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Case report

Direct economic losses of *Toxoplasma gondii* abortion outbreaks in two Spanish sheep flocks

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Abstract

This study estimates the economic losses due to outbreaks of toxoplasma abortions in a dairy (1928 sheep) and a meat (700 sheep) flock in Spain raised under intensive and semi-extensive management conditions, respectively. In both flocks, sheep were divided into multiple groups to synchronise reproduction. The outbreaks resulted in abortion rates in individual lots of 12.6% (30/239) in the dairy flock and 33.3% (70/210) in the meat flock. *Toxoplasma gondii* was definitively diagnosed in most submitted cases and the only abortifacient pathogen identified despite extensive investigation. Upon completion of lambing and lactation, veterinarians and farmers completed a questionnaire to gather the data to determine the direct economic impact. The calculated total direct economic losses were €5154.5 (€11.8/abortion) in the dairy flock and €4456 (€63.6/abortion) in the meat flock. Results suggest that flock size, production system, abortion rate and control measures are the key factors influencing economic losses, which vary greatly between individual flocks.

Keywords: *Toxoplasma gondii*; sheep; abortion; economic impact; dairy; meat

1. Introduction

Toxoplasma gondii infection is a major cause of reproductive failure and reportedly responsible for 10% to 23% of ovine abortions in Europe and USA, respectively (Dubey et al., 2009). However, determining economic losses in the sheep industry is challenging as most sheep farms are small, managed under extensive or low-input systems and do not have computerized records to accurately quantify production, reproductive or economic parameters (de Rancourt et al., 2006). In fact, there is a lack

of detailed investigations determining the specific financial loss caused by a toxoplasmosis outbreak. Therefore, after definitive diagnosis of *T. gondii* infection as the cause of two separate outbreaks of ovine abortion, one in a dairy ($n=1928$) and one in a meat flock ($n=700$), the aim of this study was to determine the direct financial loss for each farm.

2. Case presentation

Cases of aborted fetuses, and, where available, associated placentas were submitted by attending veterinarians for detailed investigation. Upon completion of lambing and lactation, veterinarians and farmers completed a questionnaire (Supplementary files 1 and 2) to estimate the economic losses based on direct costs (loss of lambs sold, laboratory fees, reduction in milk yield and reduction in fodder and maintenance expenses) (Stelzer et al., 2019). In both outbreaks, the first abortion for laboratory analysis was tested for abortifacient agents (*Brucella* spp., *Salmonella* spp., *Campylobacter* spp., *Chlamydia* spp., *Coxiella burnetii*, *Neospora caninum* and *T. gondii*) by specific PCRs, routine selective and non-selective bacteriological culture and histological examination, costing €200 (Moreno et al., 2012; Elvira-Partida et al., 2017). Once diagnosed as toxoplasmosis, the rest of the foetuses submitted within the study were analysed identically free of charge as a research collaboration.

2.1. Dairy sheep flock

Data were extracted from two software programs (DeLaval DelProTM and G10-MSD). Production data, and any relevant event or disease, from individual sheep were recorded using electronic readers and ruminal boluses (Supplementary file 1). Thirty out of 239 (12.6%) pregnant ewe lambs in a single group aborted during the middle and last thirds of gestation in a short time period (ten days) in January 2017. A total of 15/17 (88%)

fetuses and 4/4 (100%) placentas were positive for *T. gondii* DNA. Additionally, 8/17 (48%) fetuses and 2/4 (50%) placentas showed microscopic lesions consistent with protozoan infection (foci of gliosis with and without central areas of necrosis in the brain and multifocal necrotic placentitis). None of the fetuses or placenta were positive for any other abortifacient agent investigated. Considering the clinical history of the episode and the results from the submitted fetuses and placentas, ovine toxoplasmosis was assumed as the cause of the outbreak. Twenty-three of the 30 aborted ewe lambs failed to produce any milk and the remaining seven, all of which aborted in the last week of gestation, could be milked (Supplementary file 1). The income lost associated with the lack of milk from the 23 aborted ewe lambs that failed to lactate was €5862 (Supplementary file 1). The lost income associated with reduced milk production from the seven ewe lambs that aborted but did lactate was €446.6 (Supplementary file 1). The cost of the fodder ration withheld from the 23 non-milking sheep €1843.68 (€0.48/sheep for 167 days of lactation) was subtracted from the lost income. The total financial loss was €4464.92 (€5862 + €446.6 - €1843.68). In addition, the farmer estimated a loss of 30 lambs resulting in a lost income of €1029.6 (30 lambs x 11 kgs x €3.12/kg) minus the cost of the milk substitute that would have been used for rearing them, €540 (30 lambs x 20 days x €0.90/day) (Supplementary file 1) so the profit lost due to the loss of lambs was €489.6 (€1029.6 - €540). In total, the profit lost amounted to €5154.5 (€489.6 + €4464.92 + €200) or a loss of €171.8/ewe lamb affected.

