Health and Safety Executive

FIELD OPERATIONS DIVISION

SHEEP DIP SURVEY 1990

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INTRODUCTION

Over the last few years, there has been a growing interest within the farming community regarding possible health effects following the use of sheep dip. As they become aware that others are experiencing problems many farmers are voicing their complaints of ill health for the first time.

This, plus the knowledge that sheep dips are due for relicencing and review, led us to undertake a survey with the following aims:

1. To look for evidence of personal exposure and possible absorption of major constituents of sheep dip, including solvents and phenols. The increasing availability of passive monitors made this possible, whereas in the past, cumbersome pumped equipment was impractical for such an operation.

2. To validate the measurement of urinary metabolites of specific organophosphates (OPs) with a view to its future use in the routine detection and monitoring of OP absorption. The advantages of this technique would be that it is more direct and more sensitive than the traditional cholinesterase estimation. It is also non-invasive.

3. To take advantage of the availability of cholinesterase inhibition detection badges. These provide a quick field technique for detecting personal OP contamination, especially during post dip handling of flocks.

4. To address the need for correct and consistent guidance on protective clothing suitable for sheep dipping. Investigation of recent incidents had indicated that even the manufacturers were issuing free equipment of the incorrect standard.

5. To use some of the blood samples collected for other purposes for phenotype research regarding individual differences in rates of esterase activity.

Organophosphates, being the active ingredient, have traditionally been blamed for the symptoms reported following dipping. OPs, however are rarely formulated as pure compounds, but as a mixture with carriers, emulsifiers, etc. It is possible that non-specific symptoms such as headaches, reported after using these products may indeed be due to factors other than the OP.

The symptoms described tend to fall into three main categories - those which could be consistent with exposure to solvents, phenols or OPs. They are usually acute, experienced on the day or evening of dipping and lasting, at most, only a couple of days. There also have been anecdotal reports of delayed and long-term symptoms.

Non-specific symptoms such as fatigue and headache are similar to those which could be experienced following a long, hard day's work, or due to a viral or zoonotic infection.

Identifying the source of these symptoms is further bedevilled by the fact that the various chemicals present in the dips can often produce similar symptoms. Examples of these are shown in the following table:

headache	fatigue	blurred vision
pyrethroids	pyrethroids	phenols
solvents	solvents	OPs
phenols	epichlorohydrin	
glycol ethers	thiram	
OPs	OPs	

dizziness	nausea	salivation	sore throat/ cough
pyrethroids	pyrethroids	pyrethroids	solvents
solvents	solvents	phenols	phenols
phenols	glycol ethers	OPs	epichloro-hydrin
glycol ethers	OPs		

One of the most intriguing aspects of the problem is the fact that some farmers are affected and some are not. The answer to this phenomenon is not simple and often the person with ostensibly the greatest exposure is the least affected. Although working practices, protection worn and dipping sites do vary, these differences do not fully explain the mystery.

Individual variation in response to exposure may be due to genetic factors which determine enzyme systems available to detoxify, or even enhance effects of OPs and solvents.

Because of the cumulative effect of OPs, contamination from post dip handling and use of other cholinesterase inhibiting substances on the farm and in the home, may be contributory factors.

A dose-effect relationship, especially at lower levels of exposure to OPs, has always been notoriously difficult to quantify. This is because clinical cholinergic effects in OP poisoning are due to the inhibiting action of the OP on nervous tissue cholinesterase.

As we are unable to measure nervous tissue cholinesterase we must measure blood cholinesterase which appears to reflect those present in the nervous system. This indirect method is the only one recognized to estimate the biological effects of exposure to OPs. Even in cases where classical cholinergic symptoms have been exhibited, it has been reported that blood cholinesterase has shown no significant change.[1] This method is therefore of questionable value in confirming and quantifying OP absorption after the use of sheep dip, especially as the toxicity of the OPs used and the extent of exposure are of a lower magnitude than in other areas of usage.

BACKGROUND

Sheep Scab

In the UK, sheep have traditionally been dipped to control a number of ectoparasites, principally lice, keds, scab mites and blowflies.

Sheep scab infection is a Notifiable Disease under the Sheep Scab Order 1986, and causes severe distress to infected animals. The scab mite, *Psoroptes*, can infect a variety of animals. *Psoroptes ovis* is specific to sheep. Adult mites lay eggs on the skin of the animal which hatch and mature to adults within 14 days. The mite feeds by scraping the skin, causing an intense reaction. The exuded serum dries to form scabs. The mites feed on the fresh skin at the edge of the scab and spread outward from the initial site of infection. If left untreated the entire body will be covered in scabs within 3 months.

Chemical Control

The scab mite was eradicated in the UK by 1952 through a programme of controlled dipping, primarily using organochlorine based products such as dieldrin and HCH (BHC). The mite reappeared in 1973 with the result that a variety of compulsory sheep dipping programmes have been instituted.

Organochlorine products were withdrawn from use in 1984 due to concern over residue levels in the meat and the development of alternative compounds capable of controlling the scab mite; namely, the organophosphorus compounds diazinon and propetamphos. More recently a synthetic pyrethroid, flumethrin has become available for use.
Sheep are also treated to control other ectoparasites, such as blowfly, which is active during the summer. Such treatment can expose operators to the OP compounds already mentioned or to other more potent OPs such as chlorfenvinphos and chlorpyrifos. Flumethrin does not control blowflies.

All dip formulations used to control sheep scab must be approved by the Veterinary Medicines Directorate (VMD) of the Ministry of Agriculture Fisheries and Food (MAFF). They are classified as medicines under the Medicine Act 1968, not as pesticides, and are not subject to statutory control under the Food and Environment Protection Act.

Control Application Methods

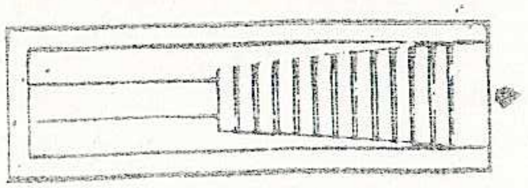
For the purposes of sheep scab control the only approved method is to plunge dip all sheep in a dip bath. Other delivery systems may be used to control the other ectoparasites. These systems include spraying, jetting and showering, which may result in greater operator contamination.

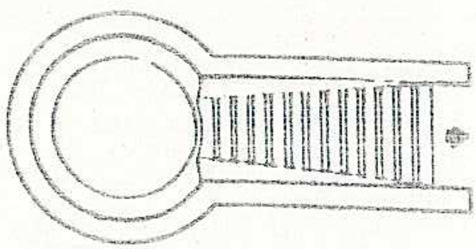
The dip bath can either be a short swim, tub or swim-around type. The sheep may be introduced to the dip either manually or by slip way entry.

DIPPING BATHS

Short swim bath

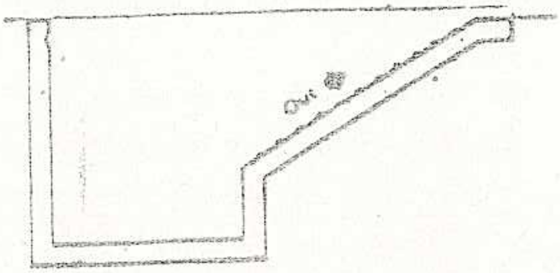
Tub bath

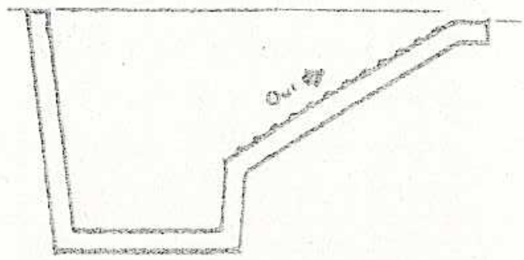




Plan

Plan





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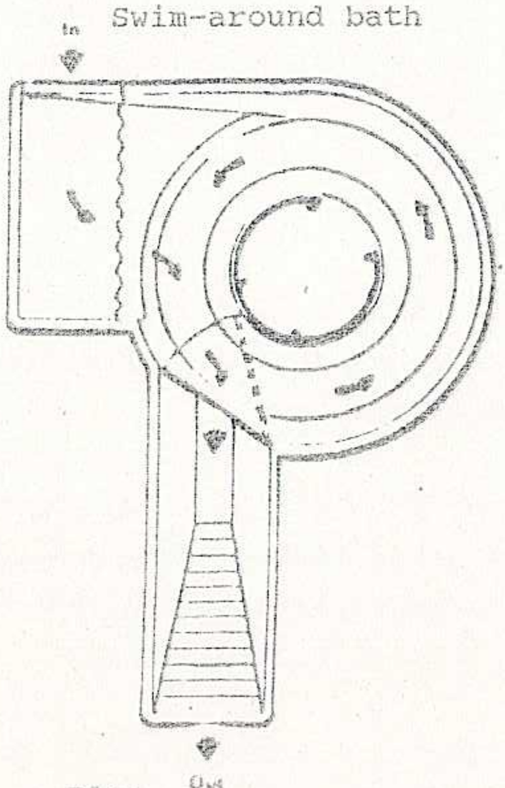
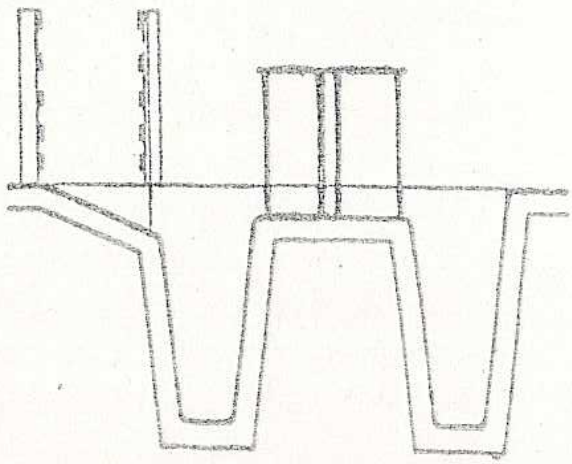
Swim-around bath





Plan

Section

For scab control the sheep must be fully immersed in the dip bath for a minimum period of one minute, with the head and ears being submerged at least once. This requires at least two operators - one presenting and one dunking the sheep. It is necessary to exercise restraint over the sheep to retain them in the dip. This is often achieved with a pivoting gate operated by a rope which eventually gets saturated by the dip solution.

The method of introduction into the dip can vary from that of gentle persuasion to actually throwing the sheep from some distance into the dip.
A metal or wooden "dipping stick" is used to submerge the sheep's head; however, some operators prefer to simply push the head under with their booted foot. This latter method quite often results in total submersion of the operator's foot and leg.

Most of the sheep are able to climb up the ramp out of the dip into the draining pen but some of them, such as lambs with heavy fleece, near-term pregnant ewes or animals in poor condition, require manual assistance. The wet sheep stand in the draining pen and shake off the surplus dip which often showers the operator.

Dip Preparation and Renewal

The recommended procedure for preparing the dip is to fill the bath with a known quantity of water and add the proportion of dip concentrate detailed by the manufacturer.

OP is removed and ("stripped") from the bath at a rate which is not proportional to the amount of water taken from the bath in the sheep's fleece. The dip therefore is replenished by one of four systems, depending upon the manufacturer's instructions.

1. Water and concentrate are added at a constant rate by an automatic metering system (eg, Powerpack).

2. Water is added constantly to maintain the dip volume with periodic addition of concentrate after a specified number of sheep have passed through (eg, Top Clip).

3. The dip volume is allowed to drop by 10% then replenished by a mixture made up at $1^1/2$ times the original dilution rate (eg, Ectomort).

4. The pyrethroid dip is replenished at the original dilution.

Some dips require the addition of either phenolic disinfectant or other bacteriostats, such as thiram, to prevent post-dipping lameness or to allow the dip to be used on the following day.

Disposal

Once the dipping operation has been completed, the dip may be emptied immediately either by sucking it out with a vacuum tanker or by bailing it out with a bucket. The dip may then be cleaned with a disinfectant.

On other occasions, the dip is left in the bath until the next dipping period, in the belief that the long period will aid the natural breakdown of the product and decrease the environmental risk.

Protective Clothing

According to the manufacturers' recommendations, the only protection required when handling the concentrate is that of protective gloves and a faceshield. Further protection advocated by some manufacturers when dealing with dilute dip or freshly dipped animals varies, but generally involves the use of wellington boots and a waterproof bib apron.

In reality, the clothing worn varies from the minimum of jeans, T-shirt and wellington boots to full protection, including gloves, impermeable suits and airstream RPE. The boots, coats and leggings worn are usually those used for normal work-wear.

