WORKING FOR A HEALTHY FUTURE

HISTORICAL RESEARCH REPORT

Research Report TM/99/02a
1999

Epidemiological study of the relationships between exposure to organophosphate pesticides and indices of chronic peripheral neuropathy, and neuropsychological abnormalities in sheep farmers and dippers. Phase 1. Development and validation of an organophosphate uptake model for sheep dippers

Sewell, C, Pilkington A, Buchanan D, Tannahill SN, Kidd M, Cherrie B, Robertson A

World Health Organisation
Collaborating Centre
For Occupational Health

RESEARCH CONSULTING SERVICES

Multi-disciplinary specialists in Occupational and Environmental Health and Hygiene

www.iom-world.org

HISTORICAL RESEARCH REPORT

Research Report TM/99/02a
1999

Epidemiological study of the relationships between exposure to organophosphate pesticides and indices of chronic peripheral neuropathy, and neuropsychological abnormalities in sheep farmers and dippers. Phase 1. Development and validation of an organophosphate uptake model for sheep dippers

Sewell, C, Pilkington A, Buchanan D, Tannahill SN, Kidd M, Cherrie B, Robertson A

The scanning of this and the other historical reports in the Research Reports series was funded by a grant from the Wellcome Trust. The IOM's research reports are freely available for download as PDF files from our web site: http://www.iom-world.org/research/libraryentry.php

INSTITUTE OF OCCUPATIONAL MEDICINE
Research Avenue North, Riccarton, Edinburgh, EH14 4AP
Tel: +44 (0)870 850 5131 Fax: +44 (0)870 850 5132
e-mail publications@iomhq.org.uk

Epidemiological study of the relationships between exposure to organophosphate pesticides and indices of chronic peripheral neuropathy, and neuropsychological abnormalities in sheep farmers and dippers

Phase 1

Development and Validation of an Organophosphate Uptake Model for Sheep Dippers

Sewell C, Pilkington A, Buchanan D, Tannahill SN, Kidd M,
Cherrie B, Robertson A
Institute of Occupational Medicine

May 1999

Report No: TM/99/02a

INSTITUTE OF OCCUPATIONAL MEDICINE

Epidemiological study of the relationships between exposure to organophosphate pesticides and indices of chronic peripheral neuropathy, and neuropsychological abnormalities in sheep farmers and dippers

Phase 1

Development and Validation of an Organophosphate Uptake Model for Sheep Dippers

by

Sewell C, Pilkington A, Buchanan D, Tannahill SN, Kidd M,
Cherrie B, Robertson A
Institute of Occupational Medicine

Institute of Occupational Medicine
8 Roxburgh Place
Edinburgh EH8 9SU

Tel: 0131 667 5131
Fax: 0131 667 0136

Price: £44.00

May 1999

CONTENTS

Epidemiological study of the relationships between exposure to organophosphate pesticides and indices of chronic peripheral neuropathy, and neuropyschological abnormalities in sheep farmers and dippers

Interim Report on Phase I:

Development and Validation of an Organophosphate Uptake Model for Sheep Dippers

Sewell C, Pilkington A, Buchanan D, Tannahill SN, Kidd M, Cherrie B, Robertson A

SUMMARY

A study of sheep dipping practice was conducted in the summer of 1996 in order to develop a model for uptake of organophosphates (OPs) based on simple task, procedural and behavioural aspects of sheep dipping, and to validate the model by comparisons with OP urinary metabolites during various dipping procedures. Occupational hygiene evaluations made by observation of work practices and biological monitoring were used to develop the model. Furthermore, methods for improving the control of exposure to OP dips during dipping operations were identified.

This study formed the first part of a three part investigation in to the possible chronic effects associated with OP exposure during sheep dipping. The hypothesis under investigation is that repeated exposures to OP pesticides may cause small increments of damage to nervous tissue, which even allowing for some recovery, may accumulate to the point where it is clinically relevant.

The study involved one day surveys of twenty dipping sessions at farms mostly located in the Scottish Borders. Each survey involved observation and recording of the activities performed by individuals including: the frequency and extent of handling the concentrate dip; the extent and time of contact with dip wash (working strength dip); protective clothing worn; hand washing; smoking and eating habits, and any other significant incidents. Sheep dippers were also asked to provide urine samples before and after work. These were used to measure metabolites of diazinon to enable an estimate of uptake to be made. Finally, a brief questionnaire on exposure to sheep dip, other pesticides, and relevant aspects of behaviour during the 72 hours prior to the visit was administered to each individual to allow other possible sources of urinary metabolites to be accounted for.

The study found that the most important source of exposure to OPs was contact with concentrate dip, which occurred almost always on the hands and usually as a result handling the concentrate container during the preparation and replenishment of the dipping bath. Levels of urinary metabolites were found to increase with increased handling of the concentrate containers. Larger flock sizes tended to result in more replenishment of the bath and hence more handling of the concentrate. Generally one person at each farm had responsibility for handling concentrate dip, this was usually the paddler, the individual responsible for submerging the sheep in the dip wash.

Increased splashing with dip wash was found to be positively associated with increment in urinary metabolites for a subset of individuals who had not been exposed to concentrate dip. Splashing with dip wash was related to proximity to the dipping bath, and was found to be highest for paddlers, then for chuckers, the individual responsible for manoeuvring the sheep into the bath, and lowest for helpers, the individual responsible for herding sheep toward the bath.

A comparison was made with the results of two earlier studies undertaken by the IOM (Niven *et al*, 1993 and Niven *et al*, 1996) which similarly looked at factors which influenced both exposure and uptake among sheep dippers. These results helped to formulate the structure of the uptake model. The present study confirmed the results of the earlier work particularly in relation to concentrate being the most important source of exposure. The limited observations of exposure to concentrate in earlier studies have been improved upon during this study to allow a quantitative exposure-response relationship to be estimated. A weaker relationship with exposure to dip wash from splashing has also been found in this study as well as in earlier work, confirming that it is also an important source of uptake.

Based on the regression analysis of the factors influencing exposure a model has been proposed for the uptake of OPs during a full sheep dipping session:-

$$\text{Uptake} = a^{*}\text{CONC} + b^{*}\text{DIP}$$

The model requires inputs from the two important sources of exposure identified in the study, CONC representing concentrate and DIP representing dip wash. However, it is acknowledged that other, as yet unconfirmed, sources may have a significant effect on uptake. CONC is the expected number of times concentrate is handled. DIP is the expected time weighted splash score had an individual been observed and data recorded in a manner similar to this study. From the regression analysis which jointly fitted terms for concentrate and dip wash estimates for the coefficients of a and b are 3.6 and 0.2 respectively. This model explains 62% of the variation measured in the present study.

Factors which may result in a more acute exposure and which have not been taken account of in the basic splash scores for concentrate and dip wash include paddlers who plunge dip with their hands and incidents of falling into the bath. Data on uptake for these events is minimal or zero in the present study so if they were to be included in the model estimates of the effects on uptake of these events would be required. Alternatively, scores could be derived based on perceived exposure, and the model used to predict the additional effect of this exposure.

The refined uptake model has been used to develop a questionnaire for retrospective exposure assessment to be used in the second part of the study. It is essential that the information sought by the questionnaire can be reliably recalled by farmers potentially over the duration of a working life. Therefore, surrogate measures of exposure to concentrate or dip wash have been chosen. The factors chosen relate to important aspects of task or behaviour observed in the present study, and are considered to be relatively constant factors, which farmers could recall in relation to specific jobs, for example the task performed, whether they prepared of replenished the bath and the size of flock.

The use of control measures including protective clothing was found to be patchy and fragmented, typical of what is often seen in small businesses. During dipping protective clothing was most commonly worn on the lower body. Gloves were worn by about half of the individuals who handled concentrate, however, none were considered to afford good protection each time the concentrate was handled. An important reason for this was that no individual habitually washed their gloves and as a result concentrate may have permeated the glove material.

Eliminating or reducing skin contact with concentrate dip is considered essential to improve the control of exposure. This could best be achieved by improving the design of concentrate containers, the effectiveness of gloves and the working practices of individuals.

1. INTRODUCTION

1.1 GENERAL INTRODUCTION TO THE EPIDEMIOLOGICAL STUDY

The overall aim of the study is to investigate possible chronic health effects associated with OP exposure. The hypothesis to be investigated is that repeated exposures to organophospate pesticides (OPs) may cause small increments of damage to nervous tissue, which even allowing for some recovery, may accumulate to the point where it is clinically relevant. In order to test this hypothesis it is necessary to consider both intensity and duration of exposure to OPs. It is suggested that an estimate of exposure can be made by considering uptake of OPs per day's dipping and number of days exposed.

The principal aim of the first phase of the study was to develop a model based on observation of task and behaviour of a number of subjects during a single day's dipping session, which could then be applied historically to obtain a retrospective assessment of OP exposure.

Previous field studies of exposure of sheep dipper to OPs have been completed by the IOM, (Niven *et al*, 1993 and Niven *et al* 1996). These workplace studies demonstrated substantial skin contact with the dilute sheep dip solution (Niven *et al*, 1993) (dip wash), which wearing recommended protective clothing substantially reduced (Niven *et al* 1996). Small increases in the levels of urinary OP metabolites were demonstrated after dipping, probably due to skin exposure, but perhaps also from ingestion or from some other source. Higher urinary concentrations were observed amongst workers who handled the OP concentrate. Observations from this work therefore formed the basis for a preliminary uptake model, relating uptake of OPs to simple descriptions of task components.

Direct measurement of exposure is very complex due to the three possible routes of exposure (skin, ingestion and inhalation), and the relative importance of these routes in sheep dipping. Furthermore, measurements of skin exposure (patches and suits) did not predict uptake well in the previous IOM studies (Niven *et al*, 1993 and Niven *et al* 1996). Therefore, post dipping urinary metabolite monitoring was used in this phase of the study as an indicator of individual uptake of OPs in preference to direct exposure measurement. In order to achieve consistency of urinary metabolites across the group of subjects studied, only those farm personnel suing diazinon dips were included.

The factors, identified by modelling of exposure in this phase, which are most commonly associated with increased urinary levels of OP metabolites will be transformed into a set of questions in the second phase of the study. The questions will consider surrogates of exposure, in order to obtain information on retrospective exposure since OPs were first in common use in sheep dips. This information will be used to assess intensity of exposure over the period of interest.

As part of the second phase exposure assessment, information will also be obtained from individuals on duration of dipping over this period of OP usage. The information on intensity and duration of exposure will then be used to estimate individual cumulative exposure. The exposure estimate will be compared against health related data for each individual, to see if there is an association between cumulative exposure to OPs and damage to nervous tissue as hypothesised.

This report describes the first phase of the study, the development and validation of the OP uptake model. The questionnaire development will be described in more detail in the results of the second phase.

