LOGISTIC REGRESSION MODELS TO EVALUATE INSPECTION OF WOOL LOTS FOR LICE

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The body louse (*Bovicola ovis)* is associated with reduced wool production and economic loss in sheep flocks.[1] Although it can be controlled by pesticides (organophosphorous, OP, synthetic pyrethroid, SP and insect growth regulator, IGR), pesticide use has several disadvantages (residues on wool and market restrictions, occupational health and safety, environmental affects, development of resistance). Most pesticide applied to Queensland sheep flocks is for louse control.[2] Although most woolgrowers consider their flocks uninfested, >90% still use pesticides, presumably as an 'insurance policy' against reinfestation.[2,3] To develop and measure the success of louse-control and pesticide-reduction extension programs, tests to estimate the prevalence of louse infestation are required. To interpret results, test characteristics must be known and the study population used for test evaluation and its characteristics must be considered. We describe a study to evaluate visual inspection of wool lots at sale for lice as a test, and to investigate flock and management characteristics that influence test performance.

Materials & Methods

Wool clips of Queensland origin offered for sale during 1998 were selected and inspected for the presence (positive or negative) of lice.[4] From a questionnaire sent to woolgrowers who owned clips inspected, information was collected on flock and pesticide use characteristics (Table 1). Information on the louse infestation status of sheep producing the wool inspected at sale and at the previous shearing was also collected from woolgrowers. Louse infestation status of sheep was categorised as uninfested or infested, depending on the response of the woolgrower to questions concerning infestation status at the two most recent shearings. If at both shearings the woolgrower considered the flock to be infested, flock status was classified as infested. If at both shearings the woolgrower considered the flock to be uninfested, flock status was classified as uninfested. Flocks in which the woolgrower's response to the two questions was discordant (yes-no or no-yes), or where there was no response or an 'unsure' response to one or both of the questions, were excluded from analysis. Information from 178 woolgrowers who provided louse infestation information at two consecutive shearings was included.[4]

Sensitivity and specificity were estimated using logistic regression models (BMDPLR, BMDP Statistical Software Inc., Los Angeles, 1990), test result being considered the dependent variable (Y) and true infestation status an independent variable (X_1).[5] Sensitivity was modelled as the probability that the inspection was positive, given that sheep were infested, $\Pr(Y=1 \mid X_1=1) = [1+\exp(-\alpha-\beta_1 X_1)]^{-1}$, where α is the Y-intercept and β_1 is the estimated coefficient for infestation status. False-positive test rate was modelled as the probability that the inspection was positive, given that sheep were uninfested, $\Pr(Y=1 \mid X_1=0) = [1+\exp(-\alpha-\beta_1 X_1)]^{-1} = [1+\exp(-\alpha)]^{-1}$. Since specificity is equal to unity minus the false-positive test rate, specificity was derived from the logistic regression model as $1-[1+\exp(-\alpha)]^{-1}$. The potential affect of flock characteristics and pesticide use practices on test sensitivity and specificity was investigated using the models $[1+\exp(-\alpha-\beta_1-\beta_2 X_2)]^{-1}$ and $1-[1+\exp(-\alpha-\beta_2 X_2)]^{-1}$, respectively, where X_2 represents the potential confounder of interest. A change in β_1 of ≥0.1 was used as evidence of confounding.

Results

Using woolgrower reports, 28 and 150 mobs of sheep were classified as infested and uninfested, respectively, and wool from 18 and 160 of these mobs were inspected positive and negative, respectively. Estimates of α and β_1 were 2.876 (standard error 0.536) and –2.289 (SE 0.363), respectively, and estimated sensitivity of inspection was 36% (95% CI, 19 to 58%) and specificity was 95% (95% CI, 89 to 98%). Only inclusion of timing of pesticide application after shearing for louse control (β_1 = -2.513) and class of pesticide last applied after shearing for louse control (β_1 = -2.467) in logistic regression models substantially (≥0.1) altered estimated test accuracy. Visual inspection was less sensitive (29%) if pesticides were applied >3 months after shearing, compared to application ≤3 months (42%), and less sensitive (21%) if an IGR was last used after shearing, compared to OP (38%) or SP (40%) pesticides.

Table 1. Frequency distribution of characteristics of Queensland flocks used to evaluate visual inspection of wool lots as a test for louse infestation.

Factor		Response	Factor		Response
Location	South	63	Wool growth	<12 mths	20
	South-west	71		≥12 mths	157
	Central-west	35	Pesticide use	Yes	169
	North-west	9		No	9
Flock size[a]	≤1000	14	Frequency of application	Once	131
	1001-5000	74		≥2	38
	5001-10000	61	Timing of application	≤3 mths	129
	>10000	27		>3 mths	36
Stocking rate/Ha	≥ 1	40	Method of application	Backline	88
	0.5 to <1	49		Dip	30
	0.25 to <0.5	41		Spray/jet	23
	< 0.25	35		Handjet	26
Shearing season	Summer	33	Pesticide class applied	OP	63
	Autumn	48		SP	21
	Winter	49		IGR	85
	Spring	47			

Discussion

The logistic regression model is useful for deriving sensitivity and specificity estimates if test performance is influenced by covariates. It also has application when test characteristics can not be directly estimated because of sample size limitations.[5] A number of potentially confounding factors were not included in logistic regression models (because of unavailability of appropriate information) including fleece diameter, fleece colour, contamination and % vegetable matter. It is plausible, for example, that visual inspection of wool for lice may be less sensitive for lots containing a high proportion of vegetable matter. The modelling approach used in this study could be applied if such information were available.

Estimated sensitivity of inspection of wool for lice was low (36%), probably the result of low-density louse infestations. Following infestation of sheep, louse populations initially increase slowly, and may remain undetectable for 6 months to 24 months.[6,7] Inadequate control of lice at shearing, or infestation some time after shearing, may result in low-density infestations at the subsequent shearing in (generally) 12 months time. Sensitivity may be improved by targeting flocks which have been treated with pesticides for louse control ≤3 months after shearing, or in which an organophosphate or synthetic pyrethroid was the last pesticide used after shearing. Late season (>3 months after shearing) pesticide applications do not eradicate lice, but only suppress louse populations, and resistance of *B.ovis* to OP and SP pesticides has been documented in Australia.[8,9] We believe that visual inspection of wool lots for lice is a potentially useful method of monitoring the prevalence of louse infestation in Queensland sheep flocks, allowing the success of extension campaigns, aimed at better control of louse infestation with reduced use of pesticides, to be measured.

References

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