J Appl Biotechnol Rep. 2022 March;9(1):458-463

Journal of
Applied Biotechnology Reports

doi 10.30491/JABR.2020.211953.1148

Mini Review

An Epidemiological Review on Toxoplasma Prevalence in Sheep and Goat Meat in Iran

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Received February 13, 2020; **Accepted** May 12, 2020; **Online Published** May 10, 2021

Abstract
There are limited parasites that can infect both humans and animals; one of these parasites is Toxoplasma. Its primary host is cats, but can infect warm-blooded animals like humans, goats, sheep, cattle, dogs, etc. Although the main transmission route in humans is via food, including raw or undercooked meat, infection route in animals is via mother to child and ingesting sporulated oocysts. Due to the dangerous results of this protozoan, including abortion, stillbirth, different degrees of mental or physical retardation, prevention of such infection has to be seriously considered. Cattle have a natural resistance against Toxoplasma infection. Therefore, its prevalence has more importance in goats and sheep. According to the studies that have measured *Toxoplasma gondii* infection and its prevalence in world- and country-wide scale, the infection of this protozoan is highly related to the geographic status, susceptible animals, potential hosts, and eating habits. In the present study, we review the prevalence and epidemiology spectrum of *T. gondii* in sheep and goat meat in Iran. This knowledge could be useful to biologists, public health workers, physicians, and veterinarians.

Keywords: *Toxoplasma Gondii*, Iran, Prevalence, Sheep, Goat, Meat
Citation: Yousefvand A, Mirhosseini SA, Ghorbani M, Sadeqi M, Montaseri D. An Epidemiological Review on Toxoplasma Prevalence in Sheep and Goat Meat in Iran. J Appl Biotechnol Rep. 2022;9(1):458-463. doi:10.30491/JABR.2020.211953.1148

Introduction

Toxoplasma gondii is one of the most widespread and common parasites among humans and animals. The most clinical importance of this parasite is due to its transmission from animals to humans, especially in pregnant women and immunocompromised individuals.[1] People with immune-suppressive drugs usage after receiving organ implants and suffering from Hodgkin syndrome are susceptible cases to this infection. *Toxoplasma gondii* infection is more prevalent in hot and humid areas and decreases with the increment of the height. Most of the reported infections in Iran are related to the provinces near the Caspian Sea e.g., Mazandaran and Gilan. Toxoplasma infection has high morbidity and low mortality. The parasite virtually infects a wide range of warm-blooded animals like cats as well as humans and livestock, including sheep and goats.[2]

Toxoplasmosis in sheep is shown with the inflammation of placenta, abortion, and white spots on cotyledons. The first case of toxoplasmosis in sheep and goats was described by Hartley and Feldman.[3,4] However, the first report on clinical infection of toxoplasmosis in cattle goes way back to 1953 when Sanger et al., reported it.[5] In pregnant animals, primary infection can lead to abortion, hence causing high economic losses.[6] In ewes, if the infection occurs between 50 and 120 days of pregnancy, it induces abortion, expulsion of mummified fetuses, or the birth of stillborn and weak lambs. After 120 days of pregnancy, the infection generally leads to apparently normal lambs that can survive for a few days or grow normally and become protected against re-infections.[7] Of the worlds' 13,459 thousand metric tons of sheep and goat meat production, 10,588 thousand metric tons (78.6%) are produced in Asia and Africa, where most of the developing countries are located. It is estimated that one-third of the world's population have antibodies against this parasite.[8]

It is suggested that drinking raw contaminated sheep and goats' milk causes toxoplasmosis in humans.[8,9,10,11] Consequently, as Iranians are consumers of sheep and goat meat and milk are at risk of infection.[12,13] In Iran, about 50% of the human population has been exposed to *T. gondii*, which makes toxoplasmosis as one of the major public health problems.[15] Contact and interaction between domesticated animals and

humans are known to be responsible for an increased risk of transmission of the parasite.[16] The focus of this review article is on the prevalence of *Toxoplasma gondii* in sheep and goats as humans have a direct contact with them in terms of nutrition and animal husbandry, so determining its prevalence in these two animals can be of great importance to human health planning.