1.2 HISTORY OF SHEEP DIPPING PRACTICE

Sheep scab has been a problem for farmers over the centuries. It is a contagious disease caused by a mite which feeds off the skin of the sheep. It is an all year round disease, although mites are more active during the winter. The mites cause intense irritation to the sheep, leading to self-inflicted damage in addition to that caused by mite activity. In an untreated outbreak there will be deaths from starvation and secondary bacterial infection.

Ticks are responsible for potentially fatal illnesses among sheep such as louping ill, tick borne fever and lamb pyaemia. Spring dips are used to control ticks, and dips are often twice as concentrated as those used at other times of the year to control other external parasites. In Scotland there is a second tick emergence in the autumn which can be severe locally.

Blowflies infest the fleece and can create open wounds making the sheep vulnerable to more extensive infection. Summer dipping is used for blowfly control.

Lice and keds cause irritation and fleece damage and generally result in sheep of poor physical condition. Autumn dipping is used to control these parasites.

Plunge dipping as a technique for controlling external parasites was introduced in the early 1800s, and the substances used at that time included arsenic oxide and soft soap. The first commercial dip (William Coopers) was introduced in 1843 and was a powder containing arsenic and sulphur, to which water was added. Over the next century substances used against scab included copper sulphate, boron compounds, tar acid derivatives and sulphur. These substances were also effective against sheep blowfly, lice, keds and ticks. Sheep scab Orders continued to be part of `Diseases of Animal Acts', but the situation deteriorated towards the end of the 19th century with an increasing number of outbreaks.

In Britain compulsory dipping began in 1906, and the substances used were lime, sulphur, arsenicals or phenolics. It was noted that outbreaks of sheep scab were more common between November and March, and MAFF made autumn dipping compulsory. The range of substances listed above continued to be commonly used and there was little progress towards eradication of sheep scab until the approval in 1948 of hexachlorocyclohexane (HCH). It was found that a single dip of this organochlorine derivative at concentrations of 0.013% eradicated the disease, and gave 12 weeks protection against reinfestation. HCH preparations were formulated with high concentrations of phenolics to prevent bacterial degradation.

In 1948 MAFF recommended a singe dip with 0.016% gama-HCH, and this controlled sheep scab, with eradication being achieved in 1952. Another organochlorine DDT had been in use since the 1870s, although its insecticidal activity remained unknown until 1939. DDT and HCH continued to be the most common insecticides used for sheep external parasites. Dieldrin was added to HCH preparations in the mid 1950s after being found to be successful for control of blowfly maggots, lice and keds. It continued to be commonly used until the mid 1960s, and was particularly popular as it easily penetrated fatty tissue, and impregnated not only the same season wool growth, but also next years growth, thus providing residual protection. MAFF were alerted about tissue residues of organochlorines, and concerned about the public health implications, advised farmers that organophosphates were preferred, and organochlorines were gradually withdrawn. Dieldrin was banned in 1965 following the recommendation of the Advisory Committee on Poisonous Substances in Agriculture.

Organophosphates had already been used successfully on cattle to kill warble fly and lice. Dips including chlorfenvinphos and diazinon were available in the 1960s, and by 1970 there were 67 approved formulations, 49 of which contained the organochlorine HCH. Dips containing HCH were still available until the end of 1984.

After 20 years with no outbreaks, sheep scab emerged as a problem again in England and Wales in 1972, possibly on sheep imported from the Republic of Ireland. Sheep scab reappeared in Scotland having been absent since 1941. Since 1972 successful eradication has not been achieved. Due to the re-emergence of scab, compulsory national dipping was reintroduced in 1976.

It was compulsory to dip once a year in mid-summer from 1976 to 1983 inclusive, except in 1980 when it was only compulsory to dip in South West England, and in 1981 when it was only compulsory to dip in England and Wales. Between 1984 and 1988 inclusive, two compulsory national dips were required (midsummer and autumn) each year.

Between 1976 and 1988 inclusive, dipping was subject to supervision. In 1989 the farmer was required to give the local authority prior notification. For the following 2 years no prior notification of dipping was required. Deregulation occurred in mid 1992, a sheep scab Revocation Order was issued, and sheep scab was no longer a notifiable disease. Responsibility for control of sheep scab transferred from MAFF to the livestock holder. The Agriculture (Miscellaneous Provision) Act 1968 and the Welfare of Animals at Markets Order 1990 among other regulations provide sanctions against owners who cause unnecessary suffering to their sheep through failure to treat scab.

HCH remained the only pesticide approved for scab until 1980, when diazinon was also approved. Approval means that the substance is able to eradicate scab following a single dip, and provide at least 4 weeks protection against reinfestation. In 1983 propetamphos was also approved. Organophosphates provide broad spectrum protection against blowflies, lice, keds and ticks, and have also been used for these proposes during a similar timescale. Table 1.1 shows, data from Scottish surveys of pesticide usage on sheep between 1978 and 1993 (Bowen *et al*, 1982, Bowen *et al*, 1983 and Shave *et al*, 1993), and for a number of pesticides examples are given of volumes of dips used and reasons for usage.

Sheep dips are classed as veterinary medicines, which are products licensed under the Medicines Act 1968 for the treatment of animals or any unlicensed product prescribed by veterinary surgeons to treat animals under their care. The sale and supply, but not use, of veterinary medicines are controlled under the Medicines Act by the licensing system. The Control of Substances Hazardous to Health (COSHH) Regulations 1994 is the only legislation presently applicable at the point of use.

Since 1st April 1995, the sale and supply of OP dips has been restricted to those individuals holding a Certificate of Competence, obtained after attending an approved training course. These courses include training in the use of protective clothing.

Although OPs are less persistent than organochlorines such as dieldrin, they require to be applied more frequently, and are potentially more toxic to terrestrial wildlife. They are usually supplied as concentrates in a solvent base and are formulated to enhance adsorption and persistence on the skin and fleece of the sheep. Concentrate dip may contain up to 60% active ingredient, and used to contain up to 20% phenols until the early 1990s. In order to treat scab effectively emersion of the sheep is required for 1 minute. It has been suggested that for short swim baths (length 3-4.3m) this equates with an hourly throughput of 30-80 sheep, and for round swim baths up to 120 per hour.

Effective eradication of scab with OPs is dependent on the correct dilution of concentrate both in the initial dip bath preparation, and on maintenance top-ups. One survey by Blanchflower *et al* (1990), found that up to 68% of prepared dips contained less than the recommended maintenance dose.

Although plunge dipping is still the most widely used technique, other methods and preparations are increasingly being used. Plunge dipping from a pit used to be the most common method used, with the plunger submerging sheep with his hands. More recently this has been replaced by plunge dipping using a dipping stick or paddle. Other techniques now used to apply insecticides include those that utilise a knapsack applicator and spray gun, known as the pour-on method and sheep showers. The synthetic pyrethroid flumethrin was approved as a dip for scab in 1984. Other pyrethroids are effective against other ectoparasites, for example, cypermethrin is available as a pour-on for ticks and lice, and as a spray-on for blowfly maggots. Treatment for headfly are now commonly carried out with pour-ons. Deltamethrin is effective as a spot-on for controlling blowfly larvae, ticks and lice. An insect growth regulator (IGR) cryomazine has also been available as a pour-on since 1989. This is a triazine compound, specifically active against blowfly larvae. There are currently a number of new insecticides under development, including alkylamine derivatives.

1.3 AIM AND OBJECTIVE

This phase of the study set out to define the factors important to the uptake of OP dips during sheep dipping operations. The objectives were:

> To develop a model for uptake of OPs based on simple task, procedural and behavioural aspects of sheep dipping, and to validate the model by comparisons with urinary OP metabolites during various dipping procedures.
>
> Also, to identify, where appropriate, methods for the improved control of exposure to OP dips during sheep dipping operations.

2. STUDY OUTLINE

In order to model the uptake of OP as a function of the dipping session, detailed observation of those factors of task and behaviour which had been identified as relevant in earlier IOM studies were made. In addition, other factors such as size of flock, bath type, container design and use of control measures were noted.

Farm personnel were studied during their usual sheep dipping work. The study was based on twenty surveys, each lasting one day. A total of sixty farm workers were studied, up to four at each study site. Both farmers and contract dippers were included and a range of bath types; long/short swim, circular, circular with island and mobile were investigated.

The surveys took place during summer 1996, mostly in the Scottish Borders. The sites were selected to represent contrasts in activities and work organisation to allow the prediction of the OP uptake model to be tested. Only farms using diazinon dips were selected, as this allowed a more reliable assessment of the impact of variations in task or behaviour than if different OPs were considered.

A short pilot study was planned prior to the start of the main investigation, to include one or two farms.

It was intended to recruit farmers and workers by telephone call or personal visit. In the event, additional help was sought from farming associations. The purpose and procedures of the study were discussed with the farmers and all who agreed to participate were given further written information before provisional dates for the survey were arranged.

Each site survey involved direct observation and recording of the following dipping activities performed by individuals: the frequency and extend of handling the concentrate; the extend and time of contact with dip wash; protective clothing worn; hand washing; smoking and eating habits and any other significant incidents.

Sheep dippers were also requested to provide urine samples before and after the work. These were used to measure metabolites of diazinon to enable an estimate of uptake to be made.

A brief questionnaire on exposure to sheep dip, other pesticides, and relevant aspects of behaviour during the 72 hours prior to the visit was administered to each individual.

All the surveys were conducted during July and August, when the summer dip against blow fly is performed. Spring and autumn dips were not included in the study. Prior to the start of the work sheep dipping experts confirmed that there should be no real difference in the methods employed during the summer dip as opposed to those in spring and autumn.

3. METHODS

3.1 FARM RECRUITMENT

A variety of approaches were used to contact and recruit sufficient farms for the study. In the event of a total of twenty five farms were recruited via one of the following methods:

(i) Names of farmers who may be willing to participate in the study were obtained from several sources. These included both previous contacts made during the earlier IOM studies of sheep dipping practice and other similar work, and new contacts made through discussions with the National Farmers Union, the Scottish Agricultural College, sheep dip manufacturers and suppliers and local farmers. This approach provided 22 farms and was the most successful.

(ii) In conjunction with the National Sheep Association a mail shot was sent out to approximately two hundred farmers in the study area. The response to the mail shot was poor and this approach provided only two farms.

(iii) One farmer was recruited by personal visit. Earlier IOM studies (Niven *et al*, 1993 and Niven *et al*, 1996) had shown this to be an effective method of recruitment, however, it proved to be too time consuming for this study as difficulties were experienced in locating farms which met the study criterion.

Recruitment was difficult as more farmers were using non-OP sheep dips, particularly for the summer dip, or opting to use a pour-on rather than a dip. Some farmers simply did not treat their sheep during the summer months. In addition, as only farms using a diazinon-based dip were suitable for the study, several farmers who used OPs and were otherwise willing to participate had to be excluded.

