Effect of mulesing and shearing on the prevalence of *Erysipelothrix rhusiopathiae* arthritis in lambs

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Objective To examine the effects of management practices and environment on the prevalence of arthritis in lambs.

Design and population A case-control study was conducted on groups of lambs from 122 Western Australian sheep flocks.

Method Arthritis was diagnosed by visual assessment of lambs at abattoirs by qualified meat inspectors. The prevalence was estimated from data collected from producers on culling practices for arthritis. Data on management practices and environmental variables were collected by personal interview. Stepwise logistic regression was used to measure the effects of the most important factors on the prevalence of arthritis.

Results Mulesing and shearing lambs increased the odds of high prevalence of arthritis by 7 (95% CI 1.9 - 25.6) and 4.3 (95% CI 0.9 - 19.6) times, respectively compared to unmarked and unshorn lambs. Lambs slaughtered between December and June had 3.7 (95% CI 0.8 - 16.6) times greater odds of having a high prevalence of arthritis than lambs slaughtered in the remainder of the year.

Conclusions This study indicates that, to decrease the risk of high prevalence of arthritis, lambs raised for meat production should not be mulesed or shorn. Recommended improvements to hygiene at mulesing such as the use of portable yards had little effect on the prevalence of arthritis.
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Arthritis in lambs causes condemnation of part or all of a carcase in abattoirs as well as a loss of production from the culling of lambs on the farm. The disease has a number of causes with *Erysipelothrix rhusiopathiae* being the most frequently identified in many countries and in Western Australia.[1-3] During the period when data were collected for this study, between 1991 and 1993, arthritis, as identified by meat inspectors in abattoirs, affected approximately 0.8 to 1.3% of lambs in Western Australia.[4] However, this is an underestimate of the prevalence, because lambs with signs of arthritis are often culled before they are sent to the abattoir.

Recommendations for the control of arthritis in lambs have concentrated on improving hygiene at ear notching and or tagging, castration and tail docking (together referred to as marking) and mulesing. These recommendations include marking and mulesing in portable yards in grassed paddocks and the disinfection of marking and mulesing instruments.[5] In a survey of prevalence of arthritis in the central wheat belt of Western Australia it was found that lamb producers who said they were using these procedures did not have a lower prevalence of arthritis (Paton, unpublished data). To the authors' knowledge no field evaluation of these procedures has been done.

This study is a case-control study of farms with low and high prevalences of arthritis in lambs as measured in the abattoir and on the farm. In this study, the effects of management practices and environmental factors on whether groups of lambs had high or low prevalence of arthritis was evaluated.

Materials and methods

Design

A case-control study was conducted to assess factors associated with the prevalence of arthritis in groups of lambs slaughtered together. Five thousand lines of lambs were examined for the prevalence of arthritis and other conditions at a Western Australian abattoir.[4] Data on management practices and environmental factors were collected by interview with flock managers. Initially, flocks were chosen for inclusion in the study if they had a prevalence of arthritis, at abattoirs of either 4% or greater or an absence of arthritis. Flocks were not chosen if they had previously received a report from the abattoir containing an extension message about arthritis, so as not to bias information collected during the subsequent interview about management practices.

The accuracy of the estimate of prevalence of arthritis on farms, obtained at the abattoir, was affected by culling or selection of lambs affected by clinical arthritis on the farm. This could lead to a higher estimate of prevalence of arthritis, if all lambs with arthritis were sent in one consignment to the abattoir, or a lower prevalence if arthritis-affected lambs were culled on the farm and therefore removed from the consignment. The details of these culling or selection practices were recorded in the questionnaire and the prevalence of arthritis used as the dependent variable was adjusted for these practices. For example, if a flock had no arthritis present in 95 lambs at the abattoir but 5 lambs from this mob were culled on the farm then the adjusted prevalence of arthritis would become 5%. That is, a flock selected as having a low prevalence on the basis of the abattoir information would become a high prevalence flock after this adjustment.

After this adjustment process was carried out, more than 30 of the selected flocks had an adjusted prevalence of arthritis between 0 and 4%. Removing these flocks may have decreased the power of the study so the value of 4% prevalence was chosen as the threshold for the dichotomised dependent variable. Case flocks were therefore those with an adjusted prevalence of higher than 4% and control flocks were those with 4% or lower. This threshold was used because it was the original prevalence chosen as the lower prevalence limit for flocks chosen as being in the highest 20% for arthritis (of all 5000 lines of lambs

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measured) on abattoir prevalence estimates. The spread of adjusted prevalence of arthritis values is given in Figure 1.

