

Sheep lice and the economic production of low residue wool

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Summary

Studies of the prevalence of lice in Australian flocks and the cost of lice to the sheep industry are reviewed. Cost estimates updated to take account of changes in sheep numbers, wool prices, louse prevalence and the cpi index, indicate that lice currently cost the Australian sheep industry between \$100m and \$150m annually. The contribution of lice treatments to the total wool residue load in the 1999/2000 season is estimated at 63%. The importance of availability of an effective offshears backline product to keeping louse prevalence low and the effect of producers changing from routine annual treatment to treatment on detection for lice control is discussed. It is concluded that unless significant improvements are made in the efficiency of louse control programs a change from annual treatment to treatment on detection is likely to result in increased industry prevalence of lice.

Keywords

Phthiraptera, *Bovicola ovis*, prevalence, cost, insecticide residues

Prevalence of louse infestation

Changes over time

Many surveys have been conducted over the years in different states to estimate the prevalence of lice. Buckman (1992) states that in WA in the late 1970's and early 1980's, the prevalence of lice was reasonably steady at about 20%. Although there were differences among states and regional variations, the Australia-wide prevalence also appears to have been at about this level (Anon, 1988). Subsequent surveys show a trend of gradually increasing prevalence during the 1980's which appeared to peak in the early 90's and a progressive drop since 1993/94 to the present time (Arundel, 1988; O'Sullivan, 1988; Pearse and Baldock, 1994; Anon., 1997; Plant and Dawson, 1999; Ward and Armstrong, 1999). The exception to this pattern was in WA where there was a drop in prevalence from 34% in 1987/88 to 25 % in 1990/91 which corresponded to the institution of the Community Sheep Lice Eradication Program. However, prevalence increased again to 31% in WA in 1991/92 and had risen to 47% by May 1993 (Morcombe *et al.*, 1994).

There are many factors which have influenced this pattern. For example, there was a marked reduction in the level of regulatory input into louse control in most states during the 1980's and early 90's (Anon, 1988; Anon, 1997) and decreased spending on lice control and increases in louse prevalence in WA were found to be associated with falling wool prices (Morcombe *et al.*, 1994). However, changes in the effectiveness of offshears backline treatments probably played a major part.

Offshears backline products, the first being synthetic pyrethroids (SP), were introduced in Australia in 1981 (Bayvel *et al.*, 1981). Significant management advantages resulted in rapid adoption by wool growers and these products achieved a market share of up to 70% within a few years of their introduction (Plant, 1986). Recent surveys suggest the proportion of producers relying on backline products is still high in most areas and many sheep properties no longer have access to operational shower or plunge dips.

The original backline products appear to have been highly effective when first introduced and resulted in a significant reduction in louse prevalence in some areas (Plant, 1986), although there were questions about the initial efficacy of some subsequent lower dose products (De Chanee *et al.*, 1989). The occurrence of strains of lice with lowered susceptibility to SP's was first reported by Boray *et al.* (1988) in NSW although anecdotal reports of poor effect from backline products were received as early as 1984 and increased through 1985 (Levot and Hughes, 1990). The level and prevalence of resistance in louse populations appears to have increased significantly since this time. Resistance factors in early reports were generally less than 25X (De Chanee *et al.*, 1989; Levot and Hughes, 1990; James *et al.*, 1993) but

high level resistance (greater than 90X) was subsequently reported in 3 states (Levot, 1992; James *et al.*, 1993; Keys *et al.*, 1993). In WA, 20% of isolates of lice collected in 1988/9 and tested for susceptibility by *in vitro* methods gave results indicating resistance (Morcombe *et al.*, 1992). James *et al.* (1993) reported a prevalence of 34% in market inspection samples collected in 1990/91 in South Australia and up to 68% in flocks from Kangaroo Island. In trials carried out in Western Australia in 1992/93, 12 of 16 (75%) randomly selected isolates of lice survived treatment with a cypermethrin backline treatment (Morcombe *et al.*, 1994) and Ward and Armstrong (1999b) found prevalence of resistance as high as 90% in studies of louse populations in the western regions of Queensland.

Since 1993/4 there has been an apparent drop in the prevalence of lice. This has no doubt been due to a number of factors, including a high level of extension to improve louse control programs and create an awareness of the problem of resistance to SP based products, the emergence of contract dippers and increasing wool prices. However, the decrease in prevalence is also coincident with the introduction and increase in market share of backline products based on active ingredients other than SP's, in particular the insect growth regulators triflumuron and diflubenzuron. As the market share of growth regulator products has increased, the prevalence of lice has fallen.

