



Toxoplasma gondii

Toxoplasma gondii
Protozoa
Division: Sporozoa / Phylum: Apicomplexa
Parasite

Characteristics and sources of *Toxoplasma gondii*

Main microbial characteristics

Toxoplasma gondii is the causative agent of toxoplasmosis, a cosmopolitan parasitosis. It is an obligate intracellular parasite belonging to the order Coccidia, phylum *Apicomplexa*. The parasitic cycle includes asexual reproduction that occurs in different tissues in warm-blooded mammals and birds (intermediate hosts) and sexual reproduction that occurs in the digestive epithelium of cats and other felines (definitive hosts). The cat sheds oocysts in its faeces that are not directly infective immediately; they become so after sporulation (1 to 5 days) and are then a potential source of infection for other hosts by ingestion. Faecal shedding of oocysts lasts 7 to 15 days after infection, the time for active immunity to develop. In the intermediate host, the oocysts are lysed and release forms which spread rapidly into the bloodstream (tachyzoites). After a brief parasitemia of a few days, the parasites become encysted in all tissues, especially striated muscle fibre and brain. These cysts may then be a source of infection for the definitive host, or for a new intermediate carnivore host by ingestion. Three main genotypes of *T. gondii* have been identified; all can infect humans, but genotype II is largely predominant in mainland France. Some highly virulent genotypes circulate in South America, including French Guiana.

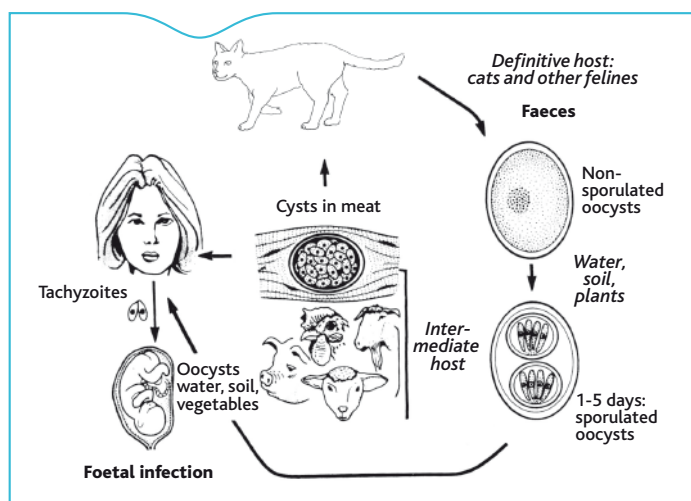
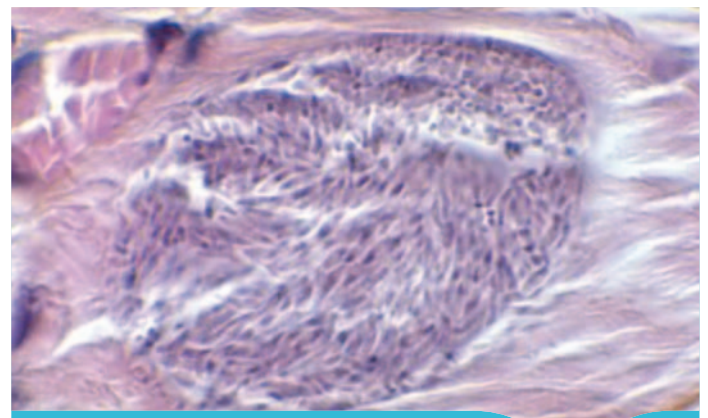


Figure 1. Diagram of the *Toxoplasma gondii* cycle (from Dubey and Beatty, 1988)



Toxoplasma gondii oocyst © Isabelle Villena



Toxoplasma gondii cyst in meat © Isabelle Villena

Sources of the hazard

Toxoplasma is a cosmopolitan parasite. In addition to animals (cats and other felines as definitive hosts, warm-blooded animals as intermediate hosts), soil and water also serve as the parasite reservoir, because of the dispersion and resistance of oocysts in the environment. An estimated 1% of cats shed oocysts at some point in their lives; levels of seroprevalence of toxoplasmosis in cats vary widely in relation to their lifestyle and diet (urban cats which do not hunt cannot become infected). The prevalence of infection with *T. gondii* varies widely among animal species and follows a decreasing gradient according to the following species: sheep, goats, pigs raised outdoors, cattle, poultry and horses.

Transmission routes

Humans become infected by ingesting cysts found in mammalian meat products (including venison), or oocysts from vegetables, fruit, water or hands contaminated by the faeces of an infected cat. Contamination by ingestion of circulating tachyzoites (e.g. via raw milk) is possible but unusual. The respective share of contamination by cysts through food containing meat or by oocysts through plants and water is not known precisely. However, different surveys have identified meat consumption among the risk factors for infection.

One European survey estimated that 30 to 63% of infections could be attributed to meat consumption; however this study did not take into account the consumption of plant-based products.

The risk of human-to-human transmission exists primarily in two situations: congenital transmission when a woman becomes infected during pregnancy, and transmission of cysts during organ transplants from a toxoplasmosis seropositive donor to a seronegative recipient.