SHEEP DIP FORMULATIONS

Proprietary dip formulations contain a variety of chemicals in addition to the organophosphorus or pyrethroid active ingredient. Properties of some of these ingredients are as follows:

ORGANOPHOSPHORUS COMPOUNDS

The property of organophosphorus compounds which makes them effective as insecticides is their ability to inhibit the enzyme, cholinesterase. Although the action of OP is identical in both man and insects, selective toxicity exists due to differences in the rate of detoxification in man compared to insects. Insects break down OPs relatively slowly compared to mammals. OPs inhibit cholinesterase by forming a stable bond at an active site of the enzyme, therefore blocking its ability to function.

The enzyme, cholinesterase, is an essential component in the control of normal nerve impulse transmission, in that it breaks down the acetylcholine produced at nerve synapses. If the acetylcholine is not broken down, nerve impulses continue unchecked. It is this continuous neurotransmission which produces cholinergic effects which give rise to the signs and symptoms of OP poisoning - abdominal cramps, vomiting, excessive salivation, cold sweats, blurred vision, muscle twitching and tremors. Clinical effects do not generally appear until plasma cholinesterase activity has fallen to 30% of normal pre-exposure values.[2]

OPs are occupationally absorbed through the skin, eyes and respiratory tract. Formulation as well as concentration must be considered when evaluating the rate of absorption into the body. Repeated absorption of small doses have a cumulative effect and can result in progressive inhibition of nervous system cholinesterase.

This occurs when repeated exposures occur within the cholinesterase recovery period and may be the result of handling contaminated clothing, dipped sheep, etc.

In addition to the acute effects, Organophosphorus Induced Delayed Polyneuropathy (OPIDP) has been recognized since the 1930s.

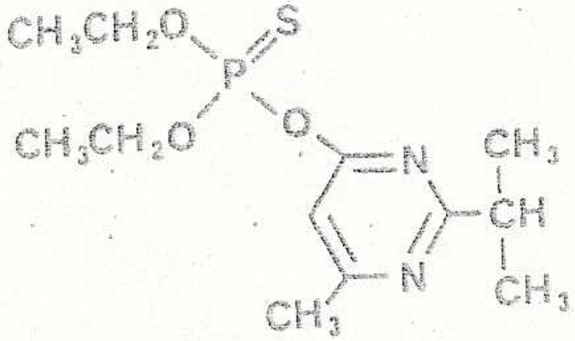
It is only recently that interest has been rekindled in this phenomenon. The signs and symptoms associated with this syndrome, which appears 1-5 weeks after acute exposure to an OP compound, are those of a distal peripheral neuropathy. Reported symptoms include leg cramps, numbness and paraesthesiae, followed by progressive leg weakness. The upper limbs may be similarly affected.

For OPIDP to occur, an enzyme, NTE (Neuropathy Target Esterase or Neurotoxic Esterase) present in nervous tissue, lymphocytes and other tissues must be inhibited by the OP. This inhibition can result in the formation of a stable non-reactive form of the enzyme. All reported cases have been due to ingestion of large quantities of concentrated chemical.

Diazinon

Chemical Name:O,O-diethyl O-2-isopropyl-6-methylpyrimidin -4-yl phosphorothioate

Structure:



In its pure form, this compound is a colourless liquid with a low vapour pressure (1.4×10^{-4} mmHg at 20°C) and relatively low toxicity. An Occupational Exposure Standard (OES) of 0.1 mg/m^3 (8 hr TWA) applies.

Diazinon is a relatively unstable product. It is broken down in the presence of UV light to form dioxodiazinon, hydroxydiazinon and other biologically active products. In the presence of water it is hydrolysed and will produce traces of monothio-TEPP, a more active cholinesterase inhibitor. Storage of diazinon over a long period also allows it to oxidize to dioxodiazinon.

In addition to its use in sheep dip, diazinon is present in various pesticides and veterinary medicines.

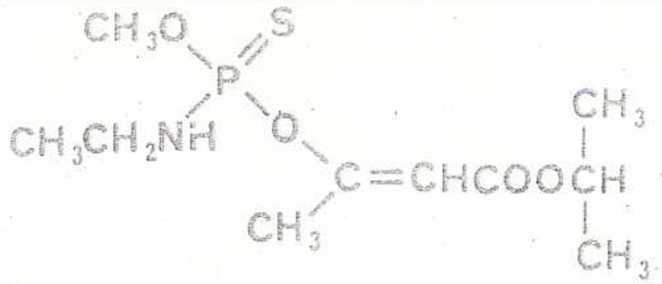
Metabolism in man

Diazinon is probably metabolised by the cytochrome P450 system. Metabolism occurs initially to diethylthiophosphate (DETP) then to diethylphosphate (DEP). Both these products can be detected in urine and provide a tool for biological monitoring.

Propetamphos

Chemical Name: Isopropyl 3-[ethylamino(methoxy)phosphinothioyloxy] isocrotonate

Structure:



Propetamphos is a colourless oil with a low vapour pressure (27.7 x 10^{-4}mmHg at 20°C) and relatively low toxicity. This compound is stable to UV light, during storage and relatively stable in solution.

Metabolism

Development studies have shown that propetamphos is metabolized by oxidation and that the major excretion product is probably exhaled CO_2. It is unlikely, therefore, that a stable metabolite is available in the urine for the purposes of biological monitoring.

PYRETHROIDS

Pyrethroids are synthetic pyrethrins which are less toxic than the natural pyrethrins. They have a very low vapour pressure.

Flumethrin, the only non-OP approved active ingredient for scab control, is a pyrethroid.

Although it is stated that there is no significant absorption through the skin, one study has shown that dermal absorption due to skin contamination whilst spraying can lead to acute intoxication.[3] Pyrethroids are absorbed and distributed throughout the body and are rapidly metabolized and detoxified by esterase action. OPs can inhibit their degradation and as a result increase their toxicity producing CNS stimulation.

Pyrethroids produce both local and systemic effects. The most common are those of facial sensations such as numbness, itching, burning, tingling and warmth, due to an excitation of sensory nerve endings. Systemic effects are headache, fatigue, dizziness, nausea and salivation.

INDUSTRIAL SOLVENTS

All the dips used in the survey contained either Shellsol R, Solvesso 150, Solvesso 200, or medium oil. These primarily comprise a mixture of aliphatic hydrocarbons in the C11-C13 range. The disinfectant of both Deosan and Diazadip contains 8.5% of kerosene in addition to the other solvents. Kerosene contains C9-C16 hydrocarbons plus small fractions of aromatic compounds (xylenes) and of saturated rings (naphthalenes).

These solvents are sold as performance products based upon their physical properties so have no precise chemical analysis; for instance, Shellsol R comprises C11-C13 in the boiling range of 205°-270°C with a flash point of 80°C.

Small amounts of contaminants may be present. Because of their high volatility compounds C9 and below will form no more than 0.2 - 1% of the mixture.

The lipophilic character of these chemicals allows them to be readily absorbed through the skin. Metabolism appears to be carried out by cytochrome P450.

The cytochrome P450 system appears to be the major metabolizer of not only aliphatic hydrocarbons, but also other constituents of the dips, such as phenols and OPs and is responsible for the metabolism of certain drugs such as paracetamol. It would seem, therefore, that this system in particular is being bombarded by the chemicals present in these mixtures, together with common drugs which may be used for headaches (following exposure to the dips!)

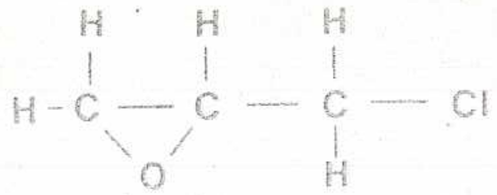
GLYCOL ETHERS

At least 3 of the dips used in the survey (Coopers Powerpack Winter Dip, Ciba Geigy Top Clip, Bayer Diazadip) contain a glycol ether.

These are not highly volatile compounds, but are very readily absorbed through the skin and classified as harmful or irritant. Exposure produces non-specific effects such as headache, giddiness, loss of coordination and nausea.

EPICHLORHYDRIN

Structure:



Two of the dips used in this survey (Diazadip and Deosan) contain this solvent.

It is highly volatile with a vapour pressure of 13 mm Hg at 20 C, and has an OES of 2 ppm (8 hr TWA) which is under review.

This compound is readily absorbed through intact skin and by inhalation; it also penetrates rubber and leather.

It is highly toxic, causing possible long term health effects and is an animal carcinogen. In addition, it is corrosive, strongly irritant and a skin sensitizer. Inhalation causes coughing, shortness of breath and pulmonary oedema. A vapour level of 100 ppm produces eye irritation. It is a CNS depressant.

PHENOLS/CRESOLS

All the dips used during the survey (including the non-OP dip) contained some form of these related chemicals. Although they can be derived either from petroleum or coal tar, those appearing as constituents in sheep dip are coal tar in origin.

Phenol has a vapour pressure of 0.35 mm Hg at 25°C and cresols a vapour pressure of 0.1-0.24 mm Hg at 25°C. The odour threshold for phenol is 5 ppm.

Phenols and cresols are readily absorbed through intact skin and by inhalation. Phenols are extremely toxic; both phenols and cresols have an assigned OES of 5 ppm (8 hr TWA).

Phenols are noted mainly for acute systemic effects through skin absorption following significant exposure, which can be severe. They are corrosive and highly irritant producing burns and other irritant symptoms such as gastric burning, sore throat and shortness of breath. Other reported effects are watery eyes and blurred vision, increased salivation and non-specific symptoms such as headache, drowsiness and dizziness. Cresols produce similar effects but to a lesser degree.

THIRAM (tetramethylthiuram disulphide)

Thiram is used as a bacteriostat for two dips, to which it may be added as a powder in a soluble sachet.

The ethyl form of this chemical is used as a pharmaceutical (disulfiram) to discourage the use of alcohol. Much of the available information on the effects of thiram is based upon the effects of disulfiram, although thiram is 10 times more toxic.

Disulfiram's use as an anti-alcoholic treatment is based on the fact that it blocks the metabolism of alcohol, resulting in the accumulation of acetaldehyde, which, in turn, produces unpleasant effects such as violent flushing, dyspnoea, headache, palpitations, tachycardia, nausea and vomiting.
Non-specific symptoms such as drowsiness, unpleasant taste, mild gastrointestinal disturbances and orthostatic hypotension are recognized side effects occurring at the beginning of treatment with this drug; ie, effects of the disulfiram without alcohol.

Thiram is a severe irritant to mucous membranes, a mild skin irritant and a potent skin sensitizer.
Its toxicity is increased in the presence of fat solvents, which promote absorption.
A warning is given with Thiram, that if alcohol is ingested within 72 hours of absorption, severe nausea and vomiting may occur.
Disulfiram, however, is eliminated from the body at a very slow rate and it may be detected in body fluids up to 7 days.

METHOD

Recruitment

A request for volunteers for this survey was published in a newsletter distributed by a local Agricultural Cooperative. This brought only two initial replies, a surprisingly small response compared to the large number of people expressing concern over the issue. A policy of pyramid recruitment was undertaken, as a result 43 "volunteers" were obtained, representing 25 dipping sites.

The first concern was that the survey population would be biased because the majority of people coming forward would be those having had symptoms in the past. This, in fact, was not the case. Many of the volunteers cooperated because they wanted to help colleagues who had experienced problems.

A second concern was that everyone would view the HSE team in its normal enforcement role and modify work practices accordingly. There was no evidence that this occurred.

We visited all participants prior to the dip to explain the aims and practical aspects of the survey. We completed questionnaires covering normal dipping practice, sheep handling in the months prior to the survey and OP products used on the farm and in the home. We also enquired about past symptoms associated with exposure to sheep dip, relevant past and present medical histories, medication and other factors such as special diets which might influence the proposed biological monitoring.

Biological Monitoring

Blood

In 3 cases, blood samples were taken before the dipping operation for the estimation of:

(1) baseline cholinesterase

(2) other enzyme systems (esterases)

using EDTA and plain tubes respectively.
In all the other volunteers, OP exposure during the preceding 60 day period could not definitely be ruled out. This was due to the use of OPs (either pesticides or veterinary medicines) and regular handling of sheep dipped during the summer months, mainly to protect against blowfly strike. In these cases retrospective baseline samples were taken in January/February 1991.

Post exposure blood samples were taken at the end of dipping for the estimation of (1) cholinesterase, (2) other esterases and (3) solvents.

Urine

Urine samples were collected for the estimation of OP metabolites (dialkylphosphates) and phenols.