Contacts with prospective participants were usually made by telephone call by one of two IOM occupational hygienists who were to be responsible for the surveys. Telephone calls were normally made at lunchtime or in the early evening as experience suggested that this was the best time to speak to farmers. The occupational hygienist described the purpose of the study and the survey procedure to the farmer. The initial telephone contact aimed to establish the following:-

(i) the farmer's willingness to participate in the study;

(ii) whether the farmer intended to dip in the summer with an OP;

(iii) the name of the product used for dipping;

(iv) the type of dipping bath used;

(v) number of individuals involved;

(vi) the number of consecutive days dipping;

(vii) the likely date of the first day os summer dipping;

This information was recorded on a specially prepared form (Appendix 1).

Each farmer willing to participate was sent a standard letter (Appendix 2) which described the survey procedure and if possible contained a provisional date for the visit. Farmers were requested to contact the IOM should this date change significantly. Alternatively, regular contact was kept with the farmer until a date could be set.

3.2 PILOT STUDY

Surveys of two dipping sessions were scheduled as a pilot to the main study. The purpose was to refine the survey procedure and the tools used to record observations and information. In the event, minimal refinements were required and as these did not alter the nature of detail of the information gathered the pilot surveys were included as part of the main study.

3.3 FIELD SURVEYS

3.3.1 Survey Teams

The surveys were conducted by two experienced senior occupational hygienists and two occupational hygiene technicians, working in teams of two. Whenever possible the senior hygienists worked as a single team to conduct the surveys. However, the summer dipping period is relatively short, with dipping restricted to fine days only, so some surveys coincided. Under these circumstances two teams were used, each was headed by one of the senior hygienists who was accompanied by a technician. This approach ensured a high level of consistency was maintained between the teams and over time. Prior to the start of the work, all team members received suitable and sufficient information, instruction and training.

3.3.2 Field Survey Procedure

The survey teams undertook to be as flexible and possible with regard to timetabling of farm visits. Consequently, participating farms were contacted at regular intervals to ensure that the survey teams could respond at short notice to the farmers' decision as to when the dipping session was to take place.

As far as possible the team arrived at each farm before preparation for dipping had started, to explain the purpose of the study to each participant and what they were required to do. It was emphasized to each individual that they should follow their usual working practices and not change their work habits due to the presence of the survey team. Individuals were also informed that information collected would be treated as confidential.

Urine samples were requested from each individual at the following times; in the morning before dipping, at the end of the day's dipping, early the next morning and 24 hours later. Each individual was provided with a sufficient number of Sterilin containers, polythene bags, labels and an information sheet about the provision, storage and collection of the samples (Appendix 3). These were posted to the farm prior to the visit in order to ensure that they were available for the provision of the first sample on the morning of the survey. Individuals were requested to record their full name, date of birth, date and time each sample was provided. The samples were collected from the farm by a member of IOM staff on the day the fourth sample was provided. They were transported back to the laboratory in a cool box.

Prior to the start of dipping a short questionnaire was administered to each participant. This enquired about task-related events which had occurred during the preceding 72 hours and which were anticipated in the proceeding 24 hours, to ensure that cumulative effects of exposure were accounted for. It was designed to identify events prior to the survey and immediately after which may have lead to an increased uptake of OPs, producing urinary metabolite levels which were higher than expected (Appendix 4).

During the dipping session observations and records of the following dipping activities were made; the frequency and extent of contact with concentrate dip, the extend and time of contact with dip wash, effectiveness of protective clothing worn, washing, smoking and eating habits and any other significant incidents. Full details of all of the information gathered can be found in Appendix 5 which contains the proforma used to record all observations described above and additional information on weather conditions, and other factors pertinent to dipping practice on the farm. The proforma should be read in conjunction with the protocol (Appendix 6) which provides detailed information on completion of the proforma. The protocol was produced to ensure a high level of consistency was maintained between the survey teams and over time.

Each individual participating in the study was assigned one or more of the following job categories:

(i)	Paddler	The worker who plunges the sheep under the dip
(ii)	Chucker	The worker who feeds the sheep into the dipping bath
(iii)	Helper	The worker who herds the sheep ready to go into the dipping bath

At some farms work was arranged so that individuals changed jobs during dipping. Where an individual spent about equal amounts of time in two or more jobs for the majority of the dipping session all relevant jobs were recorded as `principal jobs'. Any additional jobs which were carried out for more than half an hour in total were recorded as `subsidiary jobs' (Appendix 5, section 4).

Observations on the extend of contamination with concentrate and dip wash, the protection afforded by own and protective clothing and washing were recorded using a matrix format which enabled information for several body zones to be recorded. A matrix was completed every time an individual came into contact with concentrate dip (Appendix 5, section 5) and at regular intervals (maximum four) during the dipping session to record extend of contamination with dip wash (Appendix 5, section 7).

Each individual was provided with a colour coded armband to wear throughout the survey. The colour code corresponded to pages in the proforma where specific information about an individual's exposure was recorded. This minimised the likelihood of errors in recording observations and made the proforma easier to use in the field.

With the agreement of those involved in dipping video recordings and photographs were taken during the survey to support the direct observational records.

3.4 URINE ANALYSIS

3.4.1 Analysis of Urinary Dialkylphosphates

The method developed by the Health and Safety Executive's Occupational Medicine and Hygiene Laboratory (Nutley and Cocker, 1993) was used to assess exposure to organophosphorous pesticides. The method involves the derivatisation of azeotropically distilled urine with pentafluorobenzylbromide and analysis by gas chromatography with flame photometric detection.

When urine samples were returned to the laboratory they were counted and the information provided with them was scrutinised for ambiguities and anomalies by an occupational hygienist. A small number of samples were not returned as individuals failed to provide a sample. After checking, the samples were logged onto a batch control sheet and frozen. The first three samples provided by each individual were analysed. The fourth sample was not analysed, but held in storage for use later if additional information or urinary metabolite levels was required.

The frozen urines for each batch of samples to be analysed were thawed at room temperature and a 1ml aliquot transferred to a screw-capped test tube. 200 ìl of working strength dibutyl phosphate internal standard solution and 6ml of acetonitrile were added. The tube was capped and the sample well mixed before being centrifuged at 3000 rpm for 10 minutes. The supernatant was decanted into a clean test tube containing 15-20 anti-bump beads and evaporated to dryness under a stream of nitrogen on a water bath maintained at 90°C. Approximately 50 mg of anhydrous potassium carbonate was added to each tube along with 0.6ml acetonitrile and 25 ìl of pentafluorobenzylbromide. The tube was capped securely and heated overnight at 50°C. The sample was then transferred to a septum sealed vial and analysed by gas chromatography with a flame photometric detector operated in the phosphorous mode (GC/FPF). The GC was fitted with a 30 metre HP1701 capillary column and programmed to heat from 140 to 280°C.

Calibration standards were prepared with each batch of samples using blank urine spiked with known concentrations of diethyl phosphate and diethyl thiophosphate.

3.4.2 Creatinine Determination

The creatinine content of the urine samples was determined using the Jaffe reaction.

A 1ml aliquot of each urine sample was diluted to 15 ml with distilled water. An aliquot of this was reacted with alkaline picrate to produce a yellow/orange colour, the intensity of which was measured using a UV/visible spectrometer set at a wavelength of 500 nm. After acidification the absorption was remeasured. The difference in absorption is proportional to the creatinine content of the urine. The spectrometer was calibrated with known concentrations of creatinine.

3.4.3 Quality Control

Spiked urine samples were prepared on-site at each of the farms. A known volume of urine from one of the dipping team (pre-dip sample) and from an individual not exposed to organophosphorous pesticides were spiked with a known concentration of diethyl phosphate and diethyl thiophosphate. These samples were returned to the IOM laboratory where they were frozen with the other urine samples.

A set of calibration standards was prepared with each batch of samples for analysis. Quality control samples including the farm prepared spikes, additional laboratory spikes, controls and at least one duplicate sample from each farm were analysed after each set of five samples. The detection limits for DEP, DEPT and creatinine and inter-assay variation coefficients are given in Appendix 7.

For creatinine, the spectrometer was calibrated for each batch of samples analysed and at least one sample from each farm was analysed in duplicate.

3.5 DATA HANDLING

3.5.1 Data Entry and Validation

The forms from observation and interview were collated by the occupational hygienist and forwarded for data processing as a batch for a farm. The batch was checked at each stage from receipt by Systems and Computing Section through data entry, data validation, and on to the file extracted for statistical analysis to confirm that the expected number of records were carried forward.

The documents recording the results from urinary metabolite analysis were supplied by the laboratory as two batches one for the diazinon, the other for creatinine. These contained for each of the individuals at a farm a set of three measurements corresponding to the pre-dipping, end-of-day, and next-morning samples.

A Data-entry Protocol was written defining the fields to be keyed to computer with their set of valid values plus the value to be used if data is missing. A distinction in code was made between missing data and data appropriately non-present (eg. between dipping not observed in the morning and dipping did not take place in the morning). In particular, the Occupational History Questionnaire was a pilot for Phase II and none of it was to be key-entered.

The primary systematic screening was carried out at the time of key-entry by using KE-III software (1993) which was programmed to have the protocol checks of valid ranges and logical consistency.

The data was loaded onto a database implemented in SIR/PC DBMS. Derived values were computed within the database (eg. for metabolites normalised to creatine, initial concentrations of dip wash, etc).

Some across-record checking was carried out subsequent tot he loading of data onto the database. And during the stage of descriptive statistics where outlying or implausible combinations of values were present.

Suspect data was checked against manuscript records, with assistance from the Occupational Hygienist as required. Data was changed only where there was a traceable error. A record was kept of any data which differed from the manuscript (eg. setting metabolite levels to missing when they lay outside acceptable bounds), who authorised it and the date. In addition the manuscript was marked with the changes, the date, and who made them. This was done without obscuring any original entries (or blanks).

3.5.2 Data Retrieval for Analysis

Retrievals were written to provide the required variables in a form suitable for analysis, and made available to the statistician with appropriate descriptive documentation. The data forwarded for statistical analysis used study identifiers, not names of individuals or farms. (However, names were maintained on the database to ensure traceability of the identification).

Individuals were labelled for the data analysis stage by farm number (1 to 25 but non-consecutive) and within-farm worker number (1 to 4 consecutively but depending on the number of individuals at each farm). Therefore, an individual labelled 10/1 denotes farm worker 1 on farm 10.

3.5.3 Computer Hardware and Systems Security

Data collected during the project was organised and stored on suitable PCs within the IOM and Standard Operating Procedures (SOPs) dealing with modification and access to the data (integrity protection), and backups of the data (security against loss) were followed (Appendix 8).

3.5.4 Data Archiving

It is intended that for 3 months after the submission of this report the data will be available in active files, it will then be archived. The manuscript records on which the IOM has collected data from farms will be archived and retained for at least 10 years. Computerised versions of data collected or measured by the IOM, and associated documentation, will be archived in accordance with the current Systems and Computing Section SOP (with an amendment to retain data for 10 years, as agreed with the sponsors). Laboratory measurements will be preserved in accordance with current SOPs for Laboratory practice.