2.2. Meat sheep flock

Data were extracted from computerised databases that were updated manually by the farmer or clinical veterinarian (Supplementary file 2). Seventy of 210 (33%) pregnant sheep of different ages, all from a single group, aborted during last third of gestation in a short time of period (12 days) in March 2018. Due to the flock being raised outdoor,

only eight fetuses and two placentas were collected by the farmer. *T. gondii* DNA was detected in 6/8 (75%) fetuses and 1/2 placentas submitted. Furthermore, the PCR-positive placenta and 5 of the 6 fetuses positive by PCR showed histological lesions consistent with protozoan infection mentioned above. The analyses for other possible infectious causes of abortion were negative. Despite the scarce of submitted samples, ovine toxoplasmosis was assumed as the cause of the outbreak considering the clinical history together with the laboratory diagnosis. According to prolificacy, the farmer estimated that 91 (70 aborted ewes x 1.3) lambs were lost as a consequence of the abortions resulting in lost income of €5096 (91 lambs x 14 kg x €4/kg) (Supplementary file 2). The only cost saving was the 30 days of post-partum cereal supplementation that was not fed to the 70 aborted ewes, €840 (70 ewes x 30 days x 1 kg/day x €0.4/kg). The total income lost due to unsold lambs ($€5096 - €840$) and diagnostic costs (€200) was €4456 (€63.6/abortion).

3. Discussion

Although the collected information from these two flocks is still limited, direct economic losses have been calculated with the available data. In addition, it should be noted that there are indirect costs that are often difficult to quantify, such as the extra labour required, the loss of genetic progress in the flock, especially in the dairy one, and the delay in lamb development (Stelzer et al., 2019). Different resultant economic losses for the dairy and meat flocks confirm there are several factors, including primary product, reproductive management, feeding system and previous *T. gondii* flock infection, that influence the financial cost of abortions, as suggested previously (Stelzer et al., 2019). To better characterize these variables from field cases could help to

produce more accurate and useful estimations of financial losses based on mathematical models.

Remarkably, despite proven serological evidence that the dairy sheep flock had been previously exposed to *T. gondii* as close as two years before the outbreak, no control measures had been implemented (Supplementary file 1). This previous contact probably restricted the consequences of the outbreak to ewe lambs, as ewes already infected by *T. gondii* are usually protected against its abortigenic consequences (Buxton et al., 1993; Innes et al., 2009). In fact, knowing the avidity response of the whole group would have helped to confirm eventual and recent infections in non-aborting ewes. In this respect, the flock seroprevalence rate can be highly indicative of the potential economic consequences of a future outbreak of toxoplasmosis and can be used by the farmer or veterinarian to assess the need for implementation of control measures against this disease. A small naïve flock with only one lambing season per year and with no special control measures against toxoplasmosis could be dramatically hit by this disease. Edwards and Dubey (2013) reported toxoplasmosis in a small sheep flock ($n=41$) in Texas where 31 (75%) lost some or all of their lambs. Similarly, Giadinis et al. (2011) reported a 60% abortion rate in a large dairy sheep flock ($n=500$) in Greece, and Gabardo et al. (2013) reported a 40% abortion rate in a small meat-sheep flock ($n=250$) in Brazil.

The source of infection in these two outbreaks is unknown, although the feed system used in the dairy flock (e.g. TMR prepared specifically for each group of ewes through a unified system) would, theoretically, have favoured the dissemination of *T. gondii* oocysts among the affected sheep. In this respect, Zedda et al. (2010) reported the presence of *T. gondii* DNA on grain and in pellets used for sheep feed that was easily accessible to birds, cats and rodents. In contrast, the meat sheep flock might have

been infected by grazing or drinking contaminated water during gestation as *T. gondii* oocysts are highly environmentally persistent (Supplementary file 2) (Jones and Dubey, 2010).

Both flocks were larger than the average Spanish sheep farm (110,000 farms, average 325 animals, 14.6% dairy and 79.06% meat production) and large flocks remain a minority (de Rancourt et al., 2006). However, the individual groups affected in this study are actually representative, in terms of size, of the typical Spanish sheep farm. If the abortion rates (70/210, 30% for meat and 30/239, 12.6% for dairy) were extrapolated to typical Spanish flocks, the financial consequences would be more dramatic.

4. Conclusions

Financial losses due to toxoplasmosis abortions depends heavily on specific variables such as the reproductive and production management and control measures so definitive assessment of the financial impact in each outbreak requires more data. Although financial losses can be lower significant in larger flocks divided into separately managed groups according to the reproductive status of the sheep, small family farms (the most frequent in Mediterranean areas) are more financially vulnerable to *Toxoplasma*-abortions. Therefore, preventive measures, such as vaccination, biosecurity and cat and pest control will greatly reduce the occurrence of the disease.