It would appear that continued low prevalence of lice is heavily dependent on the availability of effective backline products. Any loss in efficiency of these products or limitation on their use because of residue difficulties could see a return to the high louse prevalence of the early 1990's.

Prevalence by state and management zones

Prevalence of lice is also related to the geographical area and management regime under which sheep are run. A South Australian survey of 200 producers in 1999 found that 13% of producers in the high rainfall zone, 21% in the cereal- sheep zone and 32% in the pastoral zone were aware of lice in their flocks prior to their last shearing. This pattern appears to be reflected in the prevalences of lice in the various states. In Queensland, Ward and Armstrong (1999a) from inspection of wool lots estimated a state real prevalence of 35%, which ranged from 22% in southern flocks to 73% in the north west. Parallel grower surveys suggested a 36% prevalence. In WA in 1992/93, 38% of wool bale brands tested using the Lice Detection Test (van Schie, 1987) were positive for lice. Adjusted for sensitivity and specificity, the prevalence was estimated at 47%. J Karlsson (*pers. comm.*) estimates a current prevalence in WA of about 30%. Plant and Dawson (1999) report an apparent prevalence from wool store inspections in 1997 of 10.8%. Using estimates of 36% sensitivity and 95% specificity for wool store inspections (Ward and Armstrong, 2000) this gives an estimate of real prevalence of 19%. The estimated prevalence from grower survey over the same period was 14.5%. In South Australia in 1999 the state prevalence as assessed by grower survey was 21%. A survey of wool growers in Tasmania in 1993/4, found that 15% of flocks were known to have lice at the previous shearing and a further 27% may have had lice (Horton *pers. comm.*). Brightling (1989) cites a state prevalence of 10% in Victoria and Campbell (*pers. comm.*) believes that the prevalence is probably still at about this level or perhaps a little higher, although there have been no recent surveys.

The general pattern of lower prevalence in the higher rainfall, more intensively grazed areas is probably due to a range of management factors related to ease of mustering and intensity of supervision. However, more frequent treatment of sheep for flystrike control using OP or diflubenzuron based products, which also suppress lice, may also be involved. The likely effect on lice prevalence of growers moving away from these products and towards strike control treatments based on cyromazine and dicyclanil, which constitute less of a residue risk, but which have no effect against lice, needs to be considered. The advent of Extinosad® may lessen this impact.

Estimates of industry cost

The most recent published estimate for the cost of lice comes from McLeod (1995). He estimated the cost of lice in 1994 at \$169m compared to \$161m for flystrike and \$222m for internal parasites. Taleb and Collins (1992) estimated that in 1990/91 producers spent \$134m in controlling lice and suffered production losses of \$216m for a total cost of \$340m. Beck *et al.* (1985) estimated a cost of \$475 due to lice on an average farm of 2,200 sheep in an 'average year', compared to \$4695 for internal parasites and \$2, 290 for flystrike. However, this is likely to be a significant under estimate as it assumed that there

was no production loss from lice. Figures from these three studies, updated to provide a 2001 estimate by adjusting for changes in sheep numbers (currently 115 million), wool prices at February 1, CPI adjustment for the cost of treatments (Australian Bureau of Statistics) and current louse prevalence estimated at 20%, are shown in Table 1.

Table 1. Estimates of the cost of lice to the Australian wool industry (\$million), adjusted for sheep numbers, CPI and wool prices at February, 2001.

Study	Treatment costs		Production loss		Total
	Year of study	2001	Year of study	2001	2001
Beck <i>et al.</i> (1985)	30	48	-*	28†	76
Taleb and Collins (1992)	134	118	216	113	231
McLeod (1995)	114	116	55	28	144

* Wool losses not estimated

† Wool losses estimated from McLeod, 1995.

An alternative ‘back of envelope’ estimate is also made below. The assumptions used for this estimate are: 20% real prevalence of lice; 70% of producers treating annually; of those treating annually 70% used backliners (50% with a triflumuron product, costed with labour at = \$0.47 per head, 20% using a synthetic pyrethroid product costed with labour at \$0.37 per head); 30% using plunge or shower dipping costed with labour at \$0.56 per head (contract rate of \$0.33, mustering at \$0.20 and chemical at \$0.03 per head); 8% of growers use a long wool treatment costed at average \$0.50 per head; mean wool cut per head was estimated at 3.5kg clean of 22 µm wool; lice caused a reduction in wool cut per head of 0.3kg with a further 3.5% processing loss (Wilkinson *et al.*, 1988).