1. pre and post dip - each day of dipping

2. post dip handling of sheep

3. when retrospective baseline blood samples were collected

Environmental Monitoring

Atmospheric

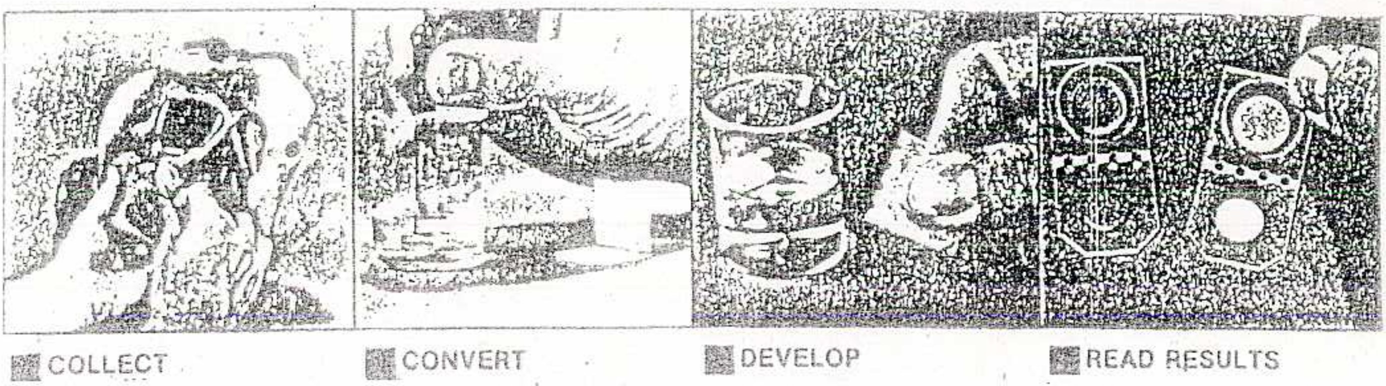
Tenax passive samplers were worn by each operator, clipped to the lapel next to the breathing zone. A fresh monitor was worn each day of the dip. These were analysed for volatile products - solvents and phenols.

The atmospheric presence of OPs was not monitored as previous studies had reported none present.

Surface Contamination

Cholinesterase inhibition detection badges were used as a simple field method to detect the presence of OPs on skin, inside protective clothing and on fleece. They were also used during handling of sheep in the months following dipping when the following procedures were carried out - drenching (oral administration of veterinary medicine), vaccinating, docking (shearing around the tail area), scanning, shearing and lambing.

In some cases, the badge tests were paralleled by quantitative laboratory analysis of either gauze patches or the garment itself.



Enzytec Pesticide Detector Kits provide a simple field method for the detection of cholinesterase inhibitors at low levels (typically 1-5 ppm). The kit includes detector badges which have two discs attached, one sealed under a foil cover (substrate disc) and one exposed (enzyme disc).

The enzyme disc is rubbed on the surface to be tested, then developed in reagent solution for three minutes. The disc was then removed from the reagent, the substrate disc uncovered and the badge folded to bring the enzyme and substrate discs into contact with each other for five minutes. At the end of this period the enzyme disc was examined for colour.

(i) white - positive (cholinesterase inhibitor present)

(ii) blue - negative

Dip Samples

Bulk samples were taken at some sites before and after the dip. This was to assess whether or not the replenishment system resulted in a higher concentration of dip chemical at the end of the period, thus creating a greater hazard to the operator.

Laboratory techniques for analysis of biological and environmental samples are listed in Appendix 1.

Observation

We initially intended to utilize a large team to carry out this survey. This proved impractical because of factors such as geographical distribution of sites and the need for close liaison and flexibility to adapt to last minute changes of dipping times and dates. Ultimately a team of two people visited all but two of the sites (either together or independently) for the purposes of personal observation of the site, weather conditions, dipping practices, and significant incidents.

Follow Up

In January/February 1991 we collected retrospective baseline blood samples and asked participants about any symptoms occurring either during the dipping or later.

RESULTS

Cholinesterase

OP exposure is measured by the inhibition of plasma and red blood cell (rbc) cholinesterase. Diazinon and propetamphos mainly affect plasma cholinesterase, propetamphos being the more active. Inhibition is determined in the individual by comparing cholinesterase levels before and after OP exposure. Pre-exposure levels, however, can only be determined if there has been no contact with OP products in the preceding 60 days.

Blood cholinesterase estimations were carried out in 39 of the 43 volunteers. All the results fell within the predicted range for a normal population; ie, plasma cholinesterase was greater than 162 daU/L and red blood cell cholinesterase greater than 97 hU/L for all subjects.

Determining individual baselines for all but a few of the subjects presented difficulties. Residual OP persists in the fleece for some time after dipping and acts as a potential source of re-exposure during the normal handling of sheep; also, the farmer's intermittent use of other compounds containing OPs calls into question how often one actually achieves a true baseline measurement.

Cholinesterase levels vary in individuals. This intra-individual variation, together with the degree of precision achieved in our laboratory, allow an individual's plasma cholinesterase to vary up to 15%, and 10% in the case of red blood cell cholinesterase, before the change can be considered significant.[4] In a population of 30-40 it is to be expected that one or two subjects will appear at the extremes of these ranges.

Plasma Cholinesterase

Pre and post dip exposure estimations were carried out on 37 subjects 30 of whom demonstrated decreased plasma levels.

These were insignificant except for one subject who showed a depression of 17%. He experienced no symptoms of ill health following this dip.

Red blood cell cholinesterase

In 30 subjects, red blood cell cholinesterase levels were higher in the post exposure samples than in the "pre-dip" or retrospective baseline samples. Two of these were at significant levels, ie, 12% and 13%, but in the reverse direction. There is no obvious explanation for this apparent trend; however, it is recognized that when red blood cell cholinesterase levels are depressed, a rebound phenomenon is triggered during recovery, whereby the red blood cell cholinesterase often overshoots its normal level. It is also true that red blood cell cholinesterase takes longer to recover than plasma cholinesterase.
These higher post dip samples therefore, may reflect a rebound recovery from an exposure during the summer. This would not be apparent in the baseline measurement as 34 of the 37 determinations were made retrospectively in Jan/Feb.

There were no reports from any of the participants in the survey of OP linked symptoms. This would be expected from these cholinesterase results. Although low plasma and red blood cell cholinesterase activity are consistent with OP exposure, normal levels do not prove a lack of exposure.

Cholinesterase estimations and percentage changes for the survey population are shown in Table 1.

TABLE 1

	CHOLINESTERASE							CHOLINESTERASE					
	PLASMA			RBC				PLASMA			RBC		
	PRE	POST	%	PRE	POST	%		PRE	POST	%	PRE	POST	%
CODE	daU/L			hU/L			CODE	daU/L			hU/L		
B1	250	247	97	155	164	106	B2	290	288	99	154	166	107
C	447	427	95	148	156	105	D	314	328	104	150	159	106
E	272	236	86	154	162	105	F	349	364	104	175	176	100
G1	271	283	103	176	169	96	G2	295	283	96	157	162	103
G3	354	302	85	177	161	90	H1	316	313	99	183	184	100
H2	174	161	92	180	208	113	H3	286	266	93	162	169	104
X1	301	297	98	159	174	109	X2	234	228	97	178	180	101
J1	263	269	102	160	157	98	J2	296	274	92	158	159	100
K	292	301	103	170	179	105	L1	273	251	92	172	190	110
L3	312	295	95	163	179	109	L4	251	230	92	171	189	110
M1	270	262	97	165	172	104	M2	272	262	96	170	166	97
N1	284	236	83	144	161	110	N2	308	299	97	154	157	101
O1	281	249	88	196	201	102	O2	255	238	93	151	160	106
P2	251	231	92	166	157	105	P3	338	369	91	188	194	105
Q1	273	273	100	156	163	104	Q2	290	284	97	165	167	101
R1	357	350	98	167	171	107	R2	287	252	87	177	186	105
S2	301	284	94	164	183	112	T	315	294	93	176	184	104
U	227	213	94	152	159	104	V	321	317	99	155	159	102
W1	268	279	104	158	168	106							

% - POST DIP READING AS A PERCENTAGE OF BASELINE

Changes in cholinesterase

	Plasma Decrease	Plasma Increase	Rbc Decrease	Rbc Increase
Total Number	30	6	4	30
Significant	1	-	-	2

Significant change Plasma > 15%

Significant change Rbc > 10%

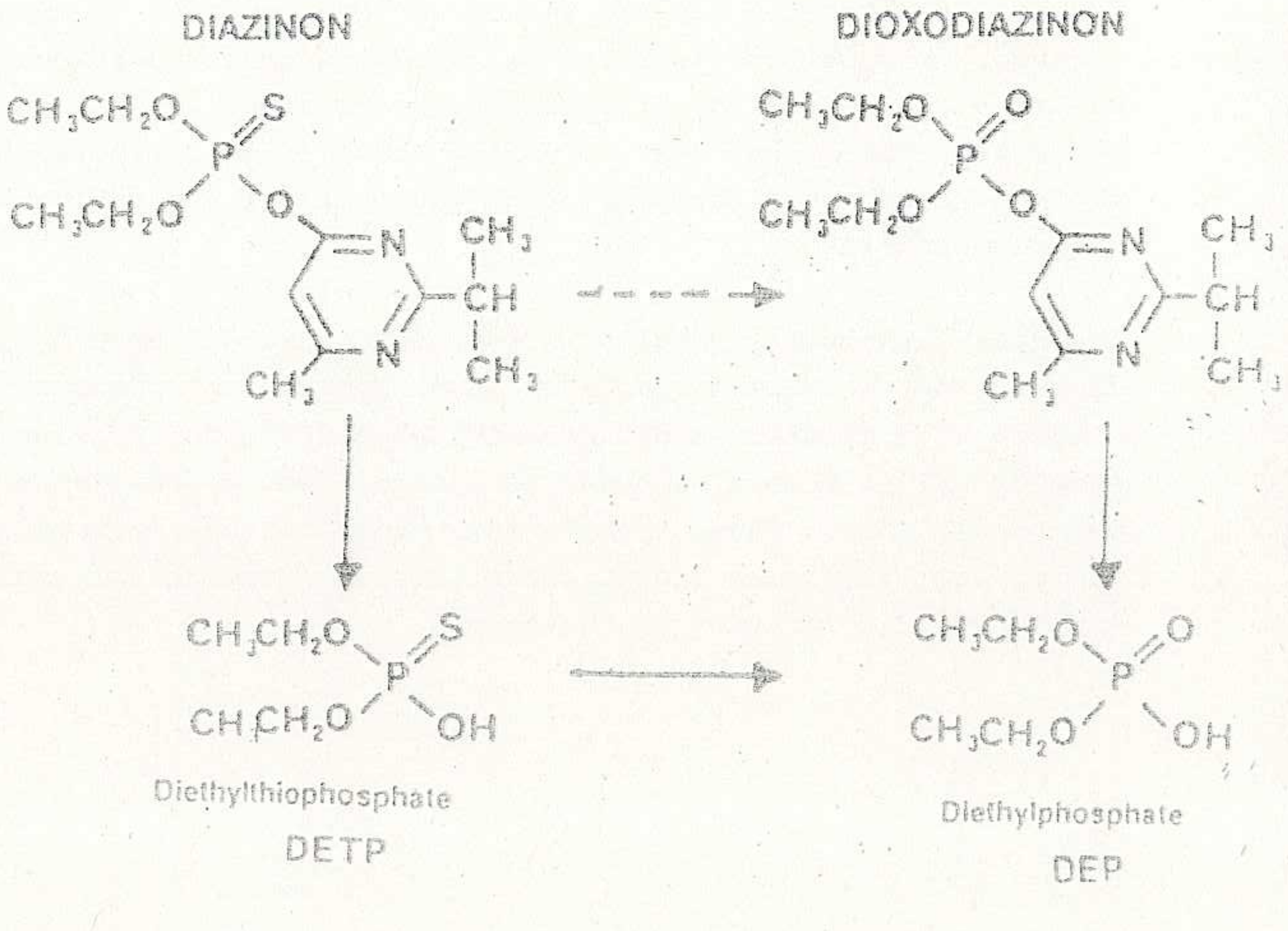
Urinary Dialkylphosphates

Part of the survey was designed to validate the use of urinary dialkyl phosphates for monitoring OP absorption. The survey was well advanced before it became apparent that there was no known measurable metabolite of propetamphos. As 40% of the dips used in the survey contained propetamphos as the active ingredient, this resulted in a significant reduction in the number of dialkyl-phosphate analyses.

As an alternative, the laboratory attempted to measure free propetamphos in the urine. This analysis poses several difficulties:

1. Propetamphos is broken down readily by factors such as a high urinary pH.
2. A relatively high absorption of propetamphos is probably necessary before it can be detected in the urine.
3. The potential for specimen contamination cannot be ignored.

METABOLISM OF DIAZINON



The levels of DETP and DEP detected in the survey were 10 times lower than those reported in American studies, when no symptoms occurred.

The exact excretion times of dialkylphosphates are unknown. Where dipping occurred over several days, sometimes with short gaps in between, it was possible to collect serial pre and post urines for analysis. We were limited by having to rely on random samples taken at the end of the dipping day. In cases where serial samples were collected, some of them represented 24 hour specimens (first morning voids on day following exposure) and some represented 48 hour specimens. Although impractical under field conditions, the ideal situation would have been to analyse 24 hour, and even better, 48 hour total collections.