Recommendations for primary production

- Intensive indoor farming helps decrease the prevalence of toxoplasmosis, especially in pigs. Toxoplasmosis in small ruminants (especially sheep) is one of the major causes of abortion in herds. A particular effort should be made to limit the access of cats to farms and feed storage areas.

Human foodborne disease

Nature of the disease

Characteristics of the disease are presented in [Table 1](#).

Susceptible population groups⁽¹⁾: pregnant women who are toxoplasmosis seronegative are at risk of infection during pregnancy (the risk of foetal transmission varies depending on the term at the time of maternal infection, 29% on average over the entire pregnancy). The foetus is at risk of developing neurological sequelae, particularly observed in maternal transmission in early pregnancy, and ocular damage that may occur regardless of the date of transmission during pregnancy.

Immunocompromised individuals (particularly AIDS and bone marrow transplant patients) who are toxoplasmosis seropositive are at risk of reactivation of infection when their cellular immunity is much lower (CD4 rate <100/mm³). Those who are toxoplasmosis seronegative are at risk of severe primary infection. The annual incidence of cerebral toxoplasmosis in AIDS patients is steadily declining: it was 0.24% in 2001 (data collected by the information system for the human immunodeficiency information and treatment centres).

Dose-effect⁽²⁾ and dose-response⁽³⁾ relationship

There is no published study on the dose-infection relationship in humans and no ID₅₀⁽⁴⁾ or LD₅₀⁽⁵⁾ values have been established. It is estimated that very low doses (oocysts, cysts and tachyzoites) may be sufficient to cause infection.

Epidemiology

Surveillance system

Since 2006 there has been a National Centre of Reference (CNR) for toxoplasmosis organised as a network of hospital laboratories specialising in the diagnosis of this disease. A surveillance system for congenital infections has been in place since 2007, recording each year the number of congenital toxoplasmosis cases diagnosed in France (266 cases in 2009). Clusters of foodborne toxoplasmosis cases are subject to mandatory notification as foodborne illness outbreaks.

Prevalence

Toxoplasmosis is a parasitic disease with worldwide distribution, and a prevalence that varies from one country to another (from 7 to 80%). In France, seroprevalence has been steadily declining for 30 years and was estimated (from national perinatal surveys) to be 44% in 2003. Prevalence varies by region, with high levels observed in Île-de-France and Aquitaine.

Few outbreaks are reported and nineteen episodes of clustered cases of toxoplasmosis were recorded worldwide between 1965 and 2001. Food was identified as the cause in 15 cases, including two due to water. The number of people infected during these episodes is usually low (2 to 37). Three major outbreaks attributed to drinking water occurred in Canada (1995) and Brazil (2002, 2006). Two foodborne illness outbreaks have been reported in France over the past 10 years following infection by ingestion of undercooked lamb (family clusters in 2001 and 2010).

(1) Susceptible population group: people with a higher than average probability of developing symptoms of the disease, or severe forms of the disease, after exposure to a foodborne hazard [definition used for the ANSES data sheets].

(2) The relationship between the dose (the amount of microbial cells ingested during a meal) and the effect on an individual.

(3) For a given effect, the relationship between the dose and the response, i.e., the probability of this effect appearing in the population.

(4) The ID₅₀ is the dose causing the onset of infection in 50% of individuals exposed.

(5) The LD₅₀ is the dose causing the death of 50% of individuals exposed.

Table 1. Characteristics of the disease

Mean incubation period	Target population	Main symptoms	Duration of symptoms	Duration of infectious period (shedding)	Complications (including lethality)	Asymptomatic forms
Two to three weeks on average	Cosmopolitan All age groups	Mild effects (15-20% of cases): cervical or occipital adenopathies, fever, myalgia, asthenia. Severe effects: pulmonary, neurological or disseminated toxoplasmosis following contamination with virulent genotypes (French Guiana). Ocular effects (frequency poorly estimated): chorioretinitis in variable locations progressing to spontaneous healing.	Variable (a few weeks to several months)	No human-to-human transmission apart from maternal-foetal transmission (following parasitaemia phase which lasts about two weeks)	Lethality: varies according to the genotype of strains and treatment. May be 100% with very virulent strains	Yes: frequency estimated to be 80% of toxoplasma infections
	Immuno-suppressed	Reactivated toxoplasmosis with cerebral (most common), ocular (combined with brain damage in 10 to 20% of cases) and pulmonary locations			Disseminated toxoplasmosis with the risk of death	

Role of food

Main foods to consider

The main foods implicated in contamination are raw or undercooked meat from an animal infected with *T. gondii* and vegetables contaminated with oocysts. Mutton, lamb, pork or venison from sheep, pigs reared outdoors and deer pose the greatest risk. The potential role of poultry has also been suggested. More recently, the possible role of imported horsemeat in contamination responsible for serious forms of toxoplasmosis has been reported.

The consumption of seafood has been mentioned as a potential source of infection (experimental infections), although this has not been proven under natural conditions. The potential role of water as a source of contamination has been shown based on epidemiological studies, but the presence of oocysts in drinking water has only been demonstrated in one outbreak.