Using these figures, the cost of treating for lice, with labour, was estimated at \$25m for backline treatments, \$14m for plunge and shower dipping and \$4m for long wool treatments for a total of \$43m in treatment costs. The estimated reduction in wool value was \$42m from decrease in wool cut with a further \$5m from processing losses for a total of \$47m. This gives a total current cost of lice of \$90m. This estimate is almost certainly conservative as it does not include costs such as the extra management costs of having lousy sheep, depreciation of dipping equipment, or post dipping losses, and it uses conservative estimates for louse prevalence and the cost of plunge dipping, shower dipping and long wool treatments.

From the updated estimates of Beck *et al.* (1985), Taleb and Collins (1992) and McLeod (1995) and the estimates above it would seem that lice are currently costing the sheep and wool industries somewhere between \$100m and \$150m annually. This does not include costs due to residues which in 1995 were estimated by the Centre for International Economics to have a gross present value of \$197m per annum (Williams and Brightling, 1999). If 50% of this cost is due to treatments for louse control (see below), this suggests a further potential loss of \$98m from the effects of lice.

Contribution of lice treatments to wool residue levels

The figures of McLeod (1995) indicate that by value almost three times the amount of chemical is applied to sheep for louse control than for blowfly control. Much of this chemical is applied soon after shearing so that there is considerable time for degradation. In addition, because of effective extension programs in most states, the numbers of producers treating their sheep routinely after each shearing and using long wool treatments is declining (Plant and Dawson, 1999; Ward and Armstrong, 1999; Riley and James, 1999). However, it is clear that sheep louse treatments contribute a significant proportion of the total residue load. Results of the wool residue survey for 1999/2000 are given in Table 2. If it is assumed that 50% of the OP residues, 95% of the SP, 50% of the diflubenzuron and 100% of the triflumuron residues are due to treatments for lice, it can be estimated that 63% of the total residue load is due to louse control treatments. Using similar calculations, louse treatments accounted for 54%, 57% and 46% of the residue loads in 1998/99, 1997/98 and 1996/97 years, respectively.

Table 2. Estimated proportion of wool residues due to louse control treatments

	Insecticide group						Total
	OP	SP	Cyrom	Dicycl	Difl	Trifl	
Total residue* 1999/2000	2.2	2.0	5.1	0.1	2.9	9.0	21.3
Estimated % due to lice	50	95	0	0	50	100	63%
Residues from louse treatments	1.1	1.9	0	0	1.45	9.0	13.4

Source: National wool residue survey, Woolmark company

The relative importance of flystrike and lice in determining residue levels appears to vary significantly between states. Ward and Armstrong (1998 and 2001) state that most of the pesticide residues on Queensland wool in most years are a result of treatments applied for louse infestation. This was also the case in South Australia where in 1997/98, the last full year in which trace backs were conducted, 75% of trace backs for residue levels above 10mg/kg were found due to lice treatments (Riley *pers. comm.*). However, in NSW and Tasmania, flystrike treatments are likely to be more important (Plant *pers. comm.*, Horton *pers. comm.*). Nevertheless, it seems that louse control treatments contribute at least half of the residue load of the Australian wool clip in most years and any residue reduction strategy will need to focus heavily on reducing the use of pesticides in sheep louse control.

The future

In response to the issues of residues, occupational health and safety concerns associated with chemical use, the development of resistance and continuing cost of production pressures many growers are modifying their louse control programs. Two changes already occurring are a move away from routine annual treatment (AT) to a treatment on detection (DT) regime and the use of chemicals which constitute a lower residue risk. In NSW the proportion of AT flocks fell from 90% to 67% between 1989 and 1997 (Plant and Dawson, 1999). In 1999, 78% of producers in South Australia treated annually (Riley and James, 1999) compared to 96% in 1982 (Tregrove *pers. comm.*). It is likely that a further reduction will occur if price premiums or penalties are incurred according to the level of pesticide residues in wool clips. It is important to consider the likely effect of these changes on louse prevalence.

The key processes influencing changes in louse prevalence in the sheep industry are the proportion of AT flocks, the efficiency of eradicating lice when flocks are treated, the sensitivity of detecting lice in DT flocks and the rate of transfer of lice between flocks (Figure 1). Sensitivity of detecting lice and the efficiency of eradicating lice when flocks are treated will affect the immediate flock prevalence of lice, but also the amount of inoculum present in the industry for future new infestations.

In flocks which are not infested (Figure 1, (a)), changing from AT to DT will result in substantial cost savings to the wool grower and will reduce the residue content of the wool clip. As these flocks are already louse free there will be no immediate net effect on louse prevalence. However, it should be noted that most post-shearing treatments provide a period of protection against new infestations and new infestations in sheep treated after shearing will be reduced by a factor determined by the protective period of the treatment. As lice appear to spread more readily among sheep with short wool (Murray, 1968), this protective effect may be more important in reducing new infestations than suggested by the length of protection *per se*.