Detection Methods of the Toxoplasma

Toxoplasma infection usually has no clinical signs or non-specific signs which are unreliable.[36,37] Diagnosis of toxoplasma depends on serological tests and bioassays, with limitations in parasite detection or determining the parasitic strains.[38,39] The main methods used in Iran for diagnosing toxoplasma are Enzyme-Linked Immuno Sorbent Assay (ELISA) for blood samples and conventional Polymerase Chain Reaction (PCR) for meat samples. The ELISA system usually includes the solid phase antigen or antibody, enzyme-labeled antigen or antibody, and the substrate of the enzyme reaction, which can be modified to test both antibodies and antigens. PCR is an efficient in vitro enzymatic amplification method that allows specific amplification of DNA from minute amounts of starting material in a short time.[40]

The only known definitive hosts for *Toxoplasma gondii* are members of the Felidae (domestic cats and their relatives) family. Unsporulated oocysts are shed in the cat's feces. Although oocysts are usually only shed for 1-3 weeks, large numbers may be shed. Intermediate hosts in nature (including birds and rodents) become infected after ingesting soil, water, or plant material contaminated with oocysts. Oocysts transform into tachyzoites shortly after ingestion. These tachyzoites localize in neural and muscle tissue and develop into tissue cyst bradyzoites. Cats become infected after consuming intermediate hosts harboring tissue cysts. Cats may also become infected directly by ingestion of sporulated oocysts. Animals bred for human consumption and wild game may also become infected with tissue cysts after ingestion of sporulated oocysts in the environment. Humans can become infected by any of several routes[44,45] (Figure 1):

- Eating undercooked meat of animals harboring tissue cysts.
- Consuming food or water contaminated with cat feces or by contaminated environmental samples (such as fecal-contaminated soil or changing the litter box of a pet cat).
- Blood transfusion or organ transplantation.
- Transplacentally from mother to fetus.

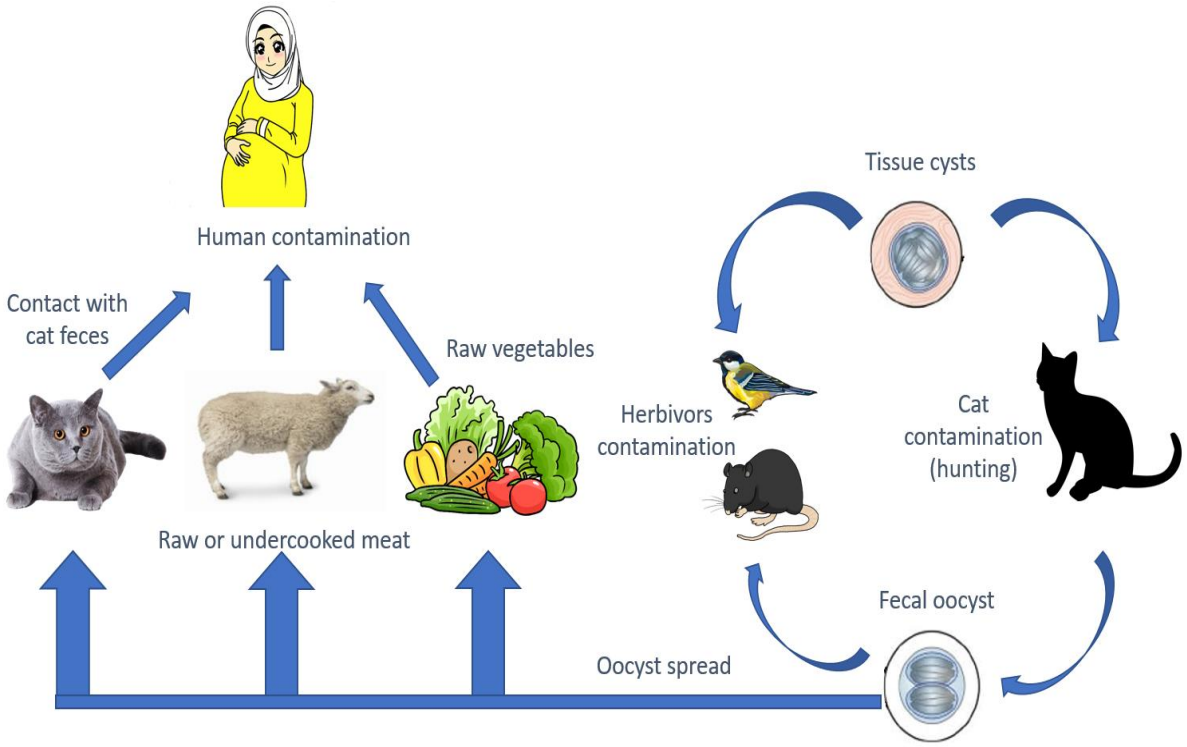

Figure 1. Complete Life Cycle of Toxoplasmosis.[44,45]