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References

- Buxton, D., Thomson, K.M., Maley, S., Wright, S., Pees, H.J., 1993. Experimental challenge of sheep 18 months after vaccination with a live (S48) *Toxoplasma gondii* vaccine. Vet. Rec. 133. 310-312. <https://doi.org/10.1136/vr.133.13.310>.
- de Rancourt, M., Fois, N., Iavali, M.P., Tchakérian, E., Vallerand, F., 2006. Mediterranean sheep and goat production: An uncertain future. Small Ruminant. Res. 62. 167-179. <https://doi.org/10.1016/j.smallrumres.2005.08.012>.
- Dubey, J.P., 2009. Toxoplasmosis in sheep—the last 20 years. Vet. Parasitol. 163. 1–14. <https://doi.org/10.1016/j.vetpar.2009.02.026>.
- Edwards, J.F., Dubey, J.P., 2013. *Toxoplasma gondii* abortion storm in sheep on a Texas farm and isolation of mouse virulent atypical genotype *T. gondii* from an aborted lamb from a chronically infected ewe. Vet. Parasitol. 192, 129-136. <https://doi.org/10.1016/j.vetpar.2012.09.037>.

- Elvira-Partida, L., Fernández, M., Gutiérrez, J., Esnal, A., Benavides, J., Pérez, V., de la Torre, A., Alvarez, M., Esperón, F., 2017. Detection of bovine viral diarrhoea virus 2 as the cause of abortion outbreaks on commercial sheep flocks. *Transbound. Emerg. Dis.* 64. 19-26. <https://doi.org/10.1111/tbed.12599>.
- Gabardo, M.P., Saes Vilaca de Olivera, J., Ecco, R., Guedes, R.M.C., 2013. Outbreak of ovine abortion by toxoplasmosis in southeastern Brazil. *Braz. J. Vet. Pathol.* 6. 37-41.
- Giadinis, N.D., Terpsidis, K., Diakou, A., Siarkou, V., Loukopoulos, P., Osman, R., Karatzias, H., Papazahariadou, M., 2011. Massive toxoplasma abortions in a dairy sheep flock and therapeutic approach with different doses of sulfadimidine. *Turk. J. Vet. Anim. Sci.* 35. 207-211. <https://doi.org/10.3906/vet-0910-170>.
- Innes, E.A., Bartely, P.M., Buxton, D., Katzer, F., 2009. Ovine toxoplasmosis. *Parasitology.* 136. 1887-1894. <https://doi.org/10.1017/S0031182009991636>.
- Jones, J.L and Dubey, J.P., 2010. Waterborne toxoplasmosis-Recent developments. *Exp. Parasitol.* 124. 10-25. <https://doi.org/10.1016/j.exppara.2009.03.013>.
- Moreno, B., Collantes-Fernández, E., Villa, A., Navarro, A., Regidor-Cerrillo, J., Ortega-Mora, L.M., 2012. Occurrence of *Neospora caninum* and *Toxoplasma gondii* infections in ovine and caprine abortions. *Vet Parasitol.* 187. 312-318. <https://doi.org/10.1016/j.vetpar.2011.12.034>.

Stelzer, S., Basso, W., Benavides-Silván, J., Ortega-Mora, L.M., Maksimov, P., Gethmann, J., Conraths, F.J., Schares, G., 2019. *Toxoplasma gondii* infection and toxoplasmosis in farm animals: Risk factors and economic impact. Food. Waterborne. Parasitol. 15. <https://doi.org/10.1016/j.fawpar.2019.e00037>.

Zedda, M.T., Rolesu, S., Pau, S., Rosati, I., Ledda, S., Satta, G., Patta, C., Masala, G., 2010. Epidemiological study of *Toxoplasma gondii* infection in ovine breeding. Zoonoses. Public. Health. 57. 102-108. <https://doi.org/10.1111/j.1863-2378.2009.01292.x>.

Highlights

- Direct economic losses of toxoplasmosis were €171.8 and €63.6/abortion in the dairy and in the meat flock, respectively
- Flock size, production system, abortion rate and control measures determine economic losses
- Larger flocks with an intensive management and several lambing lots might compensate economic losses

Author contributions

D. Gutiérrez-Expósito: Conceptualization, Investigation, Methodology, Writing-Original draft preparation. F. Tejerina: Investigation. J. Gutiérrez: Investigation, Methodology, Writing-Reviewing. M. Fernández-Escobar: Methodology. L.M. Ortega-Mora: Conceptualization and methodology. A.R. Mantecon: Investigation. V. Perez: Investigation. M. P. Dagleish: Writing-Reviewing and Editing. V. Pérez: Writing-Reviewing and Editing. J. Benavides: Conceptualization, Investigation, Supervision, Writing-Reviewing and Editing.

Conflict of interest statement

J. Gutiérrez is an employee of Merck Sharp & Dohme Animal Health, S.L, the pharmaceutical company producing and selling Ovilis® Toxovax, the only vaccine registered in Spain against ovine toxoplasmosis. None of the remaining authors received any funding or honoraria from Merck Sharp & Dohme Animal Health, S.L, nor had any financial or personal relationship with other people or organizations that could inappropriately influence or bias the content of the paper.

Ethical statement

All applicable international, national, and/or institutional guidelines for the care and use of animals were followed

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