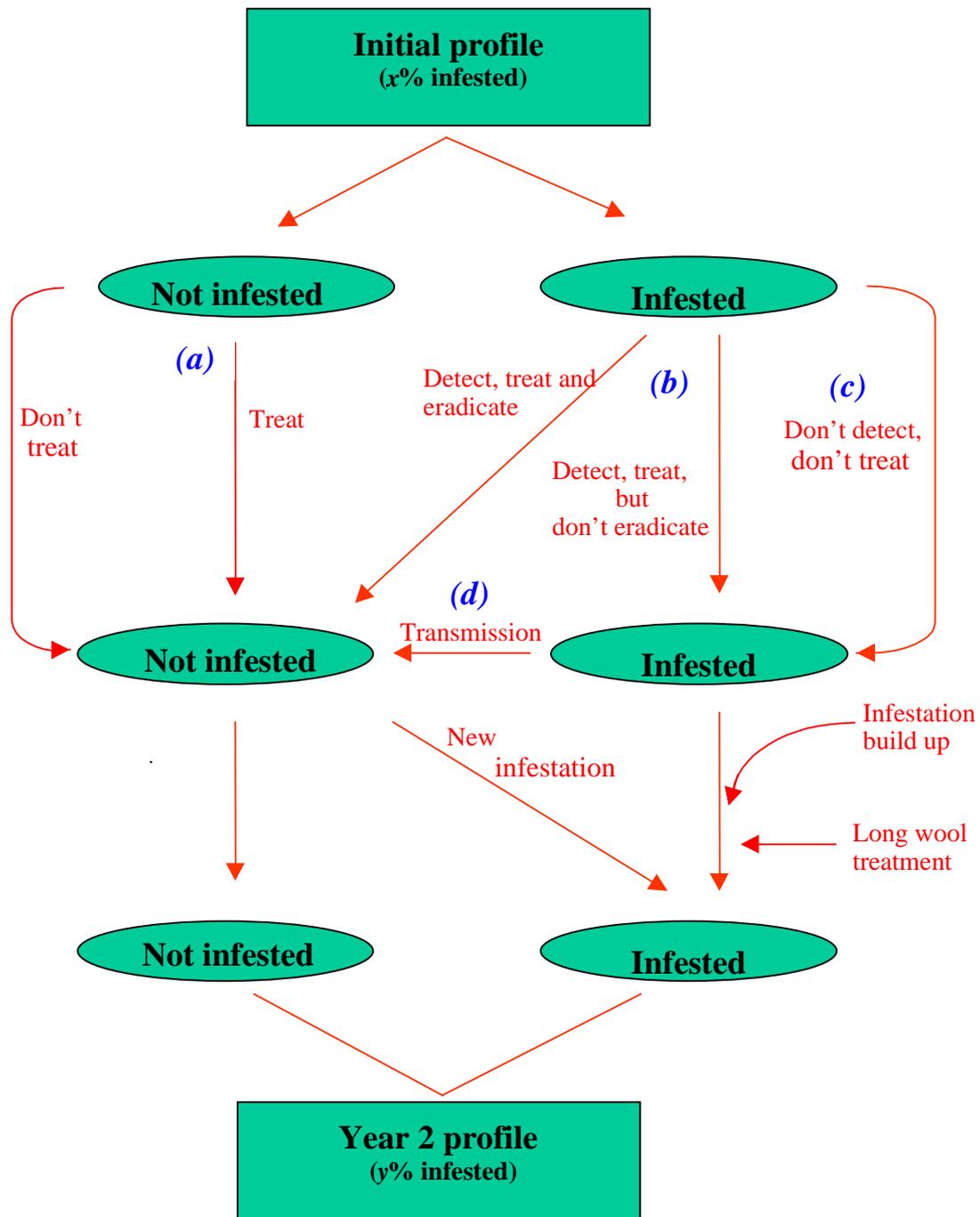


Figure 1. Flow diagram illustrating the major processes influencing changes in the prevalence of louse infestation in the sheep industry.

In infested flocks where lice are detected before or at shearing (Figure 1, (b)), change in the louse control strategy should have little net effect. These flocks would have been treated under an AT regime and they will also be treated under a DT regime. It is in the third group, those flocks infested at shearing but where the infestation is not detected (Figure 1, (c)), that there will be a change. Lice build up slowly in the early stages of an infestation and may not be detected for many months after introduction to a flock. Flocks with subclinical infestations would have been treated under an AT regime and as the numbers of lice would probably have been low, there would have been a high probability of eradication. However, with a change to DT, these flocks will now miss treatment at shearing and will remain infested. There will be a net increase in the prevalence of lice, the size of which will be determined by the sensitivity of detecting lice at shearing, and an increase in the amount of inoculum for new infestations (Figure 1, (d)).

