into human:

Although *T. gondii* is considered as food-borne pathogen, the parasite also transmits into human through other minor route for instance congenitally [28], [44] and blood transfusion [30]. After acute infection of pregnant women, *T. gondii* tachyzoite transmit into developing fetus through placenta. Depending on the infection at gestational age, virulence of the parasite strain, *T. gondii* can develop severe neurological problem or abnormal brain development of the fetus or causes still birth and abortion. *T. gondii* uses another route of transmission from one human to another through blood transfusion[30].

CONCLUSION

Prevalence of any disease incidence depends on the transmission of the causative agent from one host to another. Toxoplasmosis is highly prevalent in over the world from developing to highly developed countries. Therefore, it is important for the identification of transmission route of *T. gondii* into human. This

article summarizes the major path of *T. gondii* transmission from the definitive host "cat" to other intermediate host including human. The findings of the study indicate that *T. gondii* mainly transmit into human through oocyst contaminated fruits, vegetables and water or bradyzoite contaminated livestock meats/meats products. In conclusion, it can be said that public awareness on the transmission route might help to reduce the prevalence of *T. gondii* infection internationally.

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REFERENCE

1. Furtado, J. M. *et al.* Toxoplasmosis: a global threat. *J. Glob. Infect. Dis.* **3,** 281–4 (2011).
2. Flegr, J., Prandota, J., Sovičková, M. & Israili, Z. H. Toxoplasmosis - A global threat. Correlation of latent toxoplasmosis with specific disease burden in a set of 88 countries. *PLoS One* **9,** e90203 (2014).
3. Tenter, A. M., Heckeroth, A. R. & Weiss, L. M. Toxoplasma gondii: from animals to humans. *Int. J. Parasitol.* **30,** 1217–1258 (2000).
4. Taila, A. K., Hingwe, A. S. & Johnson, L. E. Toxoplasmosis in a patient who was immunocompetent: a case report. *J. Med. Case Rep.* **5,** 16 (2011).
5. Basavaraju, A. Toxoplasmosis in HIV infection: An overview. *Trop. Parasitol.* **6,** 129–135 (2016).
6. Lu, N., Liu, C., Wang, J., Ding, Y. & Ai, Q. Toxoplasmosis complicating lung cancer: a case report. *Int. Med. Case Rep. J.* **8,** 37–40 (2015).
7. Cong, W. *et al.* Toxoplasma gondii infection in cancer patients: Prevalence, risk factors, genotypes and association with clinical diagnosis. *Cancer Lett.* **359,** 307–313 (2015).
8. Khurana, S. & Batra, N. Toxoplasmosis in organ transplant recipients: Evaluation, implication, and prevention. *Trop. Parasitol.* **6,** 123–128 (2016).
9. Wreghitt, T. G. *et al.* Toxoplasmosis in heart and heart and lung transplant recipients. *J. Clin. Pathol.* **42,** 194–9 (1989).
10. Wang, Z.-D. *et al.* Prevalence and burden of Toxoplasma gondii infection in HIV-infected people: a systematic review and meta-analysis. *lancet. HIV* **4,** e177–e188 (2017).
