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## Epidemiological investigation of *Toxoplasma gondii* in Alpine red deer (*Cervus elaphus*): spread and effects on pregnancy

N. FORMENTI<sup>1</sup>, N. FERRARI<sup>1</sup>, L. PEDROTTI<sup>2</sup>, A. GAFFURI<sup>3</sup>, T. TROGU<sup>1</sup>, P. LANFRANCHI<sup>1</sup>

<sup>1</sup> Università degli Studi di Milano

<sup>2</sup> Consorzio Parco Nazionale dello Stelvio

<sup>3</sup> Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia Romagna, sezione di Bergamo



Several animal species can be infected by the widespread protozoan *Toxoplasma gondii* contributing to maintain both domestic and sylvatic parasite lifecycle and favouring the raise of public health issues related to its zoonotic value. As wild ungulates can be source of *T. gondii* for humans through consumption, manipulation and evisceration of carcasses, risk of infection should be evaluated in relation to the amount of game meat available from harvest plans every year. Therefore in Italy the attention should be focused on red deer (*Cervus elaphus*) because of the intense hunting activity in many Alpine areas and since this species is the most frequently consumed raw or undercooked. In particular, despite the well documented zoo-economic losses in livestock, little is known about the epidemiology of *T. gondii* infection in red deer particularly regarding any impact on populations' dynamics. Besides no assessments are reported about *T. gondii* associated-reproductive pathologies in this species although vertical transmission recorded in white tailed deer (*Odocoileus virginianus*) and natural transplacental toxoplasmosis documented in a stillborn reindeer (*Rangifer tarandus*) foetus point out the hypothesis that also red deer could be affected. In addition just few studies have investigated the effect of parasitism on fecundity of ungulates in natural conditions.

Here we performed a sero-epidemiological investigation of *T. gondii* in red deer from two areas in Stelvio National park (Italian Central Alps), and three Generalized Linear Models were set up to evaluate: (1) the epidemiological factors influencing the probability to get infected; (2) if the infection is acquired before the breeding season or in early pregnancy and (i) could cause early abortion and drive hinds to lose reproduction, (ii) may influence hinds' fertility through a delay in the physiological development of foetus.

During two consecutive weeks between the end of November and the beginning of December 2012, 81 red deer sera were collected during the culling management plan scheduled by the park, for each subject age, sex, location and morpho-biometric measures were recorded. In females, lactation and pregnancy were also registered together with foetus body weight and length. Sera were tested for the presence of anti-*T. gondii* IgG using a

commercial ELISA kit (IDVET, Montpellier, France).

An overall seroprevalence of 39.5% emerged, giving evidence to the circulation of the pathogen in the study area. In particular, a significant effect of age class (calves, 1-year-old and >2-year-old deer) was recorded: the probability to contract infection is significant lesser in calves than in the two others. No significant difference emerged between 1-year-old and >2-year-old deer pointing out an equal infection in these age classes supporting the hypothesis of a high level of environmental contamination. Considering the sporadic presence of lynx (*Lynx lynx*) in Italian Alps, feral and semi-domestic cats are the only definitive hosts responsible for *T. gondii* spreading. Calves did not contract the infection, apart just one female, and this fact suggests an almost total lack of vertical transmission in the studied population. *T. gondii* infection seems not to prevent hinds to become pregnant or to cause early abortion, leaving females apparently barren although a negative effect of the pathogen on foetuses development of 2-3 year-old hinds and of hinds from area 1 was recorded. These results highlight that the pathogen could anyway affect pregnancy supporting the hypothesis that these hinds had acquired the infection before the breeding season or in early pregnancy. In particular *T. gondii* seems to have influenced their fertility through a delay in the physiological development of foetus or to have affected hinds' breeding season provoking a delay in mating or in pregnancy.

Data arisen give evidence to a high level of *T. gondii* environmental contamination with horizontal transmission as the only route of infection in the study area. In this sense a widespread exposure to infection is supposed and should be taken into account in relation to the parasite zoonotic potential. The recorded negative impact of *T. gondii* on foetus development of both 2-3 year-old hinds and females from area 1 points out that under specific conditions the pathogen could give an impact on population dynamics of this intermediate host. Further analysis are needed to evaluate the distribution, densities and *T. gondii*-sero prevalence of semi-domestic and feral cats in order to define their role in environmental contamination and thus their effect in red deer infection.