Inactivation treatments in industrial environments

Table 2. Efficacy of inactivation treatments in an industrial environment

Heat	Cold
Cysts are killed by a temperature of 67°C. Sporulated oocysts are killed by a temperature of 60°C applied for 1 minute	Cysts in meat are killed by freezing at -12°C (core temperature) for at least 3 days. They remain infective after several weeks at 4°C. Freezing, even at -20°C, is insufficient to completely inactivate oocysts.
Curing/Smoking	Ionisation
Efficacy on cysts is very uncertain.	Oocysts: irradiation at 0.5 kGy is effective for destroying oocysts on plants. Cysts: 1 kGy can render meat free of infective cysts.
High pressure	Disinfection
Reductions in infectivity were observed for some oocysts exposed for 1 minute to pressures from 340 MPa.	Cysts: they remain infective for 2 hours in highly acidic conditions. Sporulated oocysts: they can withstand long periods in highly acidic or alkaline conditions, and are highly resistant to many agents used for disinfection, including bleach.
UV radiation - ozone	Microwaves
UV: 4 decimal reductions in the number of oocysts was noted with a dose of 20 mJ/cm ² . Ozone: treatment is not effective against oocysts (for exposure up to 9.4 mg.min L ⁻¹ in water at 20°C).	Efficacy on cysts and oocysts is uncertain.

Monitoring in food

There is no regulatory surveillance of food in France, Europe or the USA, mainly due to the lack of a standardised method for detection of *Toxoplasma* in food or the environment. In foodstuffs of animal origin, screening for parasites (cysts) is usually done by inoculating mice after enzymatic digestion of a sample of muscle. The detection sensitivity varies depending on the amount of meat processed. PCR is also used but its sensitivity has not been evaluated and no commercialised or standardised method is available.

Systematic detection of cysts in meat is not performed during slaughter; however, two monitoring plans for lamb and beef were introduced in partnership with the CNR and the National Reference Laboratory (NRL) at the request of the French Directorate General for Food (DGAL). These plans enabled the extent of this parasite in French farms to be estimated. In 2007, the estimated overall seroprevalence in sheep was 17.7% [11.6 to 31.5%] for lambs and 89% [73.5 to 100%] for adults. Live parasites were found in 11.9% [9 to 15.5%] (48/402) of carcasses of French origin (mainly in lambs). In 2009, the estimated overall seroprevalence in cattle of French origin was 11% [9-12%], and 2.5% [1-4%] for veal. Live parasites were found on two carcasses of French origin [0.03 to 0.3%].

Recommendations to operators

- Clean surfaces and utensils after cutting meat with water at a temperature $\geq 70^\circ\text{C}$.
- A temperature of 67°C is effective in destroying cysts and oocysts.
- Freezing at a temperature of -12°C (core temperature) for at least 3 days is effective on cysts found in meat matrices.
- Cooked dishes and other frozen food of animal origin (maximum temperature -18°C) can be considered as safe with respect to *T. gondii*.
- However, freezing plant products is ineffective on oocysts.

Domestic hygiene

Recommendations to consumers

Subjects concerned are susceptible population groups (pregnant women and immunocompromised individuals who are toxoplasmosis seronegative) to whom the following recommendations apply:

- wash hands after gardening (or wear gloves) or after handling food potentially contaminated with oocysts, wash kitchen utensils after cutting meat;
- wash raw vegetables thoroughly to remove oocysts;
- cook sufficiently:
 - meat (likely to contain cysts) to a core temperature of 67°C,
 - plant products (food may be contaminated by oocysts);
- freeze meat to a core temperature of -12°C for at least 3 days, to destroy cysts;
- if there is a cat in the home: do not change the litter yourself, otherwise always wear gloves and wash hands after handling the cat or its litter (tray should be cleaned with hot water at a temperature $\geq 70^\circ\text{C}$);
- cats that always stay indoors and are fed on heat-treated food (canned and dry petfood are free of parasites) are not concerned by this measure as they are not exposed to the hazard.

References and links

General reference

- *Toxoplasmose: état des connaissances et évaluation du risque lié à l'alimentation* – Report by AFSSA's *Toxoplasma gondii* working group, 2005, 324 pp. <http://www.afssa.fr/Documents/MIC-Ra-Toxoplasmose.pdf>

Links useful

- National Centre of Reference for toxoplasmosis: Laboratoire de Parasitologie, CHU Hôpital Maison-Blanche, 45, rue Cognacq-Jay, 51092 Reims. <https://www.chu-reims.fr/professionnels/cnr-toxoplasmose-1/>.
- National Reference Laboratory for foodborne parasites: ANSES Maisons-Alfort. <http://bipar.vet-alfort.fr/thematiques/891/lnr/index.html>
- <http://www.cdc.gov/parasites/toxoplasmosis/>: Information from the CDC on toxoplasmosis (description and prevention of the disease) and toxoplasma (cycle, epidemiology, biology), online reference to articles on the impact of toxoplasmosis in the USA; for professionals and the general public
- <http://www.dpd.cdc.gov/dpdx/HTML/Toxoplasmosis.htm>: DPDx site on toxoplasmosis (images, cycle and information on biological diagnosis).