Eleven flocks selected for a high prevalence of pneumonia or pleurisy also had prevalences of arthritis measured in the abattoir of between 0 and 4%. However, meeting the criteria for prevalence of arthritis measured only in the abattoir was no longer important, because the adjusted prevalence of arthritis was used. The managers of these flocks had completed the same interview.

Collection and analysis of data

This study examined 122 sheep flocks with an average size of 5350 sheep in the mixed farming area of Western Australia. A questionnaire was completed during an interview with the flock manager. This interview included questions on lamb management as well as on environmental factors. The farms were categorised into two groups using a threshold of an adjusted prevalence of arthritis of 4%, creating a dichotomous dependent variable ARTLOG. A screening procedure was used to select management and environmental factors more likely to be associated with prevalence of arthritis. Each factor was analysed against ARTLOG by chi-square analysis and those with P values ≤ 0.15 were retained for inclusion in logistic regression analysis (Table 1).

The correlation matrices of variables selected by the above screening process were examined for colinearity and no two variables had *r* values of greater than 0.35 and therefore all were available for multivariate analysis. A forward stepwise logistic regression was performed on the screened variables with ARTLOG as a dependent variable using BMDP Dynamic Release 7.0.[6] The adjusted P value for inclusion of each variable in the model was 0.1, whereas 0.15 was set as the adjusted P value to remove it from the model. Logical interaction variables of screened variables were also available for inclusion in the logistic model. All screened variables except the one "lambs spent more than 1 hour in yards after shearing", which is nested in "lambs were shorn" because it was a measure of time lambs spent in yards after shearing, were used in the model. A model excluding "lambs were shorn" but including "lambs spent more than 1 hour in yards after shearing" did not contain sufficient data, due to missing values, to obtain meaningful results.

In the stepwise logistic regression model (Table 2) the odds ratios for variables in the final model are given, as well as assess-

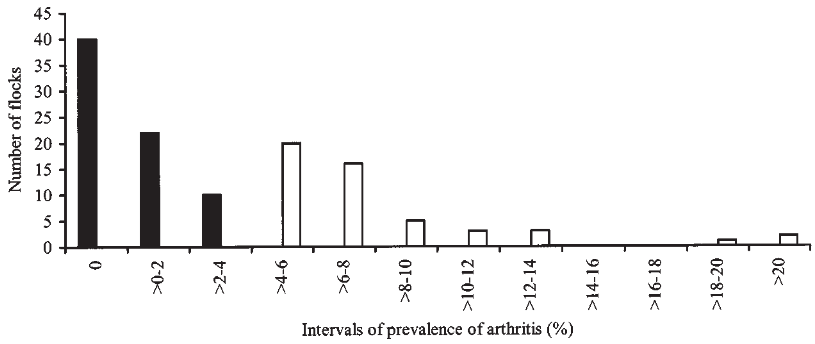

Figure 1. Frequency distribution of adjusted prevalence of arthritis in lambs from 72 flocks (controls) (■), expressed as a percentage and prevalence of arthritis from 50 flocks (cases) (❑).

Table 1. The name and description of factors obtained from responses during an interview, selected for further analysis on their association with adjusted prevalence of arthritis (P ≤ 0.15) on 50 case and 72 control farms.

Variable	Description	Representation of variables in Case (1-3) and missing (m) and Control Groups (number in each category		Chi-square P value analysed with ARTLOG
		Cases (n = 50)	Controls (n = 72)	
MULES	Lambs mulesed (Y=1, N=2)	1=30, 2=20	1=5, 2=66, m=1	< 0.001
SHEAR	Lambs shorn (Y=1, N=2)	1=37, 2=12, m=1	1=8, 2=64	< 0.001
SHTIME	Lambs spent more than 1 h in yards after shearing (Y=1, N=2)	1=23, 2=14, m=12	1=2, 2 =6, m=64	0.055
MARKYAR	Lambs marked or mulesed in portable yards in paddocks (Y=1, N=2)	1=24, 2=22, m=4	1=17, 2 = 48, m=7	0.005
DRENCH	Lambs treated with anthelmintic (Y=1, N=2)	1=40, 2=9, m=1	1=25, 2=43, m=4	< 0.001
BREED	Merino (Y=1, N=2)	1=28, 2=22	1=3, 2=69	< 0.001
WNDPDR	Marking/mulesing wounds treated with antiseptic or insect repellent powder (Y=1, N=2)	1=7, 2=42, m=1	1=4, 2=67, m=1	0.106
DISNUN	No disinfectant used on marking/mulesing instruments (Y=1, N=2)	1=1, 2=29, m=20	1=8, 2=7, m=57	< 0.001
MARKDIF	Marking/mulesing done at different sites each year (Y=1, N=2)	1=28, 2=18, m=4	1=22, 2=43, m=7	0.005
TAILCUT	Tail docking done by cutting (Y=1, N=2)	1=39, 2=11	1=44, 2=24, m=4	0.118
SLSEAS	Lambs slaughtered between December and June (Y=1, N=2)	1=33, 2=17	1=7, 2=65	< 0.001