3.6 DATA ANALYSIS

The uptake of organophosphates of individuals during the observed dipping session was measured using the increment in levels of the summed urinary metabolites diethyl phosphate (DEP) and diethyl phosphorothioate (DEPT) from pre-dip to post-dip urine samples. The urinary metabolites were first corrected for the levels of creatinine in the urine and expressed as nmol per mmol of creatinine. As is common practice, over-diluted urine samples (creatinine <0.5g/l) or over-concentrated samples (creatinine >3g/l) were rejected (Alessio *et al*, 1985). Where either of the urine samples had not been returned or creatinine measurements had fallen outside acceptable limits, then the increments were treated as missing values.

The increment in levels of urinary metabolites was related to observed exposure on the day of dipping and other variables and factors which may have had an effect on uptake. Pre-dip urinary metabolites were also separately related to responses to a short questionnaire asking about OP-related activities during the three days prior to the day of dipping.

Three routes of exposure to OPs were identified and quantified as exposure indices. These were exposure to concentrate added to the bath, exposure to the dip wash in the bath from splashing adn exposure to both concentrate and dip wash via ingestion whilst eating, drinking and smoking during the dipping session.

Exposure to concentrate was quantified using the number of concentrate handling events. A handling event was defined to be a single episode when an individual handled a container containing concentrate or an implement contaminated with concentrate, or when concentrate was spilled directly onto an individual by some other means. The total number of such events formed the most basic exposure index. The protection afforded by gloves worn during each handling event was recorded so that the total number of handling events could be broken down by whether no, poor, fair and good protective gloves were worn at the time of handling.

Exposure to dip wash was based on a time-weighted splash score derived from the observed data on the proforma. At four regular time points throughout the dipping session a snapshot picture of the degree of splashing on each individual was made for each of ten body regions. Scores were assigned to each region (0=no splashing, 1=splashed, 2=soaked) and the summed across the regions. Also recorded for each region was the protection afforded by the clothing worn at the time (none, poor, fair or good). A crude splash score was then the average of the four snapshot scores. This average score was multiplied by the length of time spent dipping by an individual to give a time-weighted splash score. The time-weighted splash score is an attempt to quantify, through observation, cumulative exposure to dip wash via splashing (ie. average concentration x time). The presence and protective quality of the clothing worn at each snapshot was noted and so the time-weighted splash score could be split into components splash scores which quantify cumulative splashing onto no, poor, fair and good quality protective clothing.

Exposure to concentrate and dip wash via ingestion was based on the number of times an individual had something to eat, drink or smoke during the dipping session. The number of these events that occurred after and individual had washed his/her hands was also recorded.

Other variables and factors which were recorded and which may be associated with the above routes of exposure were farm-specific like bath type, percent of diazinon in concentrate and number of sheep dipped, and others were individual-specific like principal task, and whether an individual washed at the end of the session. Special events which may have resulted in unusual levels of exposure were recorded and were used to help flag individuals whose exposure did not fit expected patterns.

Uptake, as measured by the increment in urinary metabolites, was examined in relation to the exposure indices using a combination of scatter plots a nd multiple linear regression, carried out within the BMDP PC software package (BMDP Statistical Software, 1994). Scatter plots of uptake against exposure were used to identity outlying and influential points which could result in spurious linear regression output. Sine this was an observational study, correlation was used to determine the degree of association, and hence the potential for confounding, among the exposure indices. Exposure indices were cross-tabulated by other factors, which may act as surrogates for exposure, and the associated analysis-of-variance (ANOVA) was carried out using the Genstat software package (Genstat 5 Committee, 1987). Graphical figures were produced using Sigmaplot (Kuo *et al*, 1993). Unless otherwise stated, tests of statistical significance were based on a 5% significance level.

4. RESULTS

4.1 SUMMARY FINDINGS FROM PARTICIPATING FARMS

A general summary of findings from all participating farms can be found in Appendix 9. This includes information on the characteristics of the dipping sessions, the dipping facilities, the dips used, dipping methods, job titles, control measures, protective clothing, pre and post dipping activities and ingestion events. Associated photographic records can be found in Appendix 10 and specific information about each of the participating farms can be found in Appendix 11.

Tables 4.1 to 4.4 provide information on the main characteristics of each dipping session. Table 4.1 details general characteristics of the dipping session by farm including bath and product type, quantity of concentrate used, number of sheep dipped and duration of the dipping session. Table 4.2 provides a summary the main features of the containers used to supply concentrate dip. Table 4.3 describes the control measures in place at each farm and Table 4.4 provides a summary of the protective clothing worn by individuals and the protection afforded. Appendix 12 provides a more detailed account of the protective clothing encountered.

4.1.1 Sources of Exposure to Concentrate Dip

Contamination with concentrate dip on the hands or fingers, or gloves, when worn, occurred almost every time a concentrate container was handled. In the majority of cases contamination was minor, however, more significant contamination occurred if individuals were careless when pouring out concentrate dip.

Contamination usually occurred because the design of concentrate containers resulted in some residual liquid being left on the container after pouring. In particular, small quantities of residue collected around the neck of the opening and on the cap, which was usually replaced each time after handling. If spillage occurred during pouring a larger quantity of liquid was held on top of the container and the sides became contaminated too.

Containers were handled most often to fill or replenish the dipping bath. On occasions, contact with contaminated measuring jugs during this task led to further contamination of individuals' hands. Open containers were also handled to wash them when empty and to carry them to storage at the end of the dipping session. Very little unnecessary contact with containers was observed.

Contamination with concentrate dip rarely occurred on other parts of the body. On four occasions splashing was recorded on the legs or feet and on one occasion on the face.

4.1.2 Sources of Exposure to Dip Wash

This most significant source of exposure to dip wash was splashing as sheep entered the bath and were submerged below the dip wash. The extent of splashing to each individual was most dependent on their proximity to the dipping bath, but working practices and the effectiveness of screens and splashboards were also influential. Some individuals were visibly soaked by splashing, while others remained relatively dry.

The work carried out by individuals determined their position in relation to the dipping bath and therefore, the amount of splashing. In general, paddlers received the most splashing, in particular on their legs and feet. Lower legs and feet were often recorded as soaked, although splashing usually occurred on all body parts. Two paddlers (03/1, 06/2) who submerged sheep by hand from a pit received the most splashing. Their hands, and most other body parts soon became soaked as dipping progressed. At a small number of farms waist height screens were positioned around the bath and these appeared to defect some splashing from the paddler. Screens across the entry to the bath also helped to reduce splashing.

The extent of splashing to chuckers appeared more variable. Proximity to the bath and working practices were again the most important influences. In general, sheep were either put manually into the bath or encouraged onto a slip way from where they slid in. The former method usually required individuals to spend longer at the bath side where splashing was greatest. The speed and manner by which sheep were introduced to the bath also influenced splashing, with fast work rates and lack of care putting sheep in the bath producing more splashing. In general chuckers received less splashing than paddlers. The lower body was most often splashed although splashing was observed on all body parts during the course of the study. Screens across the entry to the bath appeared to offer some protection to chuckers from splash back.

Helpers received the least amount of splashing, principally because they worked away from the dipping bath and the source of contamination. Some helpers remained dry throughout the session while others received limited splashing on various body parts.

A less important source of contamination was contact with the treated fleece or aerosols from it. When sheep left the bath they were always collected in draining pens, where they usually shook their fleece vigorously to remove excess dip wash. All except one site (farm 10) had pens away from the workers or high sided screens to control this source of exposure. On occasions, however, sheep shook their fleece on leaving the bath, prior to reaching the pens, resulting in additional contamination of the paddler. Although not all farms had remotely operated draining pen gates, most individuals took care when manually releasing sheep to avoid contact with a treated fleece.

Finally, a small number of individuals were observed carrying out post dipping activities, mostly emptying and cleaning the dipping bath. The extent of contamination appeared to be limited during the performance of these tasks.

4.2 UPTAKE OF OPs AMONG INDIVIDUALS STUDIED

The measured concentrations of urinary metabolites DEP and DEPT were summed, then corrected for creatinine levels, and Table 4.5 shows summary statistics for these two metabolites across individuals, both separately and summed, for the pre-dip, post-dip and next morning samples. Summary statistics are also given for the increment in the urinary metabolites from pre-dip to each post-dip sample. Pre-dip urinary metabolites were low (median 5.7 nmol/mmol) with 22 out of 54 for whom we have urine samples having no detectable levels of DEP and DEPT. Levels were higher in both samples after dipping, with a median increment of 12.8 nmol/mmol from pre-dip to first post-dip sample, and a median increment of 9.0 nmol/mmol to the next morning sample. Five individuals recorded increments of greater than 100 nmol/mmol with 385 nmol/mmol (to first post-dip) and 127 nmol/mmol (to next morning) being the highest.

In the statistical analysis uptake was estimated using the increment from pre-dip to next morning samples. Some negative increments were recorded where metabolites were detected in the pre-dip sample and there was some evidence that uptake for those with high pre-dip levels would be underestimated using a crude increment. Therefore, it was decided to restrict analysis of uptake and exposure to individuals whose pre-dip urinary metabolites were less than 40 nmol/mmol and this had the effect of excluding four individuals with non-missing urinary metabolites.

Pre-dip metabolite levels were related to responses to a short questionnaire on specific activities which might have resulted in exposure to OPs during the three days prior to the observed dipping session (Appendix 4). Table 4.6 shows the mean urinary metabolites for those answering 'yes' or 'no' to basic questions asking whether the individual had participated in sheep dipping, both cleaning or draining, use of pesticides and contact with animals. This shows that the means for those responding 'yes' to sheep dipping were clearly higher than those responding in the negative, although very small numbers participated in this activity. In fact, small numbers were recorded as having participated in each of the four activities and there was some overlap of responses which made separating out the effects of the sources of OPs difficult. Using a multiple regression approach, having adjusted for the activity of sheep dipping, non of the other three activities could explain further the variation in pre-dip urinary metabolites. Among the 34 individuals who responded that they had not participated in any of the four above-mentioned activities, 17 (50%) had non-detectable levels of urinary metabolites. Of the remaining 50%, several had urinary levels much greater than zero, including one with a measured concentration of 57.1 nmol/mmol, the maximum across all categories of response.

4.3 RELATIONSHIP BETWEEN OBSERVED EXPOSURE AND UPTAKE

The exposure indices for concentrate, dip wash and ingestion were analysed in relation to individuals' uptake as measured by the increment in urinary metabolites. The subset of those with no missing urine or exposure data (n=42) was used to determine the relative importance of the routes of exposure.

