

RISK FACTORS ASSOCIATED WITH TOXOPLASMOSIS IN NEW YORK STATE: AN EXPLORATORY ANALYSIS OF CLINICAL DATA

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La toxoplasmose demeure un problème économique et de santé publique au niveau mondial, en particulier au sein des régions de production ovine. Aux Etats Unis, des avortements causés par *Toxoplasma gondii* ont été identifiés dans les élevages ovins de nombreux Etats. La prévalence dans le cheptel ovin du Nord-Est des Etats Unis a été récemment évaluée à 59%. Nous avons réalisé une étude cas-témoin rétrospective pour identifier les facteurs qui étaient associés avec le risque d'exposition à *Toxoplasma gondii*. Les résultats de tous les tests d'inhibition de l'héماغglutination à *Toxoplasma* dans la population ovine du laboratoire d'analyses de l'Etat de New York du 3 Janvier 1988 au 17 Juin 1996 ont été utilisés pour cette étude. La population cible était définie comme celle des moutons élevés dans l'Etat de New York. Les données accessibles étaient la date de soumission de l'échantillon, le sexe, l'âge, la race, et le résultat du test. Au total, 332 ovins ont été utilisés pour cette étude. Les données ont été analysées par le test du Chi carré, le test de T et l'analyse de régression logistique. La saison et le sexe ont été identifiés comme facteurs de risque potentiel alors que les races croisées, par opposition aux races pures, semblaient avoir un risque plus limité.

INTRODUCTION

Toxoplasmosis remains a worldwide economic and public health problem particularly within the sheep producing areas. In the United States, abortions due to *Toxoplasma gondii* have been documented on sheep farms from many of the different states (Mazzola and Dubey, 1984). Prevalence within sheep in the northeastern United States has recently been shown to be 59% (Malik *et al.*, 1990), and in 1988, toxoplasmosis was reported as the cause of multiple abortions on a sheep farm in Cobleskill, NY (Dubey and Welcome, 1988). There is no reason to believe that reductions in prevalence have occurred in sheep within any of these areas of the United States, and although a commercial vaccine to prevent abortions due to *T. gondii* has been employed in Europe (Buxton and Innes, 1995), a vaccine of this type is not available in the United States. Thus, there is every reason to believe that toxoplasmosis will continue to cause economic losses to sheep farmers.

In the case of ovine toxoplasmosis, there is no doubt that the sheep are being infected with oocysts while grazing due to their strictly herbivorous nature and there being no known arthropod vectors for this disease. Also, within New York, most lambs seroconvert within one year of birth (55% of the lambs from slaughterhouses, Malik *et al.*, 1990). Thus, sometime during the first year of life, lambs are ingesting the oocysts of *Toxoplasma gondii* while feeding, drinking, or grooming. However, «the mode of postnatal acquisition of *Toxoplasma* infection in sheep is not known but appears to be due to chance exposure to oocysts» (Dubey and Towle, 1986). Once it is determined how and where lambs are acquiring the infective oocysts, then it will be possible to affect management methods in a way that will protect against infection.

We report a retrospective case-control study designed to identify factors that were associated with the risk of exposure to *T. gondii* in sheep in New York state.

MATERIALS AND METHODS

Records of all toxoplasma hemagglutination inhibition Test (HAIT) in sheep from New York State Diagnostic Laboratory (NYSDL) from January, 3rd 1988 to June 17th, 1996 formed the database for this study. This forms the study population with the Target population defined as sheep raised in New York state. Available data included date of sample submission, sex, age, breed, and test result. A total of 332 sheep were used in the study. Information on date of sample submission was available for all the sheep. This was used to determine the season of the year. Sex was recorded for 277 sheep (83% of the studied sheep). Age was available for 254 (77% of the studied sheep) and was analyzed as a continuous variable. 13 breeds of sheep were recorded. These were coded as pure breeds and mixed breeds.

Statistical analysis was carried out using BMDP statistical software (Dixon 1992). Bivariate and multivariate statistical procedures were used to study the likelihood of a particular factor being associated with risk of toxoplasmosis in sheep. The bivariate associations were evaluated using chi-square tests for the categorical variables and the t-test for age, the continuous variable. Backward elimination and forward stepwise logistic modelling procedures constituted the multivariate statistical procedures. All main effects and all two way interactions were tested. In the final model, only variables that were found to significantly affect the outcome were retained. The significance of the associations was considered at $\alpha = 0.1$.

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RESULTS

Overall, 139 out of 332 (42%) of the samples were *T. gondii* HAIT positive. Bivariate analysis revealed season and sex as the factors that are significantly associated with *T. gondii* HAIT status. Table I contains the chi-square and t statistics. While, all the logistic modelling procedures identified season as the main effects model, none of the interactions were significant. Table II shows the results of the logistic regression analysis including coefficients and the odds ratios for the main effects model.

Table I
Chi-square and t statistics for the association between putative risk factors and HAIT sero status in sheep

Variable	HAIT serostatus				Missing No.	P
	Positive No.	%	Negative No.	%		
Season					3	0.0002
Winter	90	45.5	108	54.5		
Spring	36	53.7	31	46.3		
Summer	13	20.3	51	79.7		
Total	139		190			
Sex					57	0.0768 ¹
Male	4	23.5	13	76.5		
Female	123	47.7	135	52.3		
Total	127		148			
Summer						
Breed					3	0.1600
Purebreed	109	44.5	139	55.5		
Mixedbreed	30	35.7	54	64.3		
Age					80	0.2150

¹ Fisher's exact test

Table II
Parameter estimates and odds ratios for the logistic regression model

Variable	Coefficient	SE	P	OR	95%CI
Constant	-0.0572	0.185	0.7585		
Season ¹			0.0720		
Spring	0.5412	0.323		1.72	0.9-3.3
Summer	-0.4609	0.408		0.631	0.3-1.4
Breed ²	-0.7424	0.328	0.0210	0.476	0.3-0.9

¹ Winter used as the baseline

² Purebreed used as the baseline

Risk prediction cannot be done since the background risk can only be determined from follow up studies.

DISCUSSION

Whilst appreciating the shortcomings associated with clinical data, an overall 42% *T. gondii* HIAT positive samples points to an existing problem. Indeed prevalence studies in the North Eastern United States reveal a prevalence of 59% (Malik *et al.*, 1990). NYSDL is within this region providing diagnostic as well as other services to New York state. With a prospective study in mind, examination of the NYSDL database forms a convenient starting point. The data may not be representative but it does provide a justification for a rigorous follow up study in New York state to be undertaken soon by the authors.

Toxoplasma prevalence in sheep has been shown to vary based on climate, geographical area, rainfall, and management (Munday, 1970). Management appears to be the general condition most affecting the percentage of infected sheep on any farm; sheep that are intensively managed at a high density are at the greatest risk of infection (Hartley and Moyle, 1974; Waldeland, 1977a). Also, more sheep in Norway and New Zealand become infected in cooler seasons than in warmer seasons (Hartley, 1966 and Waldeland, 1977b). Infection also varies with whether animals are maintained on lowland or mountain pastures (Waldeland, 1977b). In one case, it was felt that the study showed that sheep managed in different ways on the same farm with hogs that were kept indoors being infected at a higher level than hogs that were maintained with older ewes on pasture (Waldeland, 1977b).

This study identified season, sex and breed as potential risk factors worthy further investigation in a follow up study. Mixed breed as compared to pure breeds appears to be at lesser risk OR 0.476 95% CI 0.3-0.9. Sex was also identified as a significant factor during univariable analysis. These and other putative risk factors will further be investigated in the follow up study scheduled to commence summer 1997.

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