ments of the fit of the model, after each variable is added, allowing a comparison of the improvement to the stepwise logistic regression model that each variable makes. The probability (P) value of the 'goodness of fit chi-square' is the measure given for this model assessment. The improvement chi-square statistic is quoted and its P value indicates by how much the addition of each variable improves the model.

Table 2. Adjusted odds ratios and their 95% confidence limits (CL), for independent variables included in a forward stepwise logistic regression model, using adjusted prevalence of arthritis (categorised into two groups) as the dependent variable and improvement chi-square and goodness of fit P values.

Variable	Odds Ratio	95% CL		Improvement chi-square (P)	Goodness of fit (P)
		Lower	Upper		
CONSTANT	0.144	0.07	0.29		
MULES	7.02	1.92	25.6	<0.001	0.012
SHEAR	4.33	0.96	19.6	0.003	0.195
SLSEAS	3.68	0.81	16.6	0.099	0.344

In a concurrent study to assess the accuracy of the detection of arthritis at abattoirs, 57 joints were identified as affected by arthritis by Australian Quarantine and Inspection Service meat inspectors in abattoirs during a 3 day period.[4] These joints were examined histologically and bacteriologically at Agriculture Western Australia's Animal Health Laboratories, to identify possible causes of arthritis in these lambs.

Results

The 122 flocks had an average of 173 lambs assessed for arthritis in abattoirs. The estimate of the adjusted prevalence of arthritis for these flocks was on average 1.2% higher than the prevalence recorded at the abattoir and the difference between the adjusted prevalence ranged from an increase of 18% to a decrease of 1.4% in individual flocks. On the 50 farms with an adjusted prevalence of arthritis of greater than 4%, the average adjusted prevalence of arthritis was 8.2%. This average was 0.67% on the 72 farms with adjusted prevalence of arthritis of 4% or less. All groups of lambs in this study were marked and 29% of the groups were mulesed.

The variables selected by the screening procedure, their descriptions, frequency distribution and chi-square P values for associations with ARTLOG are given in Table 1. The stepwise logistic regression model for ARTLOG showing the odds ratios for the variables included in the model and their 95% confidence intervals are shown in Table 2. None of the possible interaction factors entered the model.

Mulesing lambs ("lambs were mulesed") increased the odds of high prevalence of arthritis by 7 times. Shearing lambs ("lambs were shorn") increased the odds of having high prevalence of arthritis by 4.3 times. Lambs slaughtered between December and June inclusive ("lambs slaughtered between December and June"), had 3.7 times the odds of having a high prevalence of arthritis.

Some of the independent variables selected by screening, which did not enter the final logistic model, may also affect the prevalence of arthritis. Lambs mulesed or marked in portable yards in paddocks rather than fixed yards (MARKYAR), had higher unadjusted prevalence of arthritis, as did drenched lambs (DRENCH), those mulesed or marked at a site that was changed from the previous year (MARKDIF) and those with tails docked by cutting (TAILCUT). Lambs on which disinfectant was not used at marking or mulesing (DISNUN) had a lower unadjusted prevalence of arthritis.

Of the 57 joints identified as affected by arthritis and examined histologically 27 had acute and 30 had chronic lesions of arthritis. Bacteria were isolated from 52% of acute lesions and from 23% of chronic lesions. All lesions in which bacteria were isolated (37% of joints) were infected with *E rhusiopathiae*. One joint was also infected with *Staphylococcus aureus* in addition to *E rhusiopathiae*.

Discussion

The procedure described in this study in which many potential risk factors were assessed, may identify some factors as having a significant association with the prevalence of arthritis in lambs, due to chance. It is therefore necessary to look at the biological plausibility of the relationships suggested by these odds ratios, other evidence for the existence of such relationships and the consistency of results using different methods of analysis to assess their practical importance.

Logistic regression was used for this study, because the dependent variable was discrete. It is possible that some of the variables identified in the screening procedure (Table 1) have an effect on arthritis in lambs but were less important when "lambs were shorn", "lambs were mulesed" and "lambs slaughtered between December and June". However, in the univariate analysis they may appear important due to confounding.