11. Lewis, J. M., Clifford, S. & Nsutebu, E. Toxoplasmosis in immunosuppressed patients: Fig. 1. *Rheumatology* **54,** 1939–1940 (2015).
12. Adams Waldorf, K. M. & McAdams, R. M. Influence of infection during pregnancy on fetal development. *Reproduction* **146,** 151–162 (2013).
13. Andiappan, H. *et al.* Toxoplasma infection in pregnant women: a current status in Songklanagarind hospital, southern Thailand. **7,** 1–7 (2014).
14. Commodaro, A. G. *et al.* Elevated Toxoplasma gondii Infection Rates for Retinas from Eye Banks, Southern Brazil. *Emerg. Infect. Dis.* **22,** 691–3 (2016).
15. Kadarisman, R. S., Marsetio, M. & Simangunsong, L. B. VISUAL IMPAIRMENT AND BLINDNESS IN OCULAR. *Southeast Asian J Trop Med Public Heal.* **9,** 99–101 (1991).
16. Moncada, P. A. & Montoya, J. G. Toxoplasmosis in the fetus and newborn: an update on prevalence, diagnosis and treatment. *Expert Rev. Anti. Infect. Ther.* **10,** 815–828 (2012).
17. Dubey, J. P. History of the discovery of the life cycle of Toxoplasma gondii. *Int. J. Parasitol.* **39,** 877–882 (2009).
18. Blader, I. J., Coleman, B. I., Chen, C.-T. & Gubbels, M.-J. Lytic Cycle of Toxoplasma gondii: 15 Years Later. (2015). doi:10.1146/annurev-micro-091014-104100
19. Cleary, M. D., Singh, U., Blader, I. J., Brewer, J. L. & Boothroyd, J. C. Toxoplasma gondii asexual development: identification of developmentally regulated genes and distinct patterns of gene expression. *Eukaryot. Cell* **1,** 329–40 (2002).
20. Dubey, J. P., Miller, N. L. & Frenkel, J. K. The Toxoplasma gondii oocyst from cat feces. *J. Exp. Med.* **132,** 636–62 (1970).
21. Hussain, M. A., Stitt, V., Szabo, E. A. & Nelan, B. Toxoplasma gondii in the Food Supply. *Pathog. (Basel, Switzerland)* **6,** (2017).
22. Jones, J. L. & Dubey, J. P. Foodborne Toxoplasmosis. *Clin. Infect. Dis.* **55,** 845–851 (2012).
23. Jones, J. L. & Dubey, J. P. Foodborne Toxoplasmosis. *Clin. Infect. Dis.* **55,** 845–851 (2012).
24. Tenter, A. M., Heckeroth, A. R. & Weiss, L. M. Toxoplasma gondii: from animals to humans. *Int. J. Parasitol.* **30,** 1217–1258 (2000).
25. Dubey, J. P., Lindsay, D. S. & Speer, C. A. Structures of Toxoplasma gondii Tachyzoites, Bradyzoites, and Sporozoites and Biology and Development of Tissue Cysts. *Clin. Microbiol. Rev.* **11,** 267–267 (1998).
26. Swierzy, I. J. & Lüder, C. G. K. Withdrawal of skeletal muscle cells from cell cycle progression triggers differentiation of Toxoplasma gondii towards the bradyzoite stage. *Cell. Microbiol.* **17,** 2–17 (2014).
27. Swierzy, I. J. *et al.* Toxoplasma gondii within skeletal muscle cells: A critical interplay for food-borne parasite transmission. *Int. J. Parasitol.* **44,** 91–98 (2014).
28. Robbins, J. R., Zeldovich, V. B., Poukchanski, A., Boothroyd, J. C. & Bakardjiev, A. I. Tissue barriers of the human placenta to infection with Toxoplasma gondii. *Infect. Immun.* **80,** 418–28 (2012).
29. Robert-Gangneux, F. *et al.* The placenta: a main role in congenital toxoplasmosis? *Trends Parasitol.* **27,** 530–6 (2011).