In the human host, the parasites form tissue cysts, most commonly in skeletal muscle, myocardium, brain, and eyes; these cysts may remain throughout the life of the host. Diagnosis is usually achieved by serology, although tissue cysts may be observed in stained biopsy specimens. Diagnosis of congenital infections can be achieved by detecting *T. gondii* DNA in amniotic fluid using molecular methods such as PCR.[50] Also, the prevalence of *Toxoplasma gondii* in sheep is investigated by various laboratory techniques in different regions of Iran (Table 1).

Table 1. Reports about the Prevalence of *Toxoplasma gondii* in Different Regions of Iran and Related Detection Techniques

Province(s)	Contaminated Animals		Technique	Year of publication	Ref
	Sheep (%)	Goat (%)			
East Azerbaijan	28	N/A	RFLP	2017	41
Lorestan	26.6	N/A	PCR	2017	42
Mazandaran	28.2	N/A	IFA	2017	43
Isfahan	12.2	4.4	ELISA	2017	45
Isfahan	17.8	8.9	PCR	2017	45
Kerman and Khorasan	56.6	44.1	PCR	2017	44
Khuzestan	10.8	20	ELISA	2018	46
Qazvin	33.6	33.4	ELISA	2019	47
Isfahan	27.3	N/A	IFA	2019	48
Khuzestan	32.6	48	ELISA	2019	49
North Khorasan	10.53	N/A	ELISA	2019	51
Semnan	18.55	N/A	PCR	2018	52

Toxoplasmosis Prevalence throughout Iran

Latest studies in Ahvaz city in Khuzestan province (south-west of Iran) indicated that the prevalence of *T. gondii* infection in sheep was 10.8% to 32.6 % in 2018-19, and 20% to 48% in goats both using ELISA.[46,49] It was opposing to the thought that the prevalence in goats is lower than that in sheep.[14] Also, in previous studies, *T. gondii* infection in sheep and goats induced abortions, pre-term deliveries, weak newborn, and neonatal mortality.[43,46]

Some authors have indicated that male animals are more susceptible to infections with protozoan parasites than females.[46] The prevalence of toxoplasma in sheep and goats has been reported in most parts of Iran (Figure 2). A study has shown that geographic differences cause a significant difference in infections among animals.[41] Also, a high prevalence of toxoplasmosis within hot and humid environments compared to cold and dry ones is attributed to the long viability of *T. gondii* oocysts under humid conditions.[42,45,47] For this reason, the higher *T. gondii* prevalence in South-West Iran could be attributed to the high relative environmental conditions such as humidity that exists in this province. Shokrani et al., (2017) reported the prevalence of the *T. gondii* in sheep to be 26.6% in Lorestan Province of Iran.[28] Also, a significantly higher prevalence of *T. gondii* was recorded in the sheep raised in Khuzestan than the ones raised in Isfahan.[45,48,49] This observation is another proof of differences in levels of humidity.

