Low residue Diprite® dipping of sheep with the Richards immersion-cage sheep dip

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Summary
This paper describes the successful combination of three disparate sources of technology to develop a means of effectively and humanely treating sheep for lice infestation at any stage of the wool growth cycle. Effective treatment is achieved without exceeding target chemical residues in the treated wool.

Keywords
Bovicola ovis, sheep lice, dipping, diazinon, wool, residues

Introduction

About 12 months ago Captec Pty Ltd registered a diazinon-based dipping product for sheep called Diprite®. Diprite® included new (patented) label instructions that enabled application of a consistent dose of chemical to all sheep dipped. Many pesticides 'strip' when used in sheep dips (including diazinon). Stripping is the process whereby the pesticide leaves the dip faster than the water removed with the dipped sheep. Traditional instructions attempt to offset this disproportionate loss of pesticide by charging the sump of the dip at a high concentration. This in fact accelerates the stripping reaction, leading to vast oscillations in sump concentration and sheep with highly variable doses of pesticide.

Development of the Diprite® instructions has been described in Sherwood *et al.* (1999) and Chandler and Sherwood (1999). These instructions apply to dips operated by constant replenishment. Doses of pesticide that are appropriate for the type of sheep being dipped are first determined by allowing for their body weight and time off shears (this correlates to the volume of dipwash the sheep retain after dipping). Sump concentrations of pesticide are set according to the required dose and type of dip. Sump volume and the method of pesticide application (shower or plunge) affect stripping. Diprite® instructions rely on allowing for stripping, and a replenishment concentration provided that closely retains the initial sump concentration (hence dose) throughout the dipping operation.

The original concept for what is now referred to as Long Wool Diprite® dipping, was contingent on a feature of dipping with diazinon that is not commonly recognised. This feature is the ability of diazinon to kill lice at extraordinarily low exposure levels. Trials conducted by Tim Watts and Nick Sherwood early in the Diprite® development showed the LC_{95} of lice treated with diazinon in sheep with 6 weeks wool growth was about 8mg/head, with 95% confidence limits 4.8 to 18.5 mg/head (N. Sherwood, unpublished data). These sheep would be expected to have about 1 kg wool/head, making the expected LC_{95} for pesticide in wool about 8 mg/kg. The vastly higher doses required to ensure effective treatment of lice on-farm is mainly to offset improper wetting of some sheep. The low LC_{95} values however indicate that properly wetted sheep require little pesticide for effective control of lice.

Dipping long wool sheep in traditional plunge and shower dips is quite a common practise, but it involves significant risks; both to the welfare of the dipped sheep and to the operator through exposure to pesticide. Farmers dip sheep in long wool when they recognise lice infestations well after shearing. Dipping may provide more satisfactory control than jetting, but both practises lead to high pesticide residues in the treated wool, and both usually provide ineffective control of lice.

The mobile ‘fish and chip fryer‘ (or immersion cage) dips developed by Greg Richards however allows long wool sheep to be effectively dipped with little risk to the sheep and negligible exposure of the operators to pesticide. This type of dip is the second critical component of Long Wool Diprite®.

Greg’s first hydraulically-operated immersion cage dip won the BHP Invention of The Year Award in 1992. The original concept has evolved through several stages and a sophisticated machine capable of dipping over 500,000 sheep pa has now been developed. The hydraulically-operated cage of these dips is raised and lowered in a constantly replenished sump. When a cage of sheep is lowered into the sump, the swimming action produces turbulence that provides exceptional wetting of even severely cotted fleeces. A slow raising cycle allows most of the dipwash to drain from the sheep before they have to move. Split draining pens allow efficient recycling of the dipwash and also allow time for the sheep to acclimatise to being wet before they leave the dip.

The final component of Long Wool Diprite® was to establish a dose that was appropriate according to the expected time to shearing and the target residue required in the wool at that time. The selected doses were initially selected using a basic computer model of wool growth and diazinon decay, assuming a half-life for diazinon in long wool of six weeks. Brian Horton and Noel Campbell subsequently refined these rates using their more sophisticated model for the decay of diazinon in wool (Campell *et al*., 1998). Dose rates were targeted at about 5 mg/kg wool at shearing.

The usefulness of this approach to treating sheep has been assessed in a preliminary pen trial followed by a series of six field trials. These are described below.

Materials and Methods

Pen trial

Location:	Pastoral and Veterinary Institute, Agriculture Victoria, Hamilton (PVI).
Trial Supervisors:	John Walsh, Leo Cummins, PVI.
Analyst:	John Walsh, PVI.
Sheep:	Medium frame merinos, heavily lice infested. The sheep were 11 months off shears at dipping.
Dip:	Richard’s Immersion Cage (4000 L sump model). Three dunkings, approx. 60 seconds swim time in total.
Lice counting / sheep management:	As per NRA Guidelines for registration of Ovine Lousicides, except three rows of seven sites were counted on each side of the sheep (42 sites/sheep). A pre-dipping count was conducted 20 days before treatment (13/5/99). The post-dipping (pre-shearing) count was conducted six weeks after dipping

Dipping formulation was Diprite®, 500 g/L diazinon EW.