The simplest concentrate exposure index, total number of handling events, appeared to be positively associated with uptake (Fig 4.1). The linear trend of this association depended heavily on one individual, 10/2, with the greatest number of concentrate handling events (22) and the highest increment (127 nmol/mmol). Another individual, 15/1, who had higher than expected uptake was noted to have had additional exposure to concentrate through the handling of contaminated clothing which was not taken account of by the concentrate exposure index. The slope coefficient of the least-squares regression line was highly influenced by the presence of these individuals. Table 4.6 summarises the fit of this single exposure index to uptake. Under this simple model, it is assumed that there is exposure to, and uptake of, a consistent amount of concentrate at each handling event, that is equivalent to approximately a 4 nmol/mmol increment in urinary metabolite over a 24-hour period.

This simple linear model accounted for 56% of the overall variance in uptake, or 64% with the outlaying individual 15/1 omitted. As can be seen in Table 4.7, this figure is inflated by the presence of individual 10/2 which is highly influential in determining the fit of the model to the data. No significant increase in explained variation was observed when the total number of handling events were categorised by the condition of the gloves worn while handling as shown in Figure 4.2(a)-(c), although separating out the effects of clothing was difficult due to the collinearity of the exposure variables. On most occasions when gloves were worn they afforded only fair or poor protection and this was reflected in the high correlation (r=0.89) between total number of handling events and the number of handling events wearing poor/fair gloves (Table 4.9). This confirmed that these gloves, which were of poorer quality and condition than the fully recommended protective gloves, did not provide an effective barrier to contamination. The exposure indices based on wearing no gloves, and good gloves, were not greatly correlated with the index for poor gloves but neither were good predictors of uptake. No individuals wore gloves which afforded good protection every time they handled concentrate, which made it difficult to assess their effectiveness objectively (Fig 4.2(c)).

Ignoring the outlier 15/1, since we know this person had exposure not recorded as a handling event and its presence tended to unduly influence the regression calculations, all other exposure indices for exposure to dip wash or via ingestion through smoking, drinking and eating, offered no statistically significant improvement to the fit of the model to uptake when included as additional explanatory variables.

Since the effect of concentrate may have masked a weaker effect of exposure to dip wash, and, since usually only a single individual at each farm was responsible for replenishing the bath with concentrate, the effect of exposure to dip wash and via ingestion was investigated for the subset of individuals not observed to have handled concentrate (n=21). Figure 4.3 shows uptake against the time-weighted splash score for dip wash for those who were never observed to have handled concentrate. This suggested a positive association despite some outlying observations. Individuals 17/2 and 23/1 both had high pre-dip urinary metabolites (28 and 26 nmol/mmol respectively) and therefore uptake may have been under-estimated for these individuals explaining their low position on the graph. Table 4.8 summarises the fit of a simple linear regression model using the time-weighted splash score as the single explanatory variable. With the two outliers mentioned above removed the linear model accounted for 32% of the variation in uptake. This low figure was in no small way due to the single individual 10/1. This individual appeared to have higher than expected uptake but no reason could be found for this from observations made on the day of dipping.

This model for those not handling concentrate assumed that uptake increases linearly with cumulative splashing, with dip wash summed equally over all ten body regions regardless of clothing. The slope coefficient, approximately 0.4, is harder to interpret in practical terms than is the case for the coefficient for exposure to concentrate since the splash score takes account of both the intensity of splashing and the time spent dipping. Figure 4.4 shows uptake against the time-weighted splash scores categorised by the quality of the clothing worn at the observation times. All show a similar relationship with uptake since all are moderately correlated with each other (Table 4.10). This was due to individuals wearing protective clothing of varying quality across the different body regions where splashing occurred most often and also removing items of clothing as the session continued.

Since there was evidence of a weak relationship between exposure to dip wash and uptake among a subset of individuals, the exposure index for dip wash was forced into the model for the full data set (n=42) which contained the total number of concentrate handling events as a single explanatory variable. Table 4.9 shows the additive effect of including the time-weighted splash score for dip wash and the total number of handling events together in a linear regression model. Although the effect of dip wash was not statistically significant, including both variables in the model like this gave unbiased estimates of the relative size of the coefficients of the two basic indices of exposure to concentrate and dip wash.

4.4 COMPARISON WITH RESULTS FROM EARLIER STUDIES

A comparison was made with the results of two earlier studies carried out by the IOM which similarly looked at factors which influenced both exposure and uptake among sheep dippers. These results helped to formulate the structure of the uptake model which was further developed in the present study. In the first study (Niven *et al*, 1996), dipping practices were observed at 13 farms where a diazinon dip was used and urine samples analysed for 36 individuals. The second study (Niven *et al*, 1996) was primarily concerned with assessing the effectiveness of the recommended protective clothing. Part of this study included observation of 6 farms using diazinon dips and urine samples analysed for 18 individuals. All individuals in the second, smaller, study wore full recommended protective clothing while, in the first study, as in the present study, very little of the recommended protective clothing was worn during dipping. In both earlier studies splash scores for dip wash were calculated, while exposure to concentrate was observed by recording the person with the principal responsibility for handling the concentrate. Uptake, as in the present study, was measured using the increment in the urinary metabolites DEP and DEPT, from pre-dip to the morning of the next day.

The first study reported that those handling concentrate had significantly higher levels of the urinary metabolites than those who did not. Correlation between splash scores for dip wash and uptake was poor, but was not adjusted for exposure to concentrate. It was reported that chuckers and paddlers had much higher mean uptake than helpers. There was also a suggestion that operators of linear baths had higher mean uptake than operators of circular or mobile baths.

The NOAH study reported two individuals, a paddler and a chucker at the same farm, with very high urinary increments of 128 and 227 nmol/mmol. In an attempt to explain these results it was observed that the paddler had been splashed with concentrate and that the session had been very long at this particular farm. No significantly higher uptake was observed in those who handled concentrate in comparison with those who did not. A significant positive association between uptake and dip wash splash score, adjusted by ignoring splashing onto areas covered by protective clothing, was observed after omitting the two outliers.

Table 4.11 shows summary statistics for uptake in the two earlier studies and the present study, with individuals categorised by principal task. For comparison purposes, those recorded as paddler/chuckers in the present study have been grouped with paddlers, and similarly chucker/helpers have been grouped with chuckers, since the earlier studies did not make these distinctions. Those with pre-dip urinary concentrations greater than 40 nmol/mmol have been excluded across all studies.

The present study found that paddlers experienced by far the highest mean increments in urinary metabolites (mean 42.7, SE 9.4) compared with chuckers (mean 6.2, SE 2.5) or helpers (mean 5.3, SE 3.7). Comparison of median increments between the present study and the first study show that paddlers had lower uptake in the first study than in the present study while chuckers, and helpers, had higher uptake in the first study than in the present study. This can be explained by the fact that in the present study, 14 of the 18 paddlers in Table 4.10 were principal concentrate handlers. In the first study around half of the paddlers (7 out of 13), and a similar proportion of the chuckers (5 out of 10), were observed to have handled concentrate. Additionally, in the first study one helper was observed to handle concentrate. In the second of the earlier studies uptake for the three principal tasks gave a similar picture to that for the first study, although concentrate was handled by the paddler at all farms.

In summary, the present study has confirmed the results of the earlier studies particularly in relation to concentrate being the most important source of exposure. The limited observations of exposure to concentrate in earlier studies have been improved upon during the present study to allow a quantitative exposure-response relationship to be estimated. A weaker relationship with exposure to dip wash from splashing has also been found in the present study as well as in an earlier study suggesting that this is also an important route of contamination. Analysis of uptake differences due to principal task suggest that this factor, used as a simple surrogate for uptake, may not be adequate and an attempt should be made to quantify the degree of exposure to both concentrate and dip wash separately.

4.5 REFINED UPTAKE MODEL

Based on the regression analysis of the factors influencing exposure in section 4.3, a proposed model for the prediction of uptake of OPs during a full sheep-dipping session is:-

$$\text{Uptake} = a*\text{CONC} + b*\text{DIP}$$

This model requires inputs for the two important sources of exposure identified in this study, CONC representing concentrate and DIP representing dip wash. However, it is acknowledged that other, as yet unconfirmed, sources may have a significant effect on uptake. CONC is the expected number of times concentrate is handled. DIP is the expected time-weighted splash score had an individual been observed and data recorded in a manner similar to this study.

From the regression analysis which jointly fitted terms for concentrate and dip wash estimates for the coefficients *a* and *b* are 3.6 and 0.2 respectively. As a model for uptake, as was measured by the increment in urinary metabolites DEP and DEPT, this explains 62% of the variation measured in the present study, during which a single dipping session was observed at a representative selection of farms.

Factors which may result in a more acute exposure and which have not been taken account of in the basic splash scores for concentrate and dip wash during any particular dipping session include paddlers who plunge with their hands and/or feet and incidents of falling into the bath. Data on uptake for these events in minimal or zero in the present study so effects if they were to be included in the model would require estimates of the effect of these special events on uptake. Alternatively, a dip wash splash score, or concentrate handling score, could be derived based on perceived exposure, and the model used to predict the additional effect of this exposure uptake.

4.6 VARIABLES INDIRECTLY RELATED TO UPTAKE

Direct assessment of the effect on uptake of many of the behavioural and environmental factors recorded is clouded by the measures of individual exposure to dip wash and, in particular, with exposure to concentrate which was found to be the strongest effect. Therefore, variables like the weather conditions, bath type and control measures used do not help explain variation among individual dippers since some will have handled concentrate and others not at all farms and hence at all levels of these variables. For principal task, where clearly paddlers experience the greatest uptake, the problem is confounding since, as described in section 4.4, paddlers were observed to have handled concentrate far more often than those employed in the other tasks. Since for retrospective exposure estimation, it will not be possible to quantify exposure to concentrate and dip wash directly. Indirectly methods will be required to produce inputs for the two sources of exposure which make up the uptake model.

Earlier studies suggested that splashing may be related to principal task and bath type. Table 4.12 shows the number, mean and standard errors of the time-weighted splash scores cross-tabulated by principal task and bath type. As might be expected, there is a decrease in mean splash score from paddler to chucker to helper, with the mean for paddler/chuckers falling between the means for paddlers and chuckers and the mean for chucker/helpers falling between the means for chuckers and helpers. This confirms the prior expectation that, due to the nature of the work within each task and their proximity to the dipping bath, paddlers are splashed more with dip wash than chuckers, and both are splashed a great deal more than helpers. A two-factor analysis-of-variance indicated that principal task and bath type both, independently, accounted for differences in the (square-root transformed) splash scores. As well as confirming the differences in the amount of splashing among principal tasks, this also confirmed that splashing was lower for circular baths (with or without islands) than for linear baths, with mobile baths resulting in the least amount of splashing, as was suggested in the earlier studies.

Table 4.13 shows mean splash scores as predicted by the fitted two-factor model with principal task and bath type as independent effects. For simplicity, and bearing in mind the need for retrospective exposure estimation, those whose principal task was paddler/chucker have been grouped with paddlers, and similarly chucker/helpers have been grouped with chuckers. It is unlikely that in retrospective exposure estimation that dual roles will be identifiable. To quantify retrospective exposure, these predicted means can be used as inputs for exposure to dip wash in the overall model of uptake if questions about principal tasks and bath types are asked about periods of time which make up an occupational history of sheep-dipping.