In a study carried out on orchard workers exposed to azinphos-methyl, it was shown that 13 out of 17 workers excreted 40% or less of their total metabolites in the morning void (totals varying from 5-80%).[5] This indicated the unreliability of partial or random sampling and demonstrated only a weak correlation between the exposure and the 24 hour urinary output. A much stronger correlation was found for the 48 hour output, possibly due to a reduced effect of individual variation. It has been suggested, therefore, that a 48 hour total urine collection is a minimum requirement for estimating total dermal absorption of organophosphates.

The dialkylphosphate results in some cases did not accord with the observation of dipping practice. Some people who appeared to be exposed to a greater extent recorded no DETP in their urine samples whilst others, exposed to a much lower degree demonstrated detectable DETP. These results may be due to the limitations of random sampling or an insufficient interval between the end of exposure and collection of the sample.

Diazinon was used by 24 participants. No DETP was detected in the urine of 8 subjects whose samples were collected not more than 8 hours after the first exposure. This may be due either to the sampling method or may represent slow metabolisers of OPs. In one subject in this group the plasma cholinesterase level fell 15% following the dip, but resulted in no symptoms. Eight of the remaining 16 diazinon users either dipped over several days, had cleaned the dip on the day before dipping, or were contract dippers with serial exposure. Precise information regarding the time intervals between exposure and sample collection is not available on the remaining 8 subjects in this group.

In 4 cases DETP levels were relatively high compared to the remainder of the group, although still at a level considered insignificant.
Two of these were related (father and son). The father dipped, but was well protected, whilst the son gathered and assisted in introducing the sheep into the dip.
A third was a contractor who had close contact with wet sheep to move them down the ramp from the elevated draining pen. Although he wore gloves for dipping the palm of one was torn.

DEP was detected in samples from only three subjects.
Two were a husband and wife who used a dip formulation not used by any other person in the survey (Diazadip). In both these subjects the level of DEP detected was higher than the DETP; the husband had however discarded summer dip from the bath some days before the dipping.
The third subject had also cleaned the dip several days before dipping, but used old dip concentrate to make up the dip. It is possible therefore that during storage some diazinon had oxidized to another derivative, dioxodiazinon, which is capable of being metabolized directly to DEP.
Information on the age of the dip concentrates used by other participants in this survey is not available at present but warrants further investigation.
The factors determining the rate of metabolism of DETP to DET are unknown and could be time or dose dependent, or indeed dependent upon specific esterase activity.

Urinary Propetamphos

The urines of 19 users of propetamphos were analysed for free propetamphos. It was detected in 2 of these.

One of the cases where it was not detected, a borderline fall of plasma cholinesterase (17%) occurred although he reported no symptoms.

Blood Solvents/Urinary Phenols

No blood solvents were detected in any of the subjects.

All urinary phenols were within normal limits taking into account endogenous sources and dietary influences.

Tenax

In practical terms the use of Tenax passive sampling tubes is ideal as they require no technical expertise and do not interfere with normal working practices. Their use in this survey to determine the presence of atmospheric solvents and phenols does however lead to some reservations. The results contained the following unexplained discrepancies.

1. Subject B1 was a contractor operating a mobile dip based on an articulated lorry. It had solid sides reaching a height of 1.5 m, resulting in a very enclosed work site. In this situation we would have expected to detect significant levels of solvent; in fact, only very low levels were found (0.3 ppm aromatic and 0.7 ppm aliphatic).

High solvent readings were anticipated on the basis that the operator complained of classical symptoms of solvent exposure, both during this dipping period and on previous occasions. These included headaches, alcohol intolerance and complaints of feeling constantly "high" throughout the dipping season. Skin absorption was also considered as a possible significant route, especially as biological monitoring showed that this man had absorbed propetamphos from the dip, probably via the skin.

A further factor which makes this particular case puzzling is the fact that in spite of the clinical history, no solvents were found in the blood. This estimation however, also required the use of tenax tubes.

The possibility that this person is demonstrating an idiosyncratic reaction to the substances to which he is exposed on a daily basis cannot be ruled out, nor is it possible to ignore the role of esterases in breaking down solvents and their potential to be inhibited by OPs.

2. Subjects H1;H3; These operators were working in an atmosphere in which the odour of phenols was strong and extremely irritant, also experienced by the survey team. Analysis of the sampler revealed no phenolic compounds to be present.

3. Subjects X1;X2; The samplers detected no phenols at this site which was very sheltered and smelt strongly of phenol. The atmosphere was so irritant that both the dip operator and the observer were coughing during the latter part of the day.

The results for H1;H2;X1 and X2 contrast sharply with another dipping operation conducted at a much more open, windy site, using an identical chemical where 4 ppm cresylic acid were detected.

4. Subjects N1;N2; This dipping operation was conducted inside a shed. No contamination was detected by the samplers. Although there was no noticeable odour around the dip the observers independently reported feelings of unnatural tiredness and throat irritation.
The farmers themselves did not complain of symptoms on this occasion, although they had been affected during the summer dip.

5. Subjects P1;P2; These 2 operators spent the majority of their time gathering sheep, and spent minimal time near the well exposed dip site. The tenax analysis, nevertheless, showed the presence of:

(i) aromatics which were known dip constituents

(ii) ketones, which, according to the manufacturers, are not dip constituents. Ketones are present in agricultural pesticide formulations. On this particular farm the dip was stored with pesticides. It is possible that the ketones collected by the sampler were present in the atmosphere of the store.

6. Subject P3; This man performed the actual dipping on the site where P1 and P2 were working. His tenax analysis showed the presence of glycol ethers. Although a glycol ether is present in this dip formulation, the 3 named in the analysis are not.

We have discussed the analytical and sampling techniques with both the laboratory scientists carrying out the analyses and the manufacturers of the equipment used (Perkin Elmer). There are, to date, unresolved differences of opinion with regard to the adsorbent material and gas chromatography columns used. If agreement is not reached before, a collection of duplicate samples at the proposed summer dip could allow comparison of the different techniques advocated. This may also resolve some of the apparent inconsistencies between clinical history, observations and laboratory results.

In retrospect, due to the dilutional factors created by monitoring in the open air, it may have been advantageous to use pumped equipment, particularly as we were looking for high molecular weight materials over a relatively short period of time.

Low levels of atmospheric contamination can only be analysed semi-quantitatively using thermal desorption techniques. This is because the errors may be as much as 50%.

TENAX RESULTS

CODE NO	SOLVENT PHENOL CODE	SOLVENT PHENOL PPM	SUBSTANCES DETECTED
B1	D1	0.3	Aromatic hydrocarbons
		0.7	Aliphatic hydrocarbons
X2	D2	0.1	Toluene
L4	D3	0.1	Xylene
L1	D4	0.1	Xylene
R1	D5	0.4	Isopropanol
P3	D6	0.1	Hydrocarbon
P3	D7	1.0	Glycol ethers
		0.04	Toluene
		4.0	Cresylic Acid
P2	D8	1.0	Toluene
		0.1	Methylethylketone
		0.1	Methylisobutylketone
P1	D9	0.3	Toluene
S2	D10	0.05	)
		0.2	) Low C hydrocarbon
T	D11	0.1	Xylene & toluene
		0.1	Aliphatic hydrocarbons
U	D12	4.0	Cresylic acid
Q2	D13	0.2	Toluene & xylene
Q2	D14	1.5	Toluene
Q1	D15	0.2	Toluene & xylene
Q1	D16	0.2	Toluene

Blood Esterases

Research assays carried out subsidiary to the survey investigated whether the biological monitoring results, or symptoms reported, were related to the activity of other enzymes in the blood. The activity of two enzymes which metabolise the OPs paraoxon and chlorpyrifos were measured. These OPs are believed to have a pattern of metabolism similar to diazinon and propetamphos. Individuals were then categorised into slow, medium or fast metabolisers of paraoxon.

It is known from previous studies that approximately 50% of the population are slow metabolisers of paraoxon. Results in the survey accord with these findings. Although some subjects fell into this category there was no correlation with the measurement of cholinesterase and urinary dialkylphosphates, nor symptoms. It is only, however, at doses resulting in cholinesterase inhibition or cholinergic symptoms, that such a relationship would be demonstrable. The doses encountered in the survey were much lower than these levels.

Dip Samples

The dips were made up following the manufacturers' recommendations. Samples of dip taken before dipping started showed wide variation. One possible reason for this was inadequate mixing of the dip before the sample was taken. If the sample had been collected after the passage of one or two sheep, a more representative sample may have been achieved.

Samples taken at the end of the dipping day were expected to vary but to be above a minimum concentration. The replenishment rate of the dip is set to maintain the active ingredient at a level which ensures sufficient residual activity in the fleece. Again, concentrations varied and fell below the minimum.

Although the method of sampling was consistent throughout the survey no attempt was made to sample in accordance with MAFF procedures.

The results are summarised in the following table:

PRODUCT	Target Conc ppm	Actual Conc (Range) ppm	Target Minimum Conc ppm	Actual Minimum Conc (Range) ppm
Top Clip Gold Shield	400	116-264	100	113-286
Bayer Diazadip	400	241	100	168
Coopers Powerpack Winter	250	166	100	104
Youngs Ectomort Dip	320	74-148	125	44-62
Youngs Jason Winter Dip	280	111-169	125	20-42
Youngs Summer Dip	320	149	125	61

RECOMMENDATIONS

1. The design of some dips, particularly the older swim through type, could be modified to ensure that the forcing pen is separated from the dip. We noted several instances where the dipper almost fell into the dip as a result of sheep escaping from the pen and trying to run past the dip.

2. Several operators experienced difficulty in reading the instructions on the tin as a consequence of both print size and spillage or rust on the outside of the tin. It would be beneficial if, in addition to the instructions printed on the tin, a separate water resistant card containing identical information was supplied by the manufacturer. This also would reduce the need to handle contaminated tins.

3. Some manufacturers also supply protective clothing "free" with their dip pack (gloves and/or apron). In our experience the gloves supplied do not provide the required protection. If with all the resources available to them, a major chemical company proves unable to select appropriate protective equipment, what hope is there for an end-user? Manufacturers must make clear, specific recommendations for protective clothing; the use of bland, standard phrases such as "use protective gloves" is totally inadequate.

4. Some manufacturers provide measuring jugs with the dip concentrate, it would be helpful if all manufacturers adopted this policy.

5. Design of the 5 litre and 25 litre containers should be improved to reduce the "glug" factor which causes splashing.

6. The introduction by one manufacturer of a system to automatically meter the dip concentrate during replenishment has obvious benefits for the operator. The process could be taken one stage further to enable the dip to be made up without the need to handle the concentrate.

Other manufacturers should be actively encouraged to develop similar systems.

7. Because diazinon gradually breaks down to other products during storage, it is advisable to use a fresh supply of concentrate for each dipping period. This is, however, not a practical option, as the dip is expensive and rarely packaged in volumes matching the requirements for smaller flocks.

8. To ensure even distribution of the dip concentrate throughout the dip bath, the water-concentrate mixture is invariably stirred with the dipping stick before dipping starts. Because most dipping sticks have wooden handles, dip is absorbed along virtually the entire length of the handle and represents an immediate source of contamination for the dipper. If the stick is used in this way it should be rinsed off before further use. A better solution would be to utilize a metal handled dipping stick which will not absorb dip and can be more easily decontaminated.

9. Splashing to the lower body could be reduced for all dip types by the installation of a solid barrier between the dipper and the dip bath, which could take the form of a sheeted hurdle. Other advantages would be that the dipper would be less likely to overbalance and fall into the dip and it would prevent the booted foot being used in lieu of a dipping stick. The barrier should not be permanently fixed but hinged at one end to allow it to be released and moved quickly aside should emergency aid be required by an animal in the dip.

10. Dips are generally filled and replenished from a natural farm supply; however, when supply is limited, river water may be used. River or stream water carries the risk of leptospirosis particularly if used to wash out eye splashes or open wounds and therefore should not be used for this purpose.

11. Most operators claimed to have a supply of running water at the dip. In many cases this was a hosepipe, either connected directly to an automatic delivery system or submerged in the dip. We recommend that an independent supply be brought to the dip to ensure that clean water is always available. Uncovered water tanks near the dip are not suitable reservoirs for washing water as they become rapidly contaminated.

12 The results from our cholinesterase inhibition detection badges demonstrated that OP contamination of the skin was effectively removed by washing with soap and water. This reinforces the importance of rinsing off skin contamination when it occurs during dipping and during post-dip handling operations.

13. On pre-dip interview, several farmers volunteered information regarding occasions when they had received eye splashes whilst dipping (as opposed to measuring the concentrate). During the actual survey we witnessed several eye splashes causing extreme pain and irritation. Despite this, most operators simply wiped their eye with their sleeve and carried on, even if water was available.