The influence of mulesing and shearing on the prevalence of arthritis may be explained by wounds from these procedures giving an entry point to *E rhusiopathiae*, the organism responsible for arthritis. The effect of time of slaughter on the prevalence of arthritis may be influenced by older lambs having more opportunity for infection. This could also be because Merino lambs, which are more likely to be mulesed and have more cuts at shearing because of more skin wrinkles than other breeds, grow more slowly and are therefore more likely to be slaughtered in the second half of the lamb growing season.

Some univariate analyses indicate that some currently recommended control measures for arthritis may have little effect. These relationships, however, should be viewed with caution because of the possible confounding in these analyses. Lambs treated with disinfectants or wound dressings at marking or mulesing had a higher unadjusted prevalence of arthritis. The observation that marking or mulesing in portable yards in paddocks rather than permanent yards was associated with higher unadjusted prevalence of arthritis has been observed before (Paton unpublished data). In the stepwise model building process these variables did not enter the logistic model because the effects of other variables were stronger. However, it remains of concern that the prevalence of arthritis is still higher in groups marked or mulesed in portable yards compared to permanent yards, because the use of portable yards is being advanced as a control for this type of arthritis.[5]

This study indicates that in lambs raised for meat production, management procedures such as mulesing, shearing or other skin breaking procedure, should not be undertaken because they increase the risk of arthritis. The study also found that recommended procedures, such as mulesing or marking in clean paddocks and doing these operations at different locations each year using various disinfectants on instruments, need further examination for their effect on the prevalence of arthritis.

About 1% of 1,009,442 lambs, assessed by meat inspectors over 3 years of recording of 14 sheep diseases in a Western Australian abattoir, had arthritis[4] and the cost of downgrading due to arthritis was about $5.00 per lamb in 1997 (P Mulcahy, WAMMCO International, personal communication). The cost in the abattoir for an average of 2 million lambs is therefore likely to be about $100,000. In addition, an average of 1.4% of lambs were culled on farms because of the presence of arthritis. The average value to producers of these lambs if they did not have arthritis would have been about $34.00, giving a statewide total of $952,000 in extra income to farmers. These two losses together have a total cost of over $1,000,000 (at 1997 prices) to the lamb industry in Western Australia.

Feedback to producers on the prevalence of arthritis recorded at abattoirs, is needed to increase the awareness of sheep producers of this problem. Further study should examine procedures to control *E rhusiopathiae* on farms on which mulesing or shearing of lambs is practiced routinely.

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BOOK REVIEW

Congenital Heart Malformations in Mammals, an illustrated text, *Michaelson M and Ho S. Imperial College Press, England. Distributed by World Scientific Publishing, Singapore, 2000, 164 pages. Price USD48.00. ISBN 1860941583.*

This book was researched and written by two paediatricians, one a cardiologist with an interest in comparative cardiology, and the other with a background in cardiac morphology.Their interest in the subject was initially sparked by the concept, published in 1947, that there is an evolutionary, rather than teratogenic origin to isolated cardiac malformations.

The text is divided into 12 chapters and 2 appendices. The first three chapters focus on comparative aspects of the normal heart in a variety of species; sequential segmental analysis as a tool for investigating cardiac malformations; and the definition, causes, frequency of occurrence and prevalence of congenital cardiovascular defects. These are by far the most interesting of the chapters and contain some of the authors' own investigative work as well information from other published sources.

The following eight chapters examine congenital heart malformations described in a number of common species of animals with small chapters on more exotic animals. The final chapter brings together a variety of sources of information to further describe and explore the comparative aspects of a large number of congenital heart defects between species.

This book is largely a review of information previously published in a variety of journals and textbooks and is supplemented with limited number of new contributions by the authors, who have contributed significantly in the descriptions of the normal heart. One unfortunate result of this extensive use of published and historical works is the necessity to reproduce a large number of black and white photographs, which in the text are rather small and in a number of cases too dark to discern in a meaningful way. This is perhaps the major deficiency in this book as we would normally expect an "illustrated text", for which this subject is ideally suited, to contain a large number of high quality images.

Apart from this, the book presents congenital malformations in a large number of mammalian species in a thorough and informative manner. It is well researched and extensively referenced. The text is written in the first person and is generally very readable.

This is a book for those with a special interest in congenital heart malformations, with particular focus on comparative aspects of these conditions between species. It will contribute significantly as a research and teaching resource, but will find few applications in clinical practice.

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