30. Karimi, G., Mardan, A. & Zadsar, M. Toxoplasma and blood transfusion. *Iran. J. Parasitol.* **9,** 597–8 (2014).
31. Räisänen, S. Toxoplasmosis transmitted by blood transfusions. *Transfusion* **18,** 329–32 (1978).
32. Scallan, E. *et al.* Foodborne illness acquired in the United States-Major pathogens. *Emerg. Infect. Dis.* **17,** 7–15 (2011).
33. Dubey, J. P. Duration of immunity to shedding of Toxoplasma gondii oocysts by cats. *J. Parasitol.* **81,** 410–5 (1995).
34. Hunter, C. A., David Sibley, L., Sibley, L. D. & David Sibley, L. Modulation of innate immunity by Toxoplasma gondii virulence effectors. *Nat. Rev. Microbiol.* **10,** 766–778 (2012).
35. Frenkel, J. K., Ruiz, A. & Chinchilla, M. Soil survival of toxoplasma oocysts in Kansas and Costa Rica. *Am. J. Trop. Med. Hyg.* **24,** 439–43 (1975).
36. Benenson, M. W., Takafuji, E. T., Lemon, S. M., Greenup, R. L. & Sulzer, A. J. Oocyst-Transmitted Toxoplasmosis Associated with Ingestion of Contaminated Water. *N. Engl. J. Med.* **307,** 666–669 (1982).
37. Bowie, W. R. *et al.* Outbreak of toxoplasmosis associated with municipal drinking water. The BC Toxoplasma Investigation Team. *Lancet (London, England)* **350,** 173–7 (1997).
38. Coutinho, S. G., Lobo, R. & Dutra, G. Isolation of Toxoplasma from the soil during an outbreak of toxoplasmosis in a rural area in Brazil. *J. Parasitol.* **68,** 866–8 (1982).
39. de Moura, L. *et al.* Waterborne Toxoplasmosis, Brazil, from Field to Gene. *Emerg. Infect. Dis.* **12,** 326–329 (2006).
40. Lass, A., Pietkiewicz, H., Szostakowska, B. & Myjak, P. The first detection of Toxoplasma gondii DNA in environmental fruits and vegetables samples. *Eur. J. Clin. Microbiol. Infect. Dis.* **31,** 1101–8 (2012).
41. Ajmal, A., Maqbool, A., Qamar, M. F., Ashraf, K. & Ahmad, A. Detection of Toxoplasma gondii in environmental matrices (water, soil, fruits and vegetables). *African J. Microbiol. Res.* **7,** 1–15 (2013).
42. Ferguson, D. Use of molecular and ultrastructural markers to evaluate stage conversion of Toxoplasma gondii in both the intermediate and definitive host. *Int. J. Parasitol.* **34,** 347–360 (2004).
43. Cook, A. J. *et al.* Sources of toxoplasma infection in pregnant women: European multicentre case-control study. *Br. Med. J.* **321,** 142–147 (2000).
44. Jones, J. L. *et al.* Risk Factors for *Toxoplasma gondii* Infection in the United States. *Clin. Infect. Dis.* **49,** 878–884 (2009).
45. Dubey, J. P. *et al.* High prevalence and genotypes of Toxoplasma gondii isolated from organic pigs in northern USA. *Vet. Parasitol.* **188,** 14–18 (2012).
46. Speedy, A. W. Global Production and Consumption of Animal Source Foods. *J. Nutr.* **133,** 4048S–4053S (2003).
47. Voth, J. An Evaluation of Sustainable Consumption in the German Meat Market. *NIL Sustain. Food Retail.* 21–29 (2015).
48. Schlüter, D. *et al.* Animals are key to human toxoplasmosis. *Int. J. Med. Microbiol.* **304,** 917–929 (2014).
49. Guo *et al.* Prevalence and Risk Factors for Toxoplasma gondii Infection in Meat Animals and Meat Products Destined for Human Consumption. *J. Food Prot.* **78,** 457–476 (2015).
50. Belluco, S. *et al.* Investigating the determinants of Toxoplasma gondii prevalence in meat: A systematic review and meta-regression. *PLoS One* **11,** 1–24 (2016).
51. De Buhr, K., Ludewig, M. & Fehlhaber, K. Toxoplasma gondii-seroprevalence – current results in German swine herds. *J. Food Saf. Food Qual.* **59,** 5–8 (2008).
52. Tenter, A. M. Toxoplasma gondii in animals used for human consumption. *Mem. Inst. Oswaldo Cruz* **104,** 364–369 (2009).
53. Hill, D. E. & Dubey, J. P. Toxoplasma gondii prevalence in farm animals in the United States. *Int. J. Parasitol.* **43,** 107–113 (2013).
54. Dubey, J. P. *et al.* Prevalence of viable Toxoplasma gondii in beef, chicken, and pork from retail meat stores in the United States: risk assessment to consumers. *J. Parasitol.* **91,** 1082–1093 (2005).
55. Dubey, J. P. Toxoplasma gondii Infections in Chickens (Gallus domesticus): Prevalence, Clinical Disease, Diagnosis and Public Health Significance. *Zoonoses Public Health* **57,** 60–73 (2010).
56. Halos, L. *et al.* An innovative survey underlining the significant level of contamination by Toxoplasma gondii of ovine meat consumed in France. *Int. J. Parasitol.* **40,** 193–200 (2010).
57. Dubey, J. P. *et al.* High prevalence and genotypes of Toxoplasma gondii isolated from goats, from a retail meat store, destined for human consumption in the USA. *Int. J. Parasitol.* **41,** 827–833 (2011).
58. Dubey, J. P. Toxoplasmosis of animals and humans. *CRC Press* **336,** 49 (2010).
59. Wilking, H., Thamm, M., Stark, K., Aebischer, T. & Seeber, F. Prevalence, incidence estimations, and risk factors of Toxoplasma gondii infection in Germany: a representative, cross-sectional, serological study. *Nat. Sci. Reports* **6,** 22551 (2016).