There is no good information available on the number of subclinical infestations present at shearing. New methods for detecting lice are presently being researched (Michalski *et al.*, 2001) and would be expected

to increase the sensitivity of detection. These methods will be important in giving producers the confidence to withhold routine annual treatment. However, it cannot be expected that they will, in themselves, have a significant effect in reducing the prevalence of lice.

The numbers of producers who treat routinely each year varies widely between states. In SA 96% of woolgrowers in the pastoral zone, 79% in the sheep wheat zone and 61% in the high rainfall zone treat annually. In NSW, 67% of producers treat annually (Plant and Dawson, 1999) and in Qld more than 95% of producers treat each year (Ward and Armstrong, 1999). In NSW, the prevalence of lice in DT flocks is 10% compared to 40% in AT flocks (Plant and Dawson, 1999). The reason for the lower prevalence of lice in DT flocks is unclear but may be that these growers have management systems that minimise the likelihood of new infestations (for example closed flocks which seldom purchase sheep, neighbours who do not run sheep, good fences, ease of mustering) or that they are the generally more innovative growers with more comprehensive louse control programs.

In DT flocks a more sensitive detection system will reduce louse prevalence. If we assume that 50% of infestations would not have been detected by conventional means, that the detection system detects 70% of subclinical infestations (85% overall sensitivity) and that nationally 25% of flocks follow a DT regime, there is a net potential reduction in louse prevalence of $0.7 \times 0.5 \times 0.1 \times 0.25 = 0.9\%$.

However, in the 75% of AT flocks, all subclinical infestations would have been treated. Unless the detection technique is 100% sensitive, a change to DT can only increase prevalence of infestation in these flocks. Using the figures above the increase could be up to $0.3 \times 0.5 \times 0.4 \times 0.75 = 4.5\%$, significantly greater than the reduction in the treatment on detection flocks. If the proportion of AT flocks is higher than assumed, the sensitivity of the detection technique lower, or there is a reduction in the efficiency of eradicating lice this increase will be higher.

Thus, in the shorter term it would be expected that reduction in annual routine treatment will reduce costs to growers and residue levels in the wool clip. However, unless there is a concurrent improvement in the efficiency of eradicating lice at treatment or in other louse control practices, a longer term increase in the prevalence of infestations could erode these gains.

Other changes likely to occur because of the pressure to decrease residues are reduced use of organophosphates for flystrike control and movement towards products based on chemicals with lower residue risk such as cyromazine and dicyclanil. Surveys indicate that OP's were used for fly control in up to 36% of flocks in NSW (Plant and Dawson, 1999). In Queensland, 21% and 16% of flocks used OPs for flystrike control in the periods between 1995 and 1997 and 1997 and 1999 respectively (Ward and Armstrong; 1998, Ward and Armstrong, 2001). In a survey of pesticide use and ectoparasite control practices in Tasmania in 1993/94, Horton (*pers. comm.*) found that 48% of all ectoparasite treatments, many used for flystrike control, contained OP's. These treatments also have effect against lice and probably suppress or eradicate many subclinical louse infestations. A shift to cyromazine and dicyclanil, which have no effect on lice, will allow these infestations to persist and spread.

On the positive side, the registration of a low residue long wool treatment for lice in Extinosad® provides a valuable option for mid-season treatment of lice that was not previously available. The registration of this product will give producers the confidence to withhold treatment at shearing, knowing that an effective, low residue means of controlling mid-season infestations of lice is available should an infestation be detected later.

Conclusion

Lice remain a significant cost to the sheep and wool industries and lice treatments are responsible for more than half of the current residue load in the Australian wool clip. The prevalence of lice has declined from the highs reached in the early part of this decade and this appears to be closely related to the availability of effective offshears treatments based on growth regulators. Loss of these products, either because of reduced efficiency or unacceptable residues, could see a return to the infestation levels of the early 1990's.

Lice have been controlled for most of the last century almost exclusively by the use of chemicals and a relatively high regulatory input. Because of the efficiency of these approaches there has been very little research into the general biology of lice or alternative methods of control. Much of the 'knowledge' associated with sheep lice and their biology is based on anecdote rather than empirical data. A significant research effort will be required to increase the efficiency of chemical use, develop alternatives to chemicals and to provide the knowledge on which to base sound IPM programs for louse control.

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