Surrogate variables for handling concentrate are more difficult to determine. It was almost always true that one person was solely responsible for handling concentrate during the dipping session. In this study by far the most common reason for handling concentrate was to replenish the bath during dipping which took account of 81% of the total of 178 handling events. Handling events during bath preparation accounted for a further 10% of the total. Regular replenishment was recommended by the dip manufacturers to ensure that the dipping bath remained at the correct dilution throughout the session. Table 4.14 shows the mean number of concentrate handling events by task across all individuals at all farms and, separately, for the subset of individuals who had the principal responsibility for replenishment of each farm. Overall, paddlers had a mean of 7 handling events compared to a mean of 1 for chuckers and less than 1 for helpers. This was due to paddlers being, in the main, the person with principal responsibility for handling concentrate at 14 out of the 20 farms visited. Among all those with principal responsibility for handling concentrate, regardless of task, there was a mean of 8 handling events throughout the dipping session.

It was suggested that, since replenishment of the bath was the major reason for handling concentrate, and that this was a regular occurrence that should depend of the number of sheep passing through the bath, the number of concentrate handling events might be associated with the size of the flock to be dipped. Figure 4.5 shows the total number of concentrate handling events at each farm against the size of the flock dipped. Farm 20 is labelled since it appears to be atypical, given the size of the flock and the relatively few occasions when the concentrate was handled. A positive statistical relationship between handling events and flock size is apparent for the remaining farms. The slope of the least-squares line fitted to this data translates to 1 handling event per 140 sheep. The slope is lower at 1 handling event per 100 sheep when farm 20 is omitted from the calculations, and this appears to fit the trend better in the remaining farms. This latter rate is also more comparable with the concentrate manufacturers' instruction which recommend replenishment every 50 or 60 sheep passing through the bath.

If the model is to be used for retrospective exposure estimation, it is of interest to assess how well the date support the model if estimated values as described above are used as inputs for CONC and DIP. Assuming a concentrate handling event every 100 sheep only for the person principally responsible for handling concentrate at each farm as an estimate of CONC, and the predicted mean splash score for the correct combination of task and bath type for all individuals as an estimate of DIP, a similar linear regression model for uptake to that described in section 4.3 was fitted. Using the complete set of 42 individuals estimates of the coefficients for CONC and DIP were 2.59 (SE 1.04) and 0.18 (SE 0.21) respectively and explained 25% of total variation in uptake (as defined by R^2, the square of the multiple correlation coefficient). Excluding the previously-defined outliers (15/1, 17/2 and 23/1), gave estimates of 2.81 (SE 0.94) for CONC and 0.01 (SE 0.22) for DIP and 28% of the variation explained. The fit of this model to uptake can be improved by omitting the concentrate handler at farm 20, where it was previously noted that an atypically low number of handling events had been observed. The model coefficient for CONC remains close to that estimated using the actual measured exposure indices. The coefficient for DIP is very low, as before, although effectively zero when the outliers are removed. It would, however, appear to be intuitively correct to retain a variable for dip wash in the model to reflect the exposure of those who do not handle concentrate which, although translates to a very low level of uptake during a single dipping session, over the course of a working life may result in a significant level of cumulative exposure. It is proposed then that for retrospective exposure estimation, when estimates of the exposure indices are used, the values of the coefficients for CONC and DIP to be used should be the same as those described in section 4.5.

A fuller discussion of percent variation explained in relation to surrogate measures of exposure can be found in Appendix 13.

5. DISCUSSION

5.1 REVIEWING THE AIMS

It has been possible to develop a model for uptake of OPs based on observation of task and behaviour during sheep dipping, although it has been difficult to quantify the impact of certain aspects of task or behaviour due to limited information on these factors in the study sample assessed, or because of the more powerful impacts of specific aspects of task and behaviour masking weaker effects.

For example there was limited information on significant incidents, such as falls in the dipping bath, or plunging with hands or feet. There was limited information on the impacts of personal habits such as smoking or eating during dipping. Aspects of the PPE worn by all individuals was assessed as offering less than adequate protection, and thi swas particularly true for gloves in relation to concentrate handling. Therefore it is likely that the protection afforded by adequate protection clothing has been underestimated based on this group of subjects.

The results of the study did however confirm the importance of concentrate handling on uptake of OPs as assessed by post dipping urinary metabolite levels. It was also possible to identify a weaker but significant effect from exposure to dip wash. Both these factors have been incorporated into the model, with a weighting for their relative importance.

Bath type and principal task were found to be related to the degree of splashing with dip wash. Although there was no significant association between flock size and individual OP uptake, it is thought that flock size might be a useful surrogated for bath replenishment, and this is discussed in more detail below.

It has therefore been possible to validate some of the findings from earlier studies, and the results of urinary metabolite levels for this population show a consistent and significant relationship with concentrate handling events and extent of splashing with dip wash. As previously stated the model explains 62% of the variation in this particular study, which analysed a single days dipping across a representative selection of farms.

It is acknowledged that the model does not explain all of the variation between individuals. It is likely that some variation can also be explained by the impact of factors which have been difficult to quantify in this study for reasons discussed above. In addition some variation will arise due to variation in absorption, metabolism and excretion of OPs between individuals and laboratory measurement error.

5.2 INTER-INDIVIDUAL VARIATION

In addition to the variation in task and behaviour which has been shown to be related to individual differences in the uptake of OPs, there are also differences between individuals in the rate of absorption, metabolism and excretion of OPs which are likely to account for some of the unexplained variation between individuals with apparently similar levels of exposure to OPs.

The main route of absorption considered in this study has been through the skin. Diazinon is assigned a skin (sk) notation by the Health and Safety Executive in their list of Occupational Exposure Limits, indicating recognition that the substance has the ability to penetrate intact skin and become absorbed by the body. The concentration of the substance in contact with the skin and the length of skin contact, are important factors in determining uptake. In relation to this study individual differences in exposure to dip wash and concentrate are of particular interest.

Variations in the rate and extent of skin absorption have been considered in earlier sections in relation to incidents of concentrate handling, soaking with dip wash and the use of effective PPE. The rate of skin absorption is also affected by evaporation from the skin surface as a result of searting, the integrity of the skin barrier, local variations in skin thickness and skin blood flow. Although there will be interindividual variations in skin thickness, particularly on the palms, in general, penetration rates through various skin areas can be ranked as follows, from the most easily penetrated to the most resistant: sole to foot, scrotal skin, palm, back of hand, forehead and scalp, arms, then legs and trunk. All of the factors listed are likely to account for some of the variation between individuals in the rate of absorption of OPs.

Interindividual differences in metabolism of OPs may also account for unexplained variations in urinary metabolites between individuals with apparently similar levels of exposure. Nutley and Cocker (1993) demonstrated that almost 80% of OPs licensed in the UK give rise to one or more of six structurally similar dialkyl phosphate metabolites. The main metabolites of diazinon, the OP used by all subjects in the initial phase of the study, are DEP (an alkylphosphate derivative) and HMP (a pyrimidine derivative, which is specific for diazinon). A further dialkylphosphate metabolite is DEPT. It is likely that these metabolites are produced by different metabolic pathways, and therfore variation in metabolism between individuals will result in a variation in the proportion of each matabolite produced for any given exposure.

Most foreign molecules, such as diazinon, are metabolised by an oxidative mechanism which is catalysed by the cytochrome P450 system. Cytochromes P450 are a family of membrane-bound enzymes which are located within the smooth endoplasmic reticulum (a membrane system) of cells. The liver has the highest concentration of these enzymes, although they can be found in most tissues. One important feature of cytochrome P450 is its inducability. Therefore, exposure to certain substances may lead to an increase in the synthesis of one or more of the enzymes in the P450 group, and may have an effect on the metabolism of a compound and influence its toxicity. Cytochrome P450 activity is influenced by a number of factors which include genetic variations in metabolism, age, alcohol consumption, smoking, medication, nutritional and disease state. The activity of certian enzymes within the group will be induced by variation in one or more of these factors.

Recent studies have suggested that a specific cytochrome P450 enzyme, CYP3A4 is primarily responsible for the activation of another OP, parathion (Mutch *et al*, 1996). This enzyme accounts for 3060% of total liver P450 content, and there is therefore considerable potential for interindividual variation (Iribarne *et al*, 1996). Variation in the levels of this enzyme could account for differences in individual susceptibility to the toxic effects of OPs. A non-invasive method now exists for *in-vivo* determination of CYP3A4 in humans (Ged *et al*, 1989).

It has been shown in animal studies that the toxicity of pesticides is related to the balance between activation (toxic) and deactivation (detoxification) pathways. It is thought that DEP and HMP are produced as the result of an activation pathway, where the intermediary metabolites produced have a potentially greater toxic effect than the parent compound. It has been shown that cytochrome P450 mediated metabolism can significantly increase t he anti-cholinesterase potential of the intermediate by comparison with the parent compound (Mutch *et al*, 1996).

It is though that DEPT is most likely associated with the deactivation pathway of diazinon. This is more likely to be mediated by esterases in the blood. This pathway is less likely to be affected by individual variation as there is usually an excess of this type of enzyme activity. Levels of urinary DEPT are therefore less likely to reflect diazinon toxicity. There are other less significant pathways involved in the matabolism of diazinon. A failure of this detoxification system could result in increased toxicity if more of the parent compound was metabolized by activation pathways, although due to the abundance of blood esterases, this is unlikely to occur in practice.

It is also recognised that differences in voiding patterns could also result in interindividual variation in urinary metabolites. The collection of 24 hour urine samples, although perhaps the method of choice, was not practical in this study. Individuals were instructed to provide samples immediately prior to dipping, immediately post-dipping, and the first void the following morning. Creatinine correction was used to adjust for misleading effects of differing degrees of hydration. Correcting the urinary concentration of the substance being studied for that of creatinine (as a ratio of concentrations) fully removes the hydration effect. Since urinary volume is the denominator for both concentrations in this ratio, this factor is cancelled and need not be considered. It is acknowledged that the stability of urinary creatinine excretion has been challenged in recent studies. However, this method still reduces interindividual variation, provides results which can be compared with other studies, and reflects currently accepted practice.

Therefore, there are several factors which might explain some of the variation between individuals not explained within the study, and methods are now available to address some of these issues in more detail.

5.3 RETROSPECTIVE EXPOSURE ESTIMATION

In developing a tool for retrospective exposure assessment it is essential that the information sought can be reliably recalled by farmers potentially over the duration of a working life. Whilst it might be desirable, based on the information from the first part of the study, to ask about the number of times concentrate was handled, or degree of splashing with dip wash, it is unlikely that this information will e recalled reliably. Therefore surrogate measures of exposure to concentrate and dip wash have been chosen. The factors chosen relate to important aspects of task or behaviour observed in the first part of the study, and are considered to be relatively constant factors, which farmers could recall in relation to specific jobs.