Treatment groups (number of sheep in brackets):

1. Untreated control (dipped in water) (4)
2. 125mg diazinon/4000L sump (5)
3. 250mg diazinon/4000L sump (5)
4. 500mg diazinon/4000L sump (5)
5. 1000mg diazinon/4000L sump (5)
6. 2000mg diazinon/4000L sump (5)

Field trials

Six field trials were conducted on six commercial farms located in western Victoria, as outlined in Table 1.

Table 1. Details of field trial sites.

Trial ID	**Location**	**Sheep type**	**No dipped**	**Weeks to shearing**	
				Predicted	**Actual**
CO33	Buangor	Merino ewes (20µ, 45Kg)	746	20	13*
CO44	Beeac	Merino ewes (19µ, 35Kg)	346 ewes plus about 200 (10 – 25Kg) lambs dipped separately	23	21
CO45	Ararat	Merino ewes (20µ, 35Kg)	1800	44	44
		Merino weaners (15 – 20Kg)	900	14	13
CO53	Pura Pura	1st X (BL/M) weaners	1000	15	12
CO54	Smythesdale	'Early shorn' Merino ewes (17-18µ, 40Kg)	277	7	8
		'Late shorn' Merino ewes (20µ, 45Kg)	333	11	14
CO63	Mt Mercer	Merino wethers (19µ, 45Kg)	840	21	20

*These sheep were shorn early following the owner deciding to sell the property.

The first two trials were conducted with an immersion dip that had a sump volume of 4000 L, the remaining trials were conducted using a dip with a 6480 L sump. Swim time was still about 60 seconds. The potential of these dips to strip (their stripping factor or SF) had previously been determined as outlined in Chandler and Sherwood (1999) and was approximately four and six for the small and large dips, respectively. The estimated volumes of dipwash removed for the adult animals ranged from 4.6 L/head for sheep with over six weeks' wool to 10.2 L/head for full wool sheep. Estimates for the weaner sheep were 1.3 to 6.1 L/head. Trials CO53, 54 and 63 used rates based on the Campbell Horton model for decay of diazinon in wool. Earlier trials used the in-house model.

Lice were counted in the same manner as for the pen trial (unless otherwise indicated), before dipping and before shearing. With the exception of trials CO53 and 54, an additional count was made approximately mid-term between dipping and shearing.

Results

Pen Trial.

The reductions in lice numbers on the dipped sheep are shown in Table 2.

Table 2. Lice infestations of the sheep when counted two weeks before dipping and before shearing (six weeks after dipping) (Range in individual counts in brackets).

Treatment group	Pre-dipping lice count	Pre-shearing lice count	Reduction (%)
1	254 (81–609)	141 (83-176)	44
2	243 (129-441)	84 (6-209)	65
3	272 (108-453)	81 (11-106)	70
4	248 (191-427)	62 (6-152)	75
5	280 (75-506)	44 (0-170)	84
6	266(115-443)	1.6 (0-6)	99.4

If the entire added chemical was adsorbed to the dipped sheep at the highest dose rate (2000 mg diazinon/4000 L sump or 0.5 mg/L of dipwash), a dose rate of about 80 mg/kg wool would have been applied.

Samples of the dipwash following mixing, but before dipping, confirmed the concentration of chemical in the sump was below the limit of detection (1 mg/L). Sheep treated at the highest dose rate were sampled for wool residues by shearing a ring around the abdomen four weeks after dipping. Thoroughly mixed samples of this wool were then assayed for diazinon. Wool contamination levels are shown in Table 3.

Table 3. Residues of diazinon in the wool of sheep dipped in 0.5mg/L diazinon, four weeks after dipping.

Sheep ear tag numbers	Residues of diazinon in the wool (mg/kg)
419/421	11.0
454/455	4.9
417/418	9.8
450/451	10.0
139/140	3.2

Field trials

The reduction in lice numbers at the shearing following dipping is shown in Table 4.

Table 4. Lice infestations prior to dipping and prior to shearing.

Trial ID		**Pre-dipping lice count** Mean number of lice / head	**Pre-shearing lice count** Total lice found/ 50 sheep counted (Number infested)
CO33		88	0 (0)
CO44		95	0 (0)
CO45	Ewes*	49	22 (8, untagged)**
	Weaners*	37	0 (0)
CO53		79	0 (0)
CO54	‘Early shorn’	177	0 (0)
	‘Late shorn’	NC	NC
CO63		76	46 (5, two tagged)

* These sheep were counted on the right side only prior to dipping. The number shown is twice this count
**No lice were found on the sheep when examined at 23 weeks after treatment. Owner used rams over these ewes that were subsequently found to have lice.
NC = Not counted

Wool from mobs of sheep included in the above trials was assessed for chemical residues following shearing. Results of the analyses are shown in Table 5.