14. The presence of highly irritant substances such as phenols and epichlorhydrin in the dips and the propensity for eye absorption of other constituents, such as OPs, require appropriate facilities for eye washing to be available. Farmers should be advised regarding both the importance and correct use of this facility.

15. A major frustration and source of contamination for the mobile dip operator is the reluctance of the sheep to leave the vehicle after dipping due to the steepness of the exit ramp. These ramps could either be lengthened to provide a more gradual descent or additional battens added to provide better grip for the sheep.

16. The design of mobile dipping systems results in operators working in relatively enclosed spaces, the sides of these vehicles being constructed of sheet metal. To prevent the build-up of vapour, additional ventilation should be provided. This could be achieved by either replacing some of this solid sheeting with weldmesh or by installing suitable exhaust ventilation. Wherever possible the vehicle should be parked on an open exposed site. Adequate ventilation is particularly important in the case of mobile dippers as they drive their vehicles back to base after a long day's dipping, sometimes long distances.

17. The comments concerning ventilation are equally valid for anyone dipping inside a shed. The scope for installing a fixed ventilation system is much greater here than in the mobile situation. Because of the large area involved a dilution system, rather than a captive system would seem preferable.

18. New dipping facilities should be constructed, as far as possible on open sites which allow the prevailing wind to disperse vapours away from the operators.

19. Disposal of spent dip and cleaning the dipping bath are significant sources of exposure. In solution, diazinon degrades into other products. It is probably better, therefore, to dispose of the dip from the bath on completion of the dipping operation. Retention until the next dipping period would increase operator exposure to any breakdown products present.

Personal Protection

I The use of cholinesterase inhibition badges showed that normal splashing readily penetrates single layers of clothing - (shirt, trousers) whilst two layers appear to resist penetration. These results were confirmed by gauze patch estimations.

Badge tests were negative on skin protected by wellington boots.

These tests were also negative on the inside surface of leggings.

Tests on an apron 12 weeks after dipping gave a positive reading. The apron had, however, been used when lambing in the intervening period.

When dipping, the following items of protective clothing may be appropriate:

1. Wellington Boots

2. Personal Clothing (shirt and trousers) covered by:

i) waterproof leggings (polyurethane on nylon) with a short fisherman's smock worn over the shirt

OR ii) overall (boiler suit) and apron

The use of leggings are probably more effective than an apron, particularly if the operator has to enter the draining pen, as they protect the entire leg. Bib and brace type leggings would provide better protection as they reach chest rather than waist height.

All waterproof protective clothing should be rinsed regularly during use and washed at the end of the day.

II A face shield is recommended by manufacturers when handling the dip concentrate. Some operators tried to dip while wearing a face shield because they had experienced eye splashes of dilute material. They found that vapour from the dip collected behind the visor so discontinued the practice.

Eye protection is recognised as advisable and, whilst there is resistance to wearing goggles, the use of chemical safety spectacles is a practical alternative. We have already mentioned the need for suitable eye washing facilities.

III The manufacturers of sheep dip recommend the use of "protective gloves" but do not specify the type. Gloves made of nitrile material resist penetration by petroleum distillate type solvents better than gloves made of either butyl rubber or neoprene. When tested against phenol in solution, neoprene and butyl rubber gloves provide greater protection. It is because of its greater resistance to solvent penetration that nitrile is recommended by glove manufacturers for use with sheep dip. Thicker nitrile will give greater protection, but there will come a point at which flexibility will be compromised.

The protection afforded by gloves is dependent not only on their being made of the correct material, but also on their correct use; ie, being rinsed off after use, internal contamination being avoided and being discarded when damaged or their recommended life is exceeded.

The majority of farmers use gloves, usually of the incorrect type, when handling the concentrate. The gloves are then put down near the dip until they are required for the next addition of concentrate, offering ideal conditions for contamination. It may be preferable if gloves were not worn, but the container and measuring device rinsed with clean water and hands washed after addition of the concentrate.

During dipping, the hands do not appear to become more contaminated than other parts of the body. They are more likely to be washed at intervals, hence there would seem to be no need to wear gloves during the dipping operation, unless a wooden handled dipping stick is used.

Four people were observed during the survey wearing gloves for dipping. Three were using the wrong type (natural rubber). One operator continued to wear a glove when it was badly torn, thus trapping dip inside, allowing continual absorption for the remainder of the day.

IV Four operators wore respiratory protection. Of these two wore disposable preformed masks (3M Farmer's Lung Mask) and two powered helmets (Racal Airstream).

In most circumstances this type of protection is not necessary. Atmospheric monitoring results show that dilutional factors at open sites should be sufficient to disperse the vapours present around the dip. At enclosed sites (mobile and covered dips) the problem should be tackled at source.

Disposable masks, of the type worn, are ineffective against volatile products. Tests on one mask showed it to be contaminated with OP, possibly as a result of splashing. This suggests the mask could act as an additional source of contamination. The only disposable mask which may provide some protection is one containing activated charcoal. This type is however recognised as being difficult to breathe through and therefore unsuitable for heavy manual work.

The powered helmets worn were fitted with activated charcoal filters. These are recommended only as "odour filters for non-hazardous substances below the OES". One of the operators commented that he could detect odours even when a new filter had been fitted, indicating breakthrough, and that on occasions he felt unwell after dipping (battery pack fully charged).

Future Investigations

1. We recommend that the summer dip 1991 be used to follow-up the survey for the following reasons:

   (i) The majority of people complaining of symptoms state that they experience them at this time.

   (ii) The atmosphere will contain a greater concentration of volatile substances.

   (iii) Other OPs; for example, chlorfenvinphos, will be used. This compound is more volatile than either diazinon or propetamphos. It is absorbed into body fats and is slowly released creating a more prolonged effect.

   (iv) Different delivery systems may be used which result in greater operator exposure.

2. We propose the following strategy:

   (i) To use the same population as that used for the autumn study.

   (ii) Urine samples for dialkylphosphate measurements to be collected from diazinon and chlorfenvinphos users at:

      (a) the end of the dipping day
      (b) 24 hours after the post dip sample
      (c) 48 hours after the post dip sample

   Whilst 24 and 48 hour total collection would be ideal it is impractical in all but one or two cases.

(iii) Atmospheric monitoring for volatiles using:

- (a) static tenax at dip
- (b) pumped and passive personal samplers in parallel at same sites (exposed and enclosed)
- (c) if appropriate, to use alternative adsorbent materials, or different gas chromatography columns

(iv) Blood sampling may be carried out to test for the presence of solvents and to analyse for specific esterases which may determine the rate of metabolism of the OPs in use.
Cholinesterase estimations are not proposed.

(v) To determine the presence of breakdown products of diazinon in dips which have remained in the bath since the previous dip; in partially used tins of concentrate

(vi) To review bulk dilutions using recognised sampling techniques at appropriate intervals.

(vii) To use the opportunity to discuss the feasibility and effectiveness of protective clothing recommendations with individuals and assess the provision of eyewash facilities.

CONCLUSIONS

Environmental monitoring demonstrated low levels of atmospheric contamination near dipping baths.

None of the results of biological monitoring were in the significant range.

The fact that no dramatic results were forthcoming does not indicate the absence of a problem, rather that the cause is more complex than originally envisaged.

This survey has carried out the basic work required in order to set targets for the future. It has also enabled new laboratory techniques, eg. dialkylphosphate estimations to be tested under field conditions and facilitates further work on esterase phenotyping.

The fact that exposure to OPs during dipping occurs at a relatively low level makes monitoring much more difficult. The limitations of certain techniques have been illustrated.

This report highlights other factors which may contribute to the symptoms reported by sheep dip users.

It has been inferred that problems associated with the use of sheep dip chemicals are encountered only in the South West of England. Reports of ill-health, however, are distributed throughout the country. Certain factions of the farming industry are convinced that compulsory dipping for sheep scab will cease in the near future. Whether or not this proves to be the case, sheep will continue to be dipped for other purposes as well as reactively when a scab outbreak occurs.

Scientists indicate that resistance may be developing to the OPs in use. This, would, in fact, give rise to the demand for stronger, more potent dips, which will demand stronger, more positive answers.

APPENDIX 1

LABORATORY METHODS

References are given for published methods where appropriate, in other cases a resumee is given.

1. Blood Cholinesterase

Lewis P E, Lowing R K, Gompertz D. Automated discrete kinetic method for erythrocyte acetylcholinesterase and plasma cholinesterase. Clinical Chemistry (1981) 27, 926-929.

2. Serum Esterase Activities

Three specific esterases were analysed:

(i) Serum carboxytesterase

Sterri S H, Fonnum F, Johnsen B A. A radiochemical assay method for carboxylesterase, and comparison of enzyme activity towards the substrates methyl [1-^{14}C] butyrate and 4 - nitrophenyl butyrate. Biochem Pharmacol (1985) 34 (15), 2779-85.

(ii) Serum Paraoxonase

W H O Technical Document
Organophosphorus Pesticides: An Epidemiological Study. World Health Organisation. Copenhagen, 1987 (Env Health series no 22), 103-107

(iii) Serum chlorpyrifos-oxonase

Furlong C E, Richter R J, Seidel S L, Motulsky A G. Role of genetic polymorphism of human plasma paraoxonase/arylesterase in hydrolysis of the insecticide metabolites chlorpyrifos oxon and paraoxon. Am J Hum Genetics (1988) 43, 230-238

3. Blood Solvents

Solvents were released from the blood samples and absorbed using Tenax tubes. These were analysed using thermal description, capillary gas chromatography and an ion trap detector.

4. Urinary Phenols and Dialkyl Phosphates

Evaluations were performed by extraction - analysis using capillary gas chromatoography and flame ionisation of flame photometric detectors.

5. Tenax Passive Samplers

Wright M D. A dual capillary column system for automated analysis of workplace contaminants by thermal descorption. Analytical Proceedings (1987) 24, 309-311

6. Bulk Dip Samples

Branchflower W J, Rice D A, Hamilton J T G. Determination of propetamphos and diazinon residues in sheep's wool. Analyst (1987) 112, 1761-1763.

REPORTS OF SYMPTOMS

SYMPTOM	THIS DIP										PREVIOUS DIPS																		
HEADACHE		X								X		X	X	X				X		X						X	X	X	X
THIRST			X						X					X									X						
TIREDNESS		X									X	X	X	X		X	X		X			X		X	X				
PARAESTHESIAE				X										X															
SORE THROAT					X	X	X	X																					
NAUSEA																				X	X								
VISION														X															
CHEST	X														X														
SUBJECT CODE	X2	B1	A1	A2	L2	L4	O1	O2	Q1	T	C	B1	E	A2	D	H1	G3	X2	L1	N1	B2	O1	Q1	W2	S1	T	U	V	W1

APPENDIX 3

1. Richard G Ames et al, Protecting Agricultural Applicators from Over-Exposure to Cholinesterase-Inhibiting Pestides: Perspectives from the California Programme. J Soc Occup Med (1989) 39, 85-92.

2. Guidance Note MS 17 from the Health and Safety Executive, Biological Monitoring of workers exposed to organo-phosphorus pesticides.

3. Shuyang Chen et al, An epidemiological study on occupational acute pyrethroid poisoning in cotton farmers. British Journal of Industrial Medicine (1991) 48, 77-81.

4. H J Mason, P J Lewis, Intra-individual Variation in Plasma and Erythrocyte Cholinesterase Activities and the Monitoring of Uptake of Organo-phosphate Pesticides. J Soc Occup Med (1989) 39, 121-124

5. C A Franklin et al, Correlation of Urinary Pesticide Metabolite Excretion with Estimated Dermal Contact in the Course of Occupational Exposure to Guthion, Journal of Toxicology and Env Health, (1981) 7, 715-731.

APPENDIX 4

RESULTS TOTAL POPULATION

APPENDIX 4.