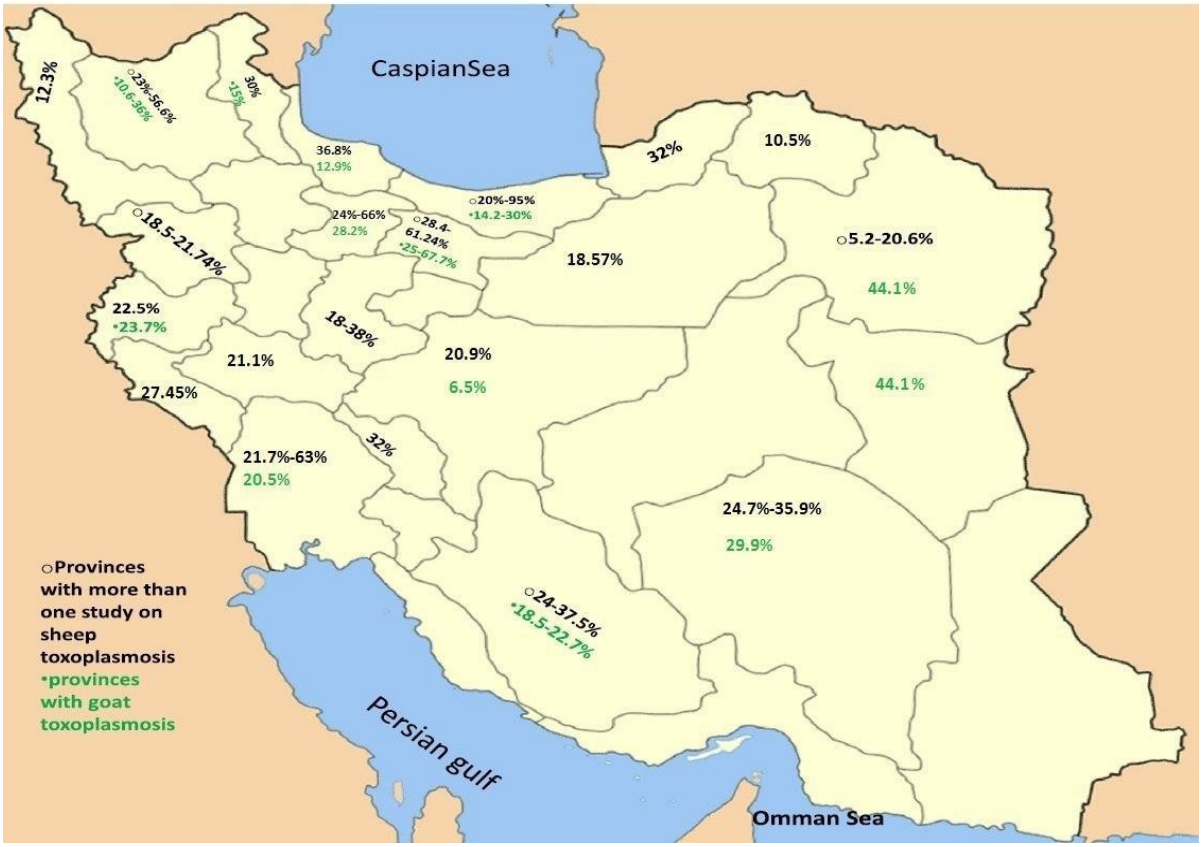

Figure 2. Toxoplasmosis Distribution in Iran (Regions with no percentage have no records of toxoplasmosis survey in sheep or goats).[9,12,13,15,31,33,41,43-46,51-54]

The prevalence of Toxoplasma in industrial livestock was significantly less than traditional livestock and stray cats roaming mostly on traditional farms. They can contaminate water and forage in their feces. A significant association was found between the prevalence of Toxoplasma and exposure of sheep to cats. A study on the risk factors of toxoplasmosis in small ruminants showed that the presence of cats in the surrounding areas of sheep is an important risk factor.[42,43,45,46,47] In northern Iran, the seroprevalence of *T. gondii* in sheep (28.2) was measured by Youssefi and Akhoundi (2017).[43] Additionally, Saraei et al., (2019) examined serum samples from sheep and goats from Iran for *T. gondii* antibodies by using the ELISA test and found the antibodies in 33.62% of sheep and 36.41% of goats in Qazvin.[47]

In a study by Gharekhani et al., (2018) on the prevalence of *T. gondii* in sheep and goats of Ahvaz, that had abortion, the presence of *T. gondii* antibodies had significantly high correlation between the number of sheep infected with *T. gondii* and abortion using the ELISA test ($p<0.05$).[46] Thus, *T. gondii* may be one of the important agents resulting in abortion in sheep of Ahvaz, Iran, and the consequent risk for humans of acquiring toxoplasmosis from consumption of sheep meat may be greater in this region. In an older survey in Europe, up to 63% of human infections were attributable to the consumption of undercooked or cured meat products.[32]

Conclusion

According to the studies that have measured *toxoplasma gondii* infection and its prevalence in world- and country-wide scale, infection of this protozoan is highly related to the geographic status, susceptible animals, potential hosts, and eating habits. The authors of this study suggest suitable control strategies, including preventing stray cats from entering any place related to meat production, and avoiding eating undercooked or raw meat to reduce the incidence of human infection.

Authors' Contributions

All authors equally contributed to the current study.

Conflict of Interest Disclosures

The authors declare that they have no conflicts interest.

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