In considering exposure to dip wash for example, exposure varied dependent on the nature of the principal task performed by the individual. It is therefore possible to ask about the proportion of time spent as a plunger, chucker or helper, within each job. The degree of splashing was also found to be related to bath type, although to a lesser degree, and therefore a specific question can be asked about this factor for each job.

When considering exposure to concentrate, it was found that the paddler was nearly always responsible for handling concentrate. Again enquiry can be made about principal task, but as concentrate handling is such a specific event, each individual can be asked about whether they were primarily responsible for that event. The number of time concentrate is handled is related to the rate of bath replenishment. Recommendations are given by manufacturers for bath replenishment based on the number of sheep dipped. Data from the current study suggested one concentrate handling event per 100 sheep. Therefore it is possible that average flock size within each job could be used as an estimate of concentrate handling if it could be recalled reliably.

The `surrogates' of job and flock size explain about 25% of the variation in daily measured uptake of OPs in this first phase of the study. The 100% variation which potentially could be explained, includes the following components;

a. laboratory variations in measured uptake;
b. day-to-day individual variations in exposure
c. systematic individual differences in uptake and metabolism

Whilst these aspects of variation are relevant to the chain from exposure to disease being investigated in the second phase, they cannot even in principle be predicted by the exposure assessment (and exposure assessment in other contexts, eg. studies of chronic lung disease, would not be expected to `explain' this variation).

Consequently, the knowledge that the `surrogates' explain about 25% of daily measured metabolites does not really tell us very much about their usefulness in Phase II. In the second phase, we are concerned with long term or cumulative exposure as a precursor to Chronic disease, and therefore average, rather than daily, variation is the important estimate.

Therefore the more important issue is whether the surrogates used are good determinants of long-term average splashing score and handling events, which are the best predictors of long-term average uptake of OPs, the parameter we are aiming to estimate. For the reasons detailed above, principal task and flock size are good predictors of long-term average splash score, and handling events.

It is proposed to limit questions on PPE to those items most commonly worn; gloves, leggings and wellingtons. Additional questions will be asked on unusual incidents such as falls into the dip bath, and plunging with hands or feet.

As previously stated, information will also be sought on the number of dipping sessions carried out within each job, and how this has varied within each job, in order to estimate duration of exposure in terms of number of dipping sessions during the period of OP usage. For the purpose of initial data collection, the relevant time period would be from 1970 onwards. It is acknowledged that dipping with OPs has become less common since compulsory dipping stopped in 1992, and that peak usage of OPs occurred between the early 1980s and 1992. Although specific attention could be given to exposure during this period, questions about exposure that directly refer to OP sheep dips, if reliably recalled, would preclude the need to partition into periods of likely or unlikely OP usage.

5.4 POWER OF PHASE I TO PREDICT THE EFFECTIVENESS OF PPE

During Phase I, almost all items of PPE observed were classified as affording only limited protection. Therefore, there was very little scope for comparison with the protection afforded by good, even recommended, quality PPE.

The implications for the model, are that we cannot quantify the protective effect of PPE on exposure from the subjects observed in Phase I.

There are however implications for control from the Phase I results. The study suggests that:

a. It is common to observe PPE which does not meet the recommendations suggested by the HSE.

b. PPE is subject to considerable "wear and tear" during dipping activities.

c. PPE which is of appropriate quality may become contaminated by inappropriate use or failure to wash.

The results do show that increasing exposure to concentrate, with a smaller secondary effect from dip wash is associated with increased uptake of OPs. Reducing exposure is dependent on appropriate work practice, and suitable and sufficient PPE. The absence of an identified beneficial effect from the use of less than adequate PPE, observed in Phase I, should not infer that good quality PPE appropriately used will not afford beneficial protection.

A fuller discussion of the options for controlling exposure to sheep dip can be found in Appendix 14.

6. SUMMARY OF MAIN FINDINGS AND RECOMMENDATIONS FOR FURTHER WORK

6.1 MAIN FINDINGS

6.1.1 The most important source of exposure to OPs was contact with concentrate dip which was almost always on the hands. Levels of urinary metabolites increased with increased handling of the concentrate containers.

6.1.2 Increased splashing with dip was found to be positively associated with the increment in urinary metabolites for a subset of individuals not exposed to concentrate.

6.1.3 Generally one person at each farm had responsibility for handling the concentrate and the most frequent reason for handling concentrate was to replenish the bath. Larger flock sizes tended to result in more replenishments of the bath and hence more handling of the concentrate.

6.1.4 Splashing with dip wash from the bath was found to be highest for paddlers and chuckers in comparison with helpers and also found to be higher for straight swim baths than for circular or mobile baths.

6.1.5 Paddlers had higher levels of urinary metabolites in this study compared with two earlier studies (Niven *et al* 1993, Niven *et al* 1996) due to the fact that this group of workers were more likely to have responsibility for handling concentrate as compared with the earlier studies.

6.1.6 The use of control measures was found to be patchy and fragmented and a variety of personal protective equipment was encountered. During dipping protective clothing was most commonly worn on the lower body. Gloves were worn by about half of the individuals who handled concentrate, however, none were considered to offer good protection every time the concentrate was handled.

6.1.7 Eliminating or reducing skin contact with concentrate is key to controlling exposure to OPs. This could best be achieved by improving the design of concentrate containers, the effectiveness of gloves and the working practices of individuals.

6.2 RECOMMENDATIONS FOR FURTHER WORK

6.2.1 Protective gloves should play an important role in controlling exposure to OP dips, however, little information is available on the protection afforded by different gloves types for the variety of sheep dip products on the market. Further investigations are required to investigate break through times at the workplace, together with the effects of washing and wear and tear.

6.2.2 The pyrimidine metabolite of diazinon HMP is produced *via* the CYP3A4 mediated pathway in the liver, and is exclusively associated with diazinon exposure. Further research could consider variations in urinary levels of this metabolite against variations in CPY3A4 activity. A better understanding of inter-individual variability in metabolism of OPs will facilitate the development of exposure-response relationships.

7. ACKNOWLEDGEMENTS

The researchers gratefully acknowledge the support of the U.K. Health and Safety Executive, the Ministry of Agriculture, Fisheries and Food and the Department of Health, in funding this investigation. Particular thanks are also due to the many organisations and individuals who helped at the recruitment stage of this study including; the National Farmers Union and the National Sheep Association. Thanks are also due to Dick Titchener of the Scottish Agricultural College for his advice on sheep dipping practice. Finally, special thanks are due to the farmers, their families and workers who so willingly and cheerfully participated.

8. REFERENCES

Alessio L, Berlin A, Dell'Orto A, Toffoletto F, Ghezzi I (1985). Reliability of urinary creatinine as a parameter used to adjust values of urinary biological indicators.

Blanchflower W, McCracken RJ, Rice DA, Clements A (1990). Survey of levels of propetamphos and diazinon to control scab in Northern Ireland. Veterinary Record; 126:263-5.

BMDP Statistical Software. BMDP New System User's Guide. BMDP Statistical Software Inc., 1994.

Bowen HM, Cutler JR, Craigie IR. A survey of sheep dip usage in Scotland in 1978. (1982). Pesticide Science; 13:563-574.

Bowen HM, Wood J, Mann A. Usage of pesticides on sheep 1983. Survey report 54. Dept. of Agriculture and Fisheries for Scotland. Edinburgh.

Ged C, Rouillin JM, Pichard L, Combalbert J, Bressot N, Bories P, Michel H, Beaune P, Maurel P (1989). The increase in urinary excretion of 6B-hydroxycortisol as a marker of human hepatic cytochrome P4503 induction. British Journal of Clinical Pharmacology; 28:373-87.

Genstat 5 Committee. Genstat 5 Reference Manual. Oxford: Clarendon Press, 1987.

Grandjean P (1990). Skin penetration: hazardous chemicals at work. Taylor and Francis: London.

Iribarne C, Berthou F, Baird S, Dreano Y, Picart D, Bail JP, Beaune P, Menez JF (1996). Involvement of cytochrome P450 3A4 enzyme in the N-demethylation of methadone in human liver microsomes. Chemical Research Toxicology; 9/2: 365-73.

Kuo J, Fox E. Sigmaplot for Windows Users Manual. Erkrath: Jandel Scientific, 1993.

Mutch E, Blain PG, Williams FM (1996). Cytochrome P450 isozymes involved in parathion metabolism in the rat. Human Exp. Toxicol. 15 (8), 687.

Niven KJM, Scott AJ, Hagen S, Waclawski ER, Lovett M, Cherrie B, Bodsworth PL, Robertson A, Elder A, Cocker J, Nutley B, Roff M (1993). Occupational hygiene assessment of sheep dipping practices and processes. Edinburgh: Institute of Occupational Medicine. (IOM Report TM/93/03).

Niven KJM, Hagen S, Scott AJ, Waclawski ER, Cherrie B, Topliss R, Wilkins H, Lovett M, Bodsworth PL, McWilliam M (1996). Occupational hygiene assessment of exposure to insecticides and the effectiveness of protective clothing during sheep dipping operations. Edinburgh: Institute of Occupational Medicine. (IOM Report TM/94/04).

Nutley B, Cocker J (1993). Biological monitoring of workers occupationally exposed to organophosphorous pesticides. Pestic. Sci. 38, 315-322.

Shave PR, Thomas LA, Nevison I. Usage of pesticides on sheep 1993. Scottish Agricultural Science Agency. Edinburgh.

Stephens R, Spurgeon A, Calvert IA, Beach J, Leonard SL, Berry H, Harrington JM (1995). Neuropsychological effects of long-term exposure to organophosphates in sheep dip. The Lancet; 345: 1135-39.

Southern Computer Systems Inc. (1993). Keyentry III reference manuals (4 vols). Birmingham, Alabama. Southern Computer Systems Inc.