CODE No.	PRODUCT NAME	SAMPLE DESCRIPTION	CHOLINESTERASE PLASMA daU/L	PLASMA % base	RBC hU/L	RBC % base	PTP nMol/L	DETP nMol /mMol creat	DEP nMol /mMol creat	SYMPTOMS	PROTECTIVE CLOTHING	R P E	SIGNIFICANT INCIDENT
A1	BAYTICOL	PRE DIP DAY 1					ND	ND	ND	THIRST	WB		smoked pipe
	FLUMETHRIN	POST DIP DAY 1					ND	ND	ND		GL(C)		constantly
		PRE DIP DAY 2					ND	ND	ND		WPL		
		POST DIP DAY 2					ND	ND	ND		A		
		POST DIP	263		188								
A2	BAYTICOL	PRE DIP DAY 1					ND	ND	ND	NONE	WB	AIRSTREAM	none
	FLUMETHRIN	POST DIP DAY 1					ND	ND	ND		GL	CHARCOAL	
		PRE DIP DAY 2					ND	ND	ND	TINGLING MOUTH	WPL	FILTER	monitor under coat
		POST DIP DAY 2					ND	ND	ND	AND TONGUE	WPC		plug disconnected
		POST DIP	284		162						BS		from helmet
B1	YOUNGS	PRE DIP DAY 1					ND	ND	ND				
	SUMMER	PRE DIP					0.6	2	ND	"FELT BAD"	WB		leaning over
	PROPETAMPHOS	POST DIP					ND	2	ND		WPL		enclosed dip
		PRE DIP					ND	ND	ND	CONSTANT	WPC (If wet)		
		POST DIP					ND	ND	ND	HEADACHES			
		POST DIP (MID)	247	97	164	106				CONSTANT "HIGH"			marker spray - B2
		R BASELINE	250		155								
		FINAL						ND	ND				
B2	YOUNGS	PRE DIP					ND	1	ND	NONE	WB		none
	SUMMER	POST DIP					ND	ND	ND		WPL		
	PROPETAMPHOS	FINAL									WPC		
		POST DIP	288	99	166	107					BS		
		R. BASELINE	290		154								
C	COOPERS	PRE DIP DAY 1					ND	ND	ND	NONE	WB		dropped dipping
	POWERPACK	POST DIP DAY 1					ND	ND	ND		GL(C)		stick - metal
	WINTER	PRE DIP DAY 2					ND	ND	ND		WPL		dip cleaned between
	DIAZINON	POST DIP DAY 2					ND	ND	ND		WPC		final urine & blood
		FINAL					ND	ND	ND				sample (26.9)
		POST DIP	427	95	156	105							
		POST DIP											
		R. BASELINE	447		148								
D	TOP CLIP	PRE DIP					ND	ND	ND	NONE	WB		
	GOLD SHIELD	POST DIP					ND	3	ND		GL(C)		
	DIAZINON	FINAL					ND	ND	ND		FS(C)		
		POST DIP									WPL		
		POST DIP	328	104	159	106					WPC		
		R. BASELINE	314		150								
E	JASON WINTER	PRE DIP DAY 1					ND	ND	ND	NONE	WB		handled dipped
	COOPER BORDER	POST DIP DAY 1					ND	ND	ND		WPL		sheep. Added
	PROPETAMPHOS	PRE DIP DAY 2					ND	ND	ND	NONE			dip concentrate
		POST DIP DAY 2					ND	ND	ND				by milk bottle
		POST SHEAR DAY 2					ND	ND	ND				rinsed in dip
		POST SHEAR DAY 1					ND	ND	ND				
		POST DIP	236	86	162	105							
		FINAL					ND	ND					
		R. BASELINE	272		154								
F	TOP CLIP	CLEANING					ND	6	ND	NONE			
	GOLD SHIELD	PRE DIP					ND	3	ND		WB		eye splash x 2
	DIAZINON	POST DIP					ND	4	ND				wet wooden handle
		POST DIP	364	104	176	100							
		FINAL					ND	ND	ND				
		R. BASELINE	349		175								
G1	TOP CLIP	PRE DIP					ND	ND	ND	NONE	WB		none
	GOLD SHIELD	POST DIP					ND	6	ND		WPL		
	DIAZINON	FINAL					ND	ND	ND		WPC		
		POST DIP	283	103	169	96							
		R. BASELINE	271		176								
G2	TOP CLIP	PRE DIP					ND	ND	ND	NONE	WB		none
	GOLD SHIELD	POST DIP					ND	ND	ND		WPL		
	DIAZINON	FINAL					ND	ND	ND		WPC		
		POST DIP	283	96	162	103							
		POST DIP											
		R. BASELINE	295		157								

APPENDIX 4.

CODE No.	PRODUCT NAME	SAMPLE DESCRIPTION	CHOLINESTERASE PLASMA daU/L	PLASMA % base	RBC hU/L	RBC % base	PTP nMol/L	DETP nMol /mMol creat	DEP nMol /mMol creat	SYMPTOMS	PROTECTIVE CLOTHING	R P E	SIGNIFICANT INCIDENT
G3	TOP CLIP	PRE DIP					ND	ND	ND	NONE	WB		prolonged gathering
	GOLD SHIELD	POST DIP					ND	ND	ND		GL		
	DIAZINON	FINAL					ND	ND	ND		FS		
		POST DIP	302	85	161	90					WPL		
		POST DIP									WPC		
		R. BASELINE	354		177								
G4	TOP CLIP	PRE DIP					ND	ND	ND	NONE	WB		none
	GOLD SHIELD	POST DIP					ND	ND	ND		WPL		
	DIAZINON	POST DIP									WPC		
		POST DIP	253		159								
H1	TOP CLIP	PRE DIP DAY 1					ND	ND	ND	IMMED - NONE	WB		tip retrieved from dip
	GOLD SHIELD	POST DIP DAY1					ND	ND	ND	LATER: NASAL	A		difficulty with gloves
	DIAZINON	FINAL					ND	ND	ND	CONGESTION			handling wet sheep
		POST DIP	313	99	184	100				ASTHMA 2 MONTHS			irritant atmosphere
		R. BASELINE	316		183					POST DIPPING			washed hands in contaminated tank
H2	TOP CLIP	PRE-HANDLING					ND	ND	ND				
	GOLD SHIELD	FINAL					ND	ND	ND				
	DIAZINON	PRE-HANDLING	174	92	180	113							
		POST HANDLING	161		208								
H3	TOP CLIP	POST DIP					ND	ND	ND	NONE	WB		handling wet sheep
	GOLD SHIELD	FINAL					ND	ND	ND				
	DIAZINON	POST DIP	266	93	169	104							
		R. BASELINE	286		162								
X1	TOP CLIP	PRE CLEANING					ND	ND	ND				
	GOLD SHIELD	POST CLEANING					ND	ND	ND				
	DIAZINON	PRE DIP DAY 1					ND	7	ND	NONE	WB		tensx in pocket
		POST DIP DAY 1					ND	35	ND				first thing
		PRE DIP DAY 2					ND	22	ND				fished out hose
		POST DIP DAY 2					ND	24	ND				irritant atmosphere
		FINAL					ND	ND	ND				
		POST DIP DAY 1	297	98	174	109							
		R. BASELINE	301		159								
X2	TOP CLIP	PRE DIP DAY 1					ND	ND	ND	NONE	WB	3M	irritant atmosphere
	GOLD SHIELD	POST DIP DAY 1					ND	60	ND		GL		coughing
	DIAZINON	PRE DIP DAY 2					ND	31	ND		A		
		POST DIP DAY 2					ND	42	ND				
		FINAL					ND	ND	ND				
		POST DIP DAY 1	228	97	180	101							
		R. BASELINE	234		178								
J1	TOP CLIP	PRE DIP					ND	ND	ND	NONE	WB		
	GOLD SHIELD	POST DIP					ND	6	ND		WPL		
	DIAZINON	FINAL					ND	ND	ND				
		POST DIP	269	102	157	98							
		R. BASELINE	263		160								
J2	TOP CLIP	PRE DIP					ND	ND	ND	NONE	WB		
	GOLD SHIELD	POST DIP					ND	ND	ND		WPL		
	DIAZINON	FINAL					ND	ND	ND				
	GOLD SHIELD	POST DIP					ND	39	ND		GL		drain in pen
	DIAZINON	PRE DIP					ND	12	ND		WPL		face & eyes splashed
		POST DIP					ND	14	ND				torn glove (R palm)
		POST DIP	301	103	179	105							
		FINAL					ND	ND					
		R. BASELINE	292		170								
L1	ECTOMORT	PRE DIP DAY 1					ND	ND	ND	NONE	WB		helped lift sheep
	PROPETAMPHOS	POST DIP DAY 1					ND	ND	ND		BS		from dip
		PRE DIP DAY 2					ND	ND	ND				
		POST DIP DAY 2					ND	ND	ND				
		FINAL					ND	ND	ND				
		POST DIP	251	92	190	110							
		R. BASELINE	273		172								

APPENDIX 4.

CODE No.	PRODUCT NAME	SAMPLE DESCRIPTION	CHOLINESTERASE PLASMA daU/L	PLASMA % base	RBC kU/L	RBC % base	PTP nMol/L	DETP nMol /mMol creat	DEP nMol /mMol creat	SYMPTOMS	PROTECTIVE CLOTHING	R P E	SIGNIFICANT INCIDENT
L2	ECTOMORT	PRE DIP DAY 1					ND	ND	ND	SORE THROAT	WB		
	PROPETAMPHOS	POST DIP DAY 1					ND	ND	ND		WPL		
		PRE DIP DAY 2					ND	ND	ND		WPC		
		POST DIP DAY 2					ND	ND	ND				
L3	ECTOMORT	PRE DIP DAY 1					ND	ND	ND	NONE	WB		bleeding dog bite
	PROPETAMPHOS	POST DIP DAY 1					ND	ND	ND				left hand fabric
		PRE DIP DAY 2					ND	ND	ND				plaster - no gloves
		POST DIP DAY 2					ND	ND	ND				helped lift sheep
		FINAL					ND	ND	ND				from dip
		POST DIP	295	95	179	109							
		R. BASELINE	312		163								
L4	ECTOMORT	PRE DIP DAY 1					ND	ND	ND	SORE THROAT	WB		none
	PROPETAMPHOS	POST DIP DAY 1					ND	ND	ND		WPL		
		PRE DIP DAY 2					ND	ND	ND		WPC		
		POST DIP DAY 2					ND	ND	ND				
		FINAL					ND	5	ND				
		POST DIP	230	92	189	110							
		R. BASELINE	251		171								
M1	TOP CLIP	PRE DIP					ND	ND	ND		WB GL(C)		lifting wooden gate
	GOLD SHIELD	POST DIP					ND	17	ND		FS(C) WPL		pulling out wet
	DIAZINON	PRE DIP	270	97	165	104					BS A(C)		sheep
		POST DIP	262		172								
M2	TOP CLIP	PRE DIP					ND	ND	ND		WB		lifting wooden gate
	GOLD SHIELD	POST DIP					ND	12	ND		WPL		pulling out wet
	DIAZINON	PRE DIP	272	96	170	97					BS		sheep
		POST DIP	262		166								
N1	ECTOMORT	PRE DIP					ND	ND	ND	NONE	WB		hands & forearms
	PROPETAMPHOS	POST DIP					ND	ND	ND		GL(C)		immersed
		FINAL					ND	ND	ND		WPL		handled wet animals
		POST DIP	236	83	161	110					BS		contaminated atmos.
		R. BASELINE	284		144								dip area?
N2	ECTOMORT	PRE DIP					ND	ND	ND	NONE	WB		handled wet sheep
	PROPETAMPHOS	POST DIP					ND	ND	ND				contaminated atmos.
		FINAL					ND	ND	ND				dip area?
		POST DIP	299	97	157	101							
		R. BASELINE	308		154								
O1	DIAZADIP	PRE DIP DAY 1					ND	ND	ND	SORE THROAT	WB	3M	
	DIAZINON	POST DIP DAY 1					ND	3	ND		WPL		
		PRE DIP DAY 2					ND	6	16		WPC		
		POST DIP DAY 2					ND	ND	13				
		FINAL					ND	ND	ND				
		POST DIP	249	88	201	102							
		R. BASELINE	281		196								
O2	DIAZADIP	PRE DIP DAY 1					ND	ND	ND	SORE THROAT	WB		filled boot
	DIAZINON	POST DIP DAY 1					ND	10	9		WPL		with dip
		PRE DIP DAY 2					ND	7	13				
		POST DIP DAY 2					ND	2	13				
		FINAL					ND	ND	ND				
		POST DIP	238	93	160	106							
		R. BASELINE	255		151								
P1	TOP CLIP	PRE DIP DAY 1					ND	7	ND	NONE	WB		
	GOLD SHIELD	POST DIP DAY 1					ND	6	ND		WPL		
	DIAZINON	PRE DIP DAY 2					ND	7	ND				
		POST DIP DAY 2					ND	8	ND				
P2	TOP CLIP	PRE DIP DAY 1					ND	ND	ND	NONE	WB		
	GOLD SHIELD	POST DIP DAY 1					ND	ND	ND		WPL		
	DIAZINON	PRE DIP DAY 2					ND	4	ND		WPC		
		POST DIP DAY 2					ND	6	ND				
		PRE DOCKING					ND	2	ND				none
		POST DOCKING					ND	11	ND				
		FINAL					ND	ND	ND				
		POST DIP	231	92	157	105							
		R. BASELINE	251		166								

APPENDIX 4.