Table 5. Chemical residue analyses of wool samples.

Trial ID		Sampling method / analytical laboratory	Time from shearing to report (weeks)	Diazonon residue (mg/Kg wool)
CO33		Grab */PVI	8	14**
CO44		Grab */PVI	9	8.5
		Core – AWTA/CSIRO	6	4.6
CO45	**Ewes**	Core – wool buyer/PVI	13	5.2
		Core – owner /CSIRO	8	ND***
	Weaners	Grab */PVI	8	9.3
CO53		Core – AWTA/CSIRO	12	4.6
CO54	**Early shorn**	Grab */PVI	3	3.9
		Core – AWTA/CSIRO	26	19****
		Grab.– owner/PVI	36	10
	Late shorn	Grab */PVI	3	5.3
		Core – AWTA/CSIRO	24	Bale 1 3.4*****
		(by bale)		Bale 2 2.8
				Bale 3 2.6
				Bale 4 3.0
				Bale 5 1.1
CO63		Core – AWTA/CSIR0	5	3.0

* Approx. 500g collected as locks from wool storage bins.
** Sheep shorn 7 weeks early.
***50ppm propetamphos detected
****0.3mg/Kg chlorpyrifos detected
***** 0.8mg/Kg deltamethrin detected

Discussion

The effective kill of lice in the sheep dipped in these trials confirmed earlier observations that highly effective lice control could be effected by very low concentrations of diazinon, provided sheep were effectively wetted. The diazinon residues on the wool of treated sheep in the pen trials showed the pesticide was potently attracted to the fleece, even from very dilute emulsions, with about 10% of the diazinon added to the sump still evident in the fleeces four weeks after dipping. The decline in residue expected over the four weeks would be expected to be less than half, indicating about 20% of the chemical in the dip would have been adsorbed (stripped) from the sump during dipping. This would give a post shearing concentration of diazinon in the wool of sheep in the highest treatment group of about 3 mg/kg (assuming 5 kg wool/head). The reduction in lice numbers was therefore better than expected from the earlier LC_{95} determination (about 8 mg/kg wool).

Exposure of insects to dilute pesticides of course is a recipe for development of insecticide resistance. In each of the above trials where the sheep were not destined to be sold for slaughter, sheep were treated with a registered lousicide within six weeks of shearing. Re-treatment following shearing is seen by the authors to be an essential component of Long Wool Diprite treatment. Sheep on three of the six farms were re-treated in short wool using the immersion cage dip. Few sheep balked or were more difficult to load into the dip at the second dipping.

The improvement in wool quality following dipping was readily apparent in all sheep in terms of reduced cotting. Rubbing was not observed with any of the dipped sheep when they were yarded subsequent to dipping, however where residual lice were detected in isolated sheep there was generally minor fleece derangement about the flanks.

Sheep on the farm at Smythesdale were exposed to nearly 70 mm rain in three weeks following dipping and some fleece rot was evident in these sheep at shearing. Nearly all dipped sheep showed some delineation in the colour of wool between that grown before and after dipping, particularly at the interface. It was impossible however to establish at shearing whether this change was due to their previous exposure to lice, to the unclean dipwash or to increased microbial activity in the wool following dipping. There was no dispute however that in all instances, both wool quality and animal welfare had been greatly enhanced by dipping.

Obviously the process of sheep dipping contains many variable elements and the accuracy of dose control is limited. One of the most difficult elements to predict is the amount of dipwash that a sheep will remove from the dip. This volume of course has a direct bearing on the amount of pesticide sheep remove from the dip (dose). No doubt dose is influenced by wool and dipwash parameters that are impossible to control. Nevertheless, the trials outlined above clearly indicated that effective lice control is possible in long wool sheep, when diazinon is applied in appropriate dose rates.

The final essential element of successful long wool dipping is appropriate dip management. Cautious management of sheep before, during and after dipping is absolutely essential. Supervision of Long Wool Diprite® dipping is envisaged as only being conducted by trained dip operators using immersion cage dips. Although the pen trial above indicated sheep could be safely dipped with useful lice control at dose rates similar to the residue target. In practice, Long Wool Diprite® dipping would however be used to suppress wool damage and animal welfare problems between the cut-off for short wool dipping (six weeks off shears) and 9 – 10 months off shears. After this period, postponing treatment until shearing and, if practical, shearing the sheep early (followed by treating the lice in short wool), would be more sensible (requiring less cost and reduced exposure of the lice to pesticide).

Conclusion

Combined use of the Richard's immersion cage dips and a controlled dose of diazinon (determined using the Diprite® principles) can be effectively used to control sheep lice in long wool sheep. A knowledge of pesticide decay in wool (provided by the Campbell:Horton model) allowed doses to be applied such that a target chemical residue for the wool was attained at subsequent shearing.

References

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