CODE No.	PRODUCT NAME	SAMPLE DESCRIPTION	CHOLINESTERASE PLASMA daU/L	PLASMA % base	RBC kU/L	RBC % base	PTP nMol/L	DETP nMol /mMol creat	DEP nMol /mMol creat	SYMPTOMS	PROTECTIVE CLOTHING	R P E	SIGNIFICANT INCIDENT
P3	TOP CLIP	PRE DIP DAY 1					ND	ND	ND	NONE	WB		
	GOLD SHIELD	POST DIP DAY 1					ND	ND	ND		GL(C)		
	DIAZINON	PRE DIP DAY 2					ND	ND	ND		FS(C)		
		POST DIP DAY 2					ND	ND	ND		WPL		
		FINAL					ND	ND	ND		WPC		
		POST DIP	338	91	194	105							
		R. BASELINE	369		188								
Q1	COOPERS BORDER	PRE DIP DAY 1					ND	ND	ND	THIRSTY	WB		handled dipped sheep boot full of dip
	PROPETAMPHOS	POST DIP DAY 1					ND	ND	ND				
		PRE DIP DAY 2					ND	ND	ND				
		POST DIP DAY 2					ND	ND	ND				
		PRE DIP DAY 3					ND	ND	ND				
		POST DIP DAY 3					ND	ND	ND				
		FINAL					ND	ND	ND				
		POST DIP	273	100	163	104							
		R. BASELINE	273		156								
Q2	COOPERS BORDER	PRE DIP DAY 1					ND	ND	ND	NONE	WB		
	PROPETAMPHOS	POST DIP DAY 1					ND	ND	ND				
		PRE DIP DAY 2					ND	ND	ND				
		PRE DIP DAY 3					ND	ND	ND				
		POST DIP DAY 3					1.6	ND	ND				
		FINAL					ND	ND	ND				
		POST DIP	284	97	167	101							
		R. BASELINE	293		165								
E1	JASON SUMMER	PRE DIP DAY 1					ND	ND	ND	NONE	WB		
	PROPETAMPHOS	POST DIP DAY 1					ND	ND	ND		GL(C)		
		PRE DIP DAY 2					ND	ND	ND		WPL		
		POST DIP DAY 2					ND	ND	ND				
		PRE DIP DAY 3					ND	ND	ND				
		POST DIP DAY 3					ND	ND	ND				
		PRE DIP DAY 4					ND	2	ND				
		POST DIP DAY 4					ND	ND	ND				
		POST DIP	350	98	171	107							
		FINAL					ND	ND					
		R. BASELINE	357		160								
E2	JASONS SUMMER	PRE DIP DAY 1					ND	ND	ND	NONE	WB		
	PROPETAMPHOS	POST DIP DAY 1					ND	ND	ND				
		PRE DIP DAY 2					ND	ND	ND				
		POST DIP DAY 2					ND	ND	ND				
		PRE DIP DAY 3					ND	ND	ND				
		POST DIP DAY 3					ND	ND	ND				
		PRE DIP DAY 4					ND	ND	ND				
		POST DIP DAY 4					ND	ND	ND				
		FINAL					ND	ND	ND				
		POST DIP	252	87	186	105							
		R. BASELINE	287		177								
S1	ECTOMORT	PRE CLEAN					ND	ND	ND				
	PROPETAMPHOS	POST CLEAN					ND	ND	ND				
	JASONS WINTER	PRE DIP DAY 1					ND	ND	ND	NONE	WB		rescued wet lamb
	PROPETAMPHOS	POST DIP DAY 1					ND	4	ND		GL(C)		
		PRE DIP DAY 2					ND	4	ND		WPL		
		POST DIP DAY 2					ND	ND	ND		WPC		
		PRE DIP DAY 3					ND	ND	ND	NONE			
		POST DIP DAY 3					ND	ND	ND				

APPENDIX 4.

CODE No.	PRODUCT NAME	SAMPLE DESCRIPTION	CHOLINESTERASE PLASMA daU/L	PLASMA % base	RBC kU/L	RBC % base	PTP nMol/L	DETP nMol /mMol creat	DEP nMol /mMol creat	SYMPTOMS	PROTECTIVE CLOTHING	R P E	SIGNIFICANT INCIDENT
S2	JASONS WINTER	PRE DIP DAY 1					ND	ND	ND		WB		
	PROPETAMPHOS	PRE DIP DAY 2					ND	ND	ND		WPL		
		POST DIP DAY 2					ND	ND	ND		WPC		
		PRE DIP DAY 3					ND	ND	ND				
		POST DIP DAY 3					ND	ND	ND				
		FINAL					ND	ND	ND				
		POST DIP	284	94	183	112							
		R. BASELINE	301		164								
T	DEOSAN	PRE DIP					ND	ND	ND				
	DIAZINON	PRE DIP DAY 1					ND	8	ND	NONE	WB	AIRSTREAM	hosing down after
		POST DIP DAY 1					ND	8	ND		GL	CHARCOAL	taking off protection
		PRE DIP DAY 2					ND	4	ND		WPL	FILTER	
		POST DIP DAY 2					ND	4	ND		WPC		
		POST DIP	294	93	184	104							
		FINAL						2	ND				
		R. BASELINE	315		176								
U	ECTOMORT	PRE DIP DAY 1					ND	4	ND	NONE	WB		crutching prior to dipping
	PROPETAMPHOS	POST DIP DAY 1					ND	ND	ND				
	POWERPACK W	PRE DIP DAY 2					ND	ND	ND				
	DIAZINON	POST DIP DAY 2					ND	9	ND				
		FINAL					ND	ND	ND				
		POST DIP	213	94	159	104							
		R. BASELINE	227		152								
V	TOP CLIP	PRE DIP DAY 1					ND	7	ND	NONE	WB		
	GOLD SHIELD	POST DIP DAY 1					ND	58	18		GL(C)		
	DIAZINON	PRE DIP DAY 2					ND	37	22		WPL		
		POST DIP DAY 2					ND	67	34				
		POST DIP	317	93	159	102							
		R. BASELINE	321		155								
W1	JASON W.D.	PRE DIP DAY 1					ND	ND	ND	NONE	WB		
	PROPETAMPHOS	POST DIP DAY 1					ND	ND	ND		WPL		
		PRE DIP DAY 2					ND	ND	ND				
		POST DIP DAY 2					ND	ND	ND				
		POST DIP DAY 3					ND	ND	ND				
		FINAL					ND	ND	ND				
		POST DIP	279	104	168	106							
		R. BASELINE	268		158								
W2	YOUNGS	PRE DIP DAY 2					ND	ND	ND	NONE	WB		none
	JASON WINTER	POST DIP DAY 2					ND	ND	ND		WPL		
	PROPETAMPHOS	PRE DIP DAY 3					ND	ND	ND				
		POST DIP DAY 3					ND	ND	ND				

PROTECTIVE CLOTHING

A - Apron
WB - Wellington boots

BS - Boiler suit
WPC - Waterproof coat

FS - Face shield
WPL - Waterproof Leggings

GL - Gloves
(C) - Equipment worn when handling concentrate only

APPENDIX 5

RESULTS DIAZINON USERS

APPENDIX 5.

CODE No.	PRODUCT NAME	SAMPLE DESCRIPTION	DATE OF SAMPLE	DETP nMol /mMol creat	DEP nMol /mMol creat	PROTECTIVE CLOTHING	R P E	DIP TYPE	DIP POSITION	PEN	WEATHER	SIGNIFICANT INCIDENT
C	COOPERS	PRE DIP DAY 1	24/09/90	ND	ND	WB		SET	SO	U	windy	dropped dipping
	POWERPACK	POST DIP DAY 1	24/09/90	ND	ND	GL(C)					heavy showers	stick - metal
	WINTER	PRE DIP DAY 2	25/09/90	ND	ND	WPL					sunny warm	dip cleaned between
	DIAZINON	POST DIP DAY 2	25/09/90	ND	ND	WPC						final urine & blood
		FINAL	09/01/91	ND	ND							sample (26.9)
D	TOP CLIP	PRE DIP	04/10/90	ND	ND	WB		SES	O	U	cool fine .	
	GOLD SHIELD	POST DIP	04/10/90	3	ND	GL(C)					slight breeze	
	DIAZINON	FINAL	15/01/91	ND	ND	FS(C)						
		POST DIP	04/10/90			WPL						
		POST DIP	04/10/90			WPC						
F	TOP CLIP	CLEANING	05/10/90	6	ND							
	GOLD SHIELD	PRE DIP	06/10/90	3	ND	WB		SET	SO	U	windy cold	eye splash x 2
	DIAZINON	POST DIP	06/10/90	4	ND							wet wooden handle
		POST DIP	06/10/90									
		FINAL	09/01/91	ND	ND							
G1	TOP CLIP	PRE DIP	17/10/90	ND	ND	WB		SET	SO	D	overcast breezy	none
	GOLD SHIELD	POST DIP	17/10/90	6	ND	WPL						
	DIAZINON	FINAL	21/01/91	ND	ND	WPC						
G2	TOP CLIP	PRE DIP	17/10/90	ND	ND	WB		SET	SO	D	overcast breezy	none
	GOLD SHIELD	POST DIP	17/10/90	ND	ND	WPL						
	DIAZINON	FINAL	21/01/91	ND	ND	WPC						
G3	TOP CLIP	PRE DIP	17/10/90	ND	ND	WB		SET	SO	D	overcast breezy	prolonged gathering
	GOLD SHIELD	POST DIP	17/10/90	ND	ND	GL						
	DIAZINON	FINAL	21/01/91	ND	ND	FS						
		POST DIP	17/10/90			WPL						
		POST DIP	17/10/90			WPC						
G4	TOP CLIP	PRE DIP	17/10/90	ND	ND	WB		SET	SO	D	overcast breezy	none
	GOLD SHIELD	POST DIP	17/10/90	ND	ND	WPL						
	DIAZINON	POST DIP	17/10/90			WPC						
H1	TOP CLIP	PRE DIP DAY 1	17/09/90	ND	ND	WB		MS	SO	S	intermittent drizzle	tap retrieved from dip
	GOLD SHIELD	POST DIP DAY1	17/09/90	ND	ND	A					breeze	difficulty with gloves
	DIAZINON	FINAL	19/12/90	ND	ND							handling wet sheep
												irritant atmosphere
												washed hands in
												contaminated tank
H2	TOP CLIP	PRE-HANDLING	17/09/90	ND	ND							
	GOLD SHIELD	FINAL	19/12/90	ND	ND							
	DIAZINON	PRE-HANDLING	17/09/90									
		POST HANDLING	19/12/90									
H3	TOP CLIP	POST DIP	17/09/90	ND	ND	WB		MS	SO	S	inermittent drizzle	handling wet sheep
	GOLD SHIELD	FINAL	18/01/91	ND	ND						breeze	
	DIAZINON	POST DIP	17/09/90									
		R. BASELINE	18/01/91									
X1	TOP CLIP	PRE CLEANING	10/10/90	ND	ND							
	GOLD SHIELD	POST CLEANING	10/10/90	ND	ND							
	DIAZINON	PRE DIP DAY 1	11/10/90	7	ND	WB		MS	S	D	calm overcast mild	tenax in pocket
		POST DIP DAY 1	11/10/90	35	ND							first thing
		PRE DIP DAY 2	12/10/90	22	ND							fished out hose
		POST DIP DAY 2	12/10/90	24	ND							irritant atmosphere
		FINAL	15/01/91	ND	ND							
X2	TOP CLIP	PRE DIP DAY 1	11/10/90	ND	ND	WB	R 3M	MS	S	D	calm overcast mild	irritant atmosphere
	GOLD SHIELD	POST DIP DAY 1	11/10/90	60	ND	GL						coughing
	DIAZINON	PRE DIP DAY 2	12/10/90	31	ND	A						
		POST DIP DAY 2	12/10/90	42	ND							
		FINAL	15/01/91	ND	ND							
J1	TOP CLIP	PRE DIP	16/10/90	ND	ND	WB		MS	SO	D	cool overcast	
	GOLD SHIELD	POST DIP	16/10/90	8	ND	WPL					some sun	
	DIAZINON	FINAL	14/01/91	ND	ND							

APPENDIX 5.

CODE No.	PRODUCT NAME	SAMPLE DESCRIPTION	DATE OF SAMPLE	DETP nMol /mMol	DEP nMol /mMol	PROTECTIVE CLOTHING	R P E	DIP TYPE	DIP POSITION	PEN	WEATHER	SIGNIFICANT INCIDENT
J2	TOP CLIP	PRE DIP	16/10/90	ND	ND	WB		MS	SO	D	cool overcast	
	GOLD SHIELD	POST DIP	16/10/90	ND	ND	WPL					some sun	
	DIAZINON	FINAL	14/01/91	ND	ND							
K	TOP CLIP	PRE DIP	12/10/90	20	ND	WB		SET	S	D	warm breeze	difficulty emptying
	GOLD SHIELD	POST DIP	12/10/90	39	ND	GL						drain in pen
	DIAZINON	PRE DIP	01/11/90	12	ND	WPL						face & eyes splashed
		POST DIP	01/11/90	14	ND							torn glove (R palm)
		FINAL	01/02/91	ND								
M1	TOP CLIP	PRE DIP	24/09/90	ND	ND	WB GL(C)		MS	S		clear cold	lifting wooden gate
	GOLD SHIELD	POST DIP	24/09/90	17	ND	FS(C) WPL						pulling out wet
	DIAZINON	PRE DIP	24/09/90			BS A(C)						sheep
M2	TOP CLIP	PRE DIP	24/09/90	ND	ND	WB		MS	SC		clear cold	lfiting wooden gate
	GOLD SHIELD	POST DIP	24/09/90	12	ND	WPL						pulling out wet
	DIAZINON	PRE DIP	24/09/90			BS						sheep
O1	DIAZADIP	PRE DIP DAY 1	28/09/90	ND	ND	WB	R 3M				sunny warm	
	DIAZINON	POST DIP DAY 1	28/09/90	3	ND	WPL						
		PRE DIP DAY 2	29/09/90	6	16	WPC		MS			wet	
		POST DIP DAY 2	29/09/90	ND	13							
		FINAL	14/01/91	ND	ND							
O2	DIAZADIP	PRE DIP DAY 1	28/09/90	ND	ND	WB		MS			sunny warm	filled boot
	DIAZINON	POST DIP DAY 1	28/09/90	10	9	WPL						with dip
		PRE DIP DAY 2	29/09/90	7	13						wet	
		POST DIP DAY 2	29/09/90	2	13							
		FINAL	14/01/91	ND	ND							
P1	TOP CLIP	PRE DIP DAY 1	16/10/90	7	ND	WB		SESR	O	C		
	GOLD SHIELD	POST DIP DAY 1	16/10/90	6	ND	WPL						
	DIAZINON	PRE DIP DAY 2	17/10/90	7	ND						heavy showers	
		POST DIP DAY 2	17/10/90	8	ND						overcast windy	
P2	TOP CLIP	PRE DIP DAY 1	16/10/90	ND	ND	WB		SESR	O	C	sunny warm	
	GOLD SHIELD	POST DIP DAY 1	16/10/90	ND	ND	WPL						
	DIAZINON	PRE DIP DAY 2	17/10/90	4	ND	WPC						
		POST DIP DAY 2	17/10/90	6	ND							
		PRE DOCKING	19/10/90	2	ND						overcast windy	none
		POST DOCKING	19/10/90	11	ND						heavy showers	
		FINAL	21/01/91	ND	ND							
P3	TOP CLIP	PRE DIP DAY 1	16/10/90	ND	ND	WB		SESR	O	C		
	GOLD SHIELD	POST DIP DAY 1	16/10/90	ND	ND	GL(C)						
	DIAZINON	PRE DIP DAY 2	17/10/90	ND	ND	FS(C)					heavy showers	
		POST DIP DAY 2	17/10/90	ND	ND	WPL					overcast windy	
		FINAL	21/01/91	ND	ND	WPC						
T	DEOSAN	PRE DIP	24/09/90	ND	ND							
	DIAZINON	PRE DIP DAY 1	05/10/90	8	ND	WB	R AIRSTREAM	SES	O	D	fine	hosing down after
		POST DIP DAY 1	05/10/90	8	ND	GL	CHARCOAL					taking off protection
		PRE DIP DAY 2	03/11/90	4	ND	WPL	FILTER					
		POST DIP DAY 2	03/11/90	4	ND	WPC						
		FINAL	01/02/91	2	ND							
V	TOP CLIP	PRE DIP DAY 1	27/09/90	7	ND	WB		MS	S	S	frosty warm clear	
	GOLD SHIELD	POST DIP DAY 1	27/09/90	58	18	GL(C)						
	DIAZINON	PRE DIP DAY 2	28/09/90	37	22	WPL						
		POST DIP DAY 2	28/09/90	67	34							

PROTECTIVE CLOTHING

A - Apron
WB - Wellington boots
BS - Boiler suit
WPC - Waterproof coat
FS - Face shield
WPL - Waterproof leggings
GL - Gloves
(C) - Equipment worn when handling concentrate only

DIP POSITION

C - Covered
SC - Semi-covered
O - Open
SO - Semi-open
S - Sheltered

PEN

C - Crosswind
D - Downwind
U - Upwind

APPENDIX 6

RESULTS PROPETAMPHOS USERS

CODE No.	PRODUCT NAME	SAMPLE DESCRIPTION	DATE OF SAMPLE	PTP nMol/L	PROTECTIVE CLOTHING	DIP TYPE	DIP POSITION	PEN	WEATHER	SIGNIFICANT INCIDENT
B1	YOUNGS	PRE DIP DAY 1	24/09/90	ND						
	SUMMER	PRE DIP	04/10/90	0.6	WB	SES	C		covered	leaning over
	PROPETAMPHOS	POST DIP	04/10/90	ND	WPL		S		overcast	enclosed dip
		PRE DIP	15/10/90	ND	WPC (If wet)		S	D	windy	
		POST DIP	15/10/90	ND						
B2	YOUNGS	PRE DIP	15/10/90	ND	WB	SES	S	D	heavy showers	none
	SUMMER	POST DIP	15/10/90	ND	WPL				windy	
	PROPETAMPHOS	FINAL	15/01/91		WPC					
		POST DIP	15/10/90		BS					
E	JASON WINTER	PRE DIP DAY 1	27/09/90	ND	WB	SET	SO		fine	handled dipped
	COOPER BORDER	POST DIP DAY 1	27/09/90	ND	WPL					sheep
	PROPETAMPHOS	PRE DIP DAY 2	01/10/90	ND		MS	S	S	overcast calm	added dip concentrate
		POST DIP DAY 2	01/10/90	ND						by milk bottle
		POST SHEAR DAY 2	18/12/90	ND						rinsed in dip
		POST SHEAR DAY 1	17/12/90	ND						
		FINAL	11/2/91	ND						
L1	ECTOMORT	PRE DIP DAY 1	23/10/90	ND	WB	MS	S	U	cool overcast	helped lift sheep
	PROPETAMPHOS	POST DIP DAY 1	23/10/90	ND	BS					from dip
		PRE DIP DAY 2	24/10/90	ND						
		POST DIP DAY 2	24/10/90	ND						
		FINAL	18/01/91	ND						
L2	ECTOMORT	PRE DIP DAY 1	23/10/90	ND	WB	MS	S	U	cool overcast	
	PROPETAMPHOS	POST DIP DAY 1	23/10/90	ND	WPL					
		PRE DIP DAY 2	24/10/90	ND	WPC					
		POST DIP DAY 2	24/10/90	ND						
L3	ECTOMORT	PRE DIP DAY 1	23/10/90	ND	WB	MS	S	U	overcast cool	bleeding dog bite
	PROPETAMPHOS	POST DIP DAY 1	23/10/90	ND						left hand fabric
		PRE DIP DAY 2	24/10/90	ND						plaster - no gloves
		POST DIP DAY 2	24/10/90	ND						helped lift sheep
		FINAL	18/01/91	ND						from dip
L4	ECTOMORT	PRE DIP DAY 1	23/10/90	ND	WB	MS	S	U	overcast cool	none
	PROPETAMPHOS	POST DIP DAY 1	23/10/90	ND	WPL					
		PRE DIP DAY 2	24/10/90	ND	WPC					
		POST DIP DAY 2	24/10/90	ND						
		FINAL	18/01/91	ND						
N1	ECTOMORT	PRE DIP	18/9/90	ND	WB	SES	C	S	indoors	hands & forearms
	PROPETAMPHOS	POST DIP	18/9/90	ND	GL(C)					immersed
		FINAL	15/01/91	ND	WPL					handled wet animals
		POST DIP	18/9/90		BS					contaminated atmos.
		R. BASELINE	15/01/91							dip area?
N2	ECTOMORT	PRE DIP	18/9/90	ND	WB	SES	C	S	indoors	handled wet sheep
	PROPETAMPHOS	POST DIP	18/9/90	ND						contaminated atmos.
		FINAL	15/01/91	ND						dip area?
Q1	COOPERS BORDER	PRE DIP DAY 1	08/10/90	ND	WB	MS	S	S	fine calm	handled dipped sheep
	PROPETAMPHOS	POST DIP DAY 1	08/10/90	ND						boot full of dip
		PRE DIP DAY 2	10/10/90	ND					overcast calm	
		POST DIP DAY 2	10/10/90	ND						
		PRE DIP DAY 3	11/10/90	ND						
		POST DIP DAY 3	11/10/90	ND						
		FINAL	15/01/91	ND						
Q2	COOPERS BORDER	PRE DIP DAY 1	08/10/90	ND	WB	MS	S	S	fine calm	
	PROPETAMPHOS	POST DIP DAY 1	08/10/90	ND						
		PRE DIP DAY 2	10/10/90	ND					overcast calm	
		PRE DIP DAY 3	11/10/90	ND						
		POST DIP DAY 3	11/10/90	1.6						
		FINAL	15/01/91	ND						

APPENDIX 6.

CODE No.	PRODUCT NAME	SAMPLE DESCRIPTION	DATE OF SAMPLE	PTP nMol/L	PROTECTIVE CLOTHING	DIP TYPE	DIP POSITION	PEN	WEATHER	SIGNIFICANT INCIDENT
R1	JASON SUMMER	PRE DIP DAY 1	24/9/90	ND	WB	SES	O	U	overcast showery	
	PROPETAMPHOS	POST DIP DAY 1	24/9/90	ND	GL(C)				breeze from west	
		PRE DIP DAY 2	25/9/90	ND	WPL					
		POST DIP DAY 2	25/9/90	ND						
		PRE DIP DAY 3	29/9/90	ND						
		POST DIP DAY 3	29/9/90	ND						
		PRE DIP DAY 4	01/10/90	ND						
		POST DIP DAY 4	01/10/90	ND						
		FINAL	11/02/91	ND						
R2	JASONS SUMMER	PRE DIP DAY 1	24/9/90	ND	WB	SES	O	C	overcast showers	
	PROPETAMPHOS	POST DIP DAY 1	24/9/90	ND					breeze from west	
		PRE DIP DAY 2	25/9/90	ND						
		POST DIP DAY 2	25/9/90	ND						
		PRE DIP DAY 3	29/9/90	ND						
		POST DIP DAY 3	29/9/90	ND						
		PRE DIP DAY 4	10/01/90	ND						
		POST DIP DAY 4	10/01/90	ND						
		FINAL	09/01/91	ND						
S1	ECTOMORT	PRE CLEAN	22/9/90	ND						
	PROPETAMPHOS	POST CLEAN	22/9/90	ND						
	JASONS WINTER	PRE DIP DAY 1	24/9/90	ND	WB	MS	S	D	overcast	rescued wet lamb
	PROPETAMPHOS	POST DIP DAY 1	24/9/90	ND	GL(C)				light breeze	
		PRE DIP DAY 2	01/10/90	ND	WPL					
		POST DIP DAY 2	01/10/90	ND	WPC					
		PRE DIP DAY 3	04/10/90	ND						
		POST DIP DAY 3	04/10/90	ND						
S2	JASONS WINTER	PRE DIP DAY 1	24/9/90	ND	WB	SET	S	U		
	PROPETAMPHOS	PRE DIP DAY 2	01/10/90	ND	WPL					
		POST DIP DAY 2	01/10/90	ND	WPC					
		PRE DIP DAY 3	04/10/90	ND						
		POST DIP DAY 3	04/10/90	ND						
		FINAL	21/01/91	ND						
U	ECTOMORT	PRE DIP DAY 1	28/9/90	ND	WB	MS				crutching prior to
	PROPETAMPHOS	POST DIP DAY 1	28/9/90	ND						dipping
	POWERPACK W	PRE DIP DAY 2	03/10/90	ND						
	DIAZINON	POST DIP DAY 2	03/10/90	ND						
		FINAL	09/01/91	ND						
W1	JASON W.D.	PRE DIP DAY 1	10/10/90	ND	WB	MS	SO	D	overcast	
	PROPETAMPHOS	POST DIP DAY 1	10/10/90	ND	WPL					
		PRE DIP DAY 2	13/10/90	ND					fine	
		POST DIP DAY 2	13/10/90	ND						
		POST DIP DAY 3	15/10/90	ND					fine	
		FINAL	14/01/91	ND						
W2	YOUNGS	PRE DIP DAY 2	13/10/90	ND	WB	MS	SO	D	overcast	none
	JASON WINTER	POST DIP DAY 2	13/10/90	ND	WPL					
	PROPETAMPHOS	PRE DIP DAY 3	15/10/90	ND					fine	
		POST DIP DAY 3	15/10/90	ND						

DIP POSITION

C - Covered

O - Open

S - Sheltered

SC - Semi-covered

SO - Semi-open

PEN

C - Crosswind

D - Downwind

U - Upwind