TABLE 1.1 Estimates of volumes of certain types of dip made up and reasons for their use (Pesticide usage in Scotland - Scottish Agricultural Science Agency). Data as presented in survey reports for periods listed

1978 Chemical	Volume (10^6) litres used against		
	Ticks	Flies	Scab/lice/keds
Chlorpyrifos	5.03	0.57	1.10
Chlorfenvinphos	0.67	13.30	3.11
Diazinon	0.07	0.77	0.33

1983 Chemical	Volume (10^6) litres used against				
	Ticks	Flies	Scab	Lice	Keds
Chlorpyrifos	2.28	0.30	0.51	0.29	-
Chlorfenvinphos	0.73	8.56	8.40	0.12	-
Diazinon	0.98	3.16	2.86	1.24	0.22

1993 Chemical	Volume (10^6) litres used against				
	Ticks	Flies	Scab	Lice	Keds
Chlorfenvinphos/phenols	-	4.31	0.15	-	-
Diazinon	1.44	6.30	1.77	0.12	-
Propetamphos/phenols	0.21	8.72	6.72	0.54	-

TABLE 4.1 Summary Characteristics of Dipping by Farm

Farm No.	No. of individuals involved	Bath Type	Bath Volume (l)	Product Name	% Active Ingredient	Initial Concentration of Dip Wash (ml/l)	Quantity of Concentrate Used (mls)	No. of Sheep Dipped	Duration of Dipping Session (mins)
01	3	Short swim	825	Coopers All Season Fly and Scab Dip	16	0.39	9650	1000	325
03	3	Short swim	910	Diazadip	60	0.33	2300	600	255
04	3	Circular with island	2200	Diazadip	60	0.41	4500	900	335
05	3	Long swim	4000	Neocidol	60	0.28	9700	1500	360
06	3	Short swim	1350	Diazadip	60	0.40	2380	1400	360
07	3	Mobile	1600	Diazadip	60	0.38	3200	700	155
08	3	Mobile	1138	Coopers All Seasons Fly and Scab Dip	16	0.35	5220	500	160
10	3	Mobile	1137	Diazadip	60	0.28	5150	1500	488
11	2	Mobile	900	Coopers All Seasons Fly and Scab Dip	16	0.44	4900	285	170
13	3	Mobile (Mobidip)	2960	Diazadip	60	0.39	7000	1100	445
14	3	Circular with island	2275	Coopers All Seasons Fly and Scab Dip	60	N.A	3750	800	220
15	3	Long swim	800	Neocidol	60	0.27	1800	400	491
17	3	Circular with island	2500	Neocidol	60	0.30	1640	600	295
18	3	Circular with island	1820	Diazadip	60	0.40	3200	450	195
20	4	Long swim	1700	Paracide Plus	16	0.42	8700	1700	293
21	2	Circular	1700	Coopers All Seasons Fly and Scab Dip	16	0.38	7000	500	265
22	4	Long swim	1820	Deosan Diazinon Sheep Dip	60	0.40	2300	600	235
23	3	Long swim	2730	Deosan Diazinon Sheep Dip	60	N.A	2750	250	290
24	3	Long swim	2275	Deosan Diazinon Sheep Dip	60	0.4	9000	1100	377
25	3	Short swim	1092	Diazadip	60	N.A	1800	420	165

N.A:- Initial Concentration not available as dip wash used from previous day's dipping.

Initial concentration determined by: $\dfrac{\text{Volume of concentrate initially added to the bath} \times \text{\% active ingredient}}{\text{Volume of water initially added to the bath}}$

TABLE 4.2 Summary of Container Features by Farm

Farm No.	Product Name	Container Capacity (L)	Shape	Opening/Pouring Mechanism
01	Coopers All Season Fly and Scab Dip	20	Cylindrical	Ring pull cap with pull up plastic spout. Fixed metal carrying handle with surface identification below.
03	Diazadip	5	Rectangular	Ring pull cap with pull up plastic spout. Plastic handle.
04	Diazadip	5	Rectangular	Ring pull cap with pull up plastic spout. Plastic handle.
05	Neocidol	5	Rectangular	Metal screw cap with secondary metal seal. Wide neck. No pouring mechanism. Fixed metal handle
06	Diazadip	5	Rectangular	Ring pull cap with pull up plastic spout. Plastic handle.
07	Diazadip	5	Rectangular	Ring pull cap with pull up plastic spout. Plastic handle.
08	Coopers All Season Fly and Scab Dip	20	Cylindrical	Metal screw cap with secondary metal seal. No pouring mechanism. Fixed metal handle with surface identification below.
10	Diazadip	2.5	Rectangular	Metal screw cap with plastic pouring trough. Fixed metal handle.
	Diazadip	5	Rectangular	Ring pull cap with pull up plastic spout. Plastic handle.
11	Coopers All Season Fly and Scab Dip	5	Cylindrical	Metal screw cap with secondary metal seal. Plastic pouring trough. Fixed metal handle.
13	Diazadip	5	Rectangular	Ring pull cap with pull up plastic spout. Wide neck. Fixed metal handle.
14	Coopers All Season Fly and Scab Dip	20	Cylindrical	Metal screw cap with secondary metal seal. No pouring mechanism. Fixed metal handle with surface identification below.
15	Neocidol	5	Rectangular	Metal screw cap with secondary metal seal. Wide neck. Plastic pouring trough. Fixed metal handle
17	Neocidol	5	Rectangular	Metal screw cap with secondary metal seal. Wide neck. No pouring mechanism.
18	Diazadip	5	Rectangular	Ring pull cap with pull up plastic spout. Plastic handle.

Farm No.	Product Name	Container Capacity (L)	Shape	Opening/Pouring Mechanism
20	Paracide Plus	10	Cylindrical	Metal screw cap. Pull up plastic pouring spout. Fixed metal handle with surface identification below.
21	Coopers All Season Fly and Scab Dip	5	Cylindrical	Metal screw cap with secondary metal seal. Plastic pouring trough. Fixed metal handle
22	Deosan	5	Rectangular	Ring pull cap with pull up plastic spout. Plastic handle.
23	Deosan	5	Rectangular	Ring pull cap with pull up plastic spout. Plastic handle.
24	Deosan	5	Rectangular	Ring pull cap with pull up plastic spout. Plastic handle.
25	Diazadip	5	Rectangular	Ring pull cap with pull up plastic spout. Plastic handle.

TABLE 4.3 Summary of Control Measures by Farm

Farm No.	Bath Type	Location	Entry Method	Submerge Method	Piped Supply of Clean Water	Engineering Controls						
						Metered System	Race	Screen Across Entry to Barn	Waist Height Splash Boards	High Sided Screens at Exit	Remote Draining Pens	Remotely Operated Draining Pen Gates
01	Short swim	Outside/exposed	Manual	Crook wooden handle	Y	N	N	N	N	N	Y	Y
03	Short swim	Outside/sheltered	Manual	Hands	N	N	N	N	N	N	Y	N
04	Circ. with island	Outside/exposed	Side entry (slipway)	Crook metal handle	Y	N	Y	Y	Y	Y	Y	Y
05	Long swim	Outside/exposed	Side entry (slipway)	Crook PVC sheath handle	Y	N	N	Y	N	N	Y	N
06	Short swim	Outside/exposed	Manual	Hands	Y	N	N	N	N	N	Y	N
07	Mobile	Within trailer	Side entry (slipway)	Crook metal handle	N	N	Y	N	N	Y	Y	Y
08	Mobile	Outside/exposed	Side entry (slipway)	Crook metal handle	Y	N	Y	N	Y	Y	Y	Y
10	Mobile	Within trailer	Side entry (slipway)	Crook metal handle	N	N	Y	Y	Y	N	N	Y
11	Mobile	Within trailer	Side entry (slipway)	Crook wooden handle	Y	N	Y	N	N	N	Y	N
13	Mobile (Mobidip)	Within trailer	Walk-in	Crook wooden handle	Y	N	N	N	N	N	Y	Y
14	Circ. with island	Outside/exposed	Manual	Crook wooden handle	Y	N	N	N	N	N	Y	Y
15	Long swim	Outside/sheltered	Manual	Crook metal handle & feet	Y	N	N	N	N	N	Y	N
17	Circ. with island	Outside/sheltered	Side entry (slipway)	Crook metal handle	Y	N	Y	Y	N	N	Y	Y
18	Circ. with island	Outside/exposed	Manual	Crook metal handle	Y	N	N	N	N	Y	Y	Y
20	Long swim	Outside/exposed	Side entry (Slipway)	Crook wooden handle	N	N	Y	Y	N	N	Y	N
21	Circular	Outside/exposed	Side entry (Slipway)	Crook wooden handle	Y	N	Y	Y	N	N	Y	Y
22	Long swim	Outside/exposed	Manual	Crook wooden handle	N	N	N	N	N	N	Y	N
23	Long swim	Outside/exposed	Side entry (Slipway)	Crook metal handle	Y	N	Y	N	N	N	Y	N
24	Long swim	Outside/sheltered	Slope	Crook wooden handle	Y	N	Y	N	N	N	Y	N
25	Short swim	Manual	Manual	Crook wooden handle	Y	N	N	Y	N	N	Y	N

TABLE 4.4 Summary of Protective Clothing Worn by Individuals

Protective clothing worn during work with dip wash (60 individuals)

	Hands	Face	Hair	Torso F	Torso B	Arms L	Arms U	Legs L	Legs U	Feet
No. of individuals wearing protection	11	12	1	16	12	14	12	52	46	48
Typical protection afforded by clothing where worn	Fair	Fair	Good	Fair	Good	Good	Good	Good	Good	Good

Protective clothing worn during work with concentration (32 individuals)

	Hands	Face	Hair	Torso F	Torso B	Arms L	Arms U	Legs L	Legs U	Feet
No. of individuals wearing protection	14	8	0	13	9	10	9	31	29	28
Typical protection afforded by clothing where worn	Fair	Fair	NA	Good	Good	Good	Good	Good	Good	Good

Note: Information on protective clothing not available for one individual who handled concentrate.

Table 4.5 Summary of metabolites DEP and DEPT measured in urine samples (nmol/mmol creatinine) including standard deviation (SD) and the first and third quartiles (Q1, Q3).

Metabolite	Time	n	Mean	Median	SD	Min	Max	Q1	Q3
DEP	Pre-dip	54	5.7	3.4	6.8	0.0	28.4	0.0	10.4
	Post-dip	48	10.6	6.7	15.1	0.0	85.7	0.0	14.3
	Next Morning	52	15.0	10.4	16.6	0.0	82.4	5.7	17.8
	Post Dip - Pre-Dip	46	5.8	4.5	12.6	-10.6	64.0	0.0	9.4
	Next Morning - Pre-Dip	50	9.5	7.4	14.8	-28.4	60.7	0.8	13.7
DEPT	Pre-dip	54	5.1	0.0	9.7	0.0	47.1	0.0	6.6
	Post-dip	48	27.7	11.2	55.0	0.0	348.0	1.1	29.3
	Next Morning	52	14.3	6.2	22.2	0.0	105.2	0.0	20.0
	Post Dip - Pre-Dip	46	23.2	8.4	53.5	-10.3	321.4	0.0	23.5
	Next Morning - Pre-Dip	50	9.2	1.6	24.7	-32.1	105.2	0.0	14.4
DEP+DEPT	Pre-dip	54	10.8	5.7	14.6	0.0	57.1	0.0	15.8
	Post-dip	48	38.2	14.9	68.2	0.0	433.7	7.8	44.5
	Next Morning	52	29.3	19.2	32.0	0.0	127.6	9.5	38.1
	Post Dip - Pre-Dip	46	29.0	12.8	63.6	-20.9	385.4	0.0	30.4
	Next Morning - Pre-Dip	50	18.6	9.0	32.9	-47.4	127.6	0.0	25.7

Table 4.6 **Summary of Pre-dip Urinary Metabolites (DEP+DEPT) in relation to activities during 3 days prior to the observed dipping session.**

	Response					
Activity	Yes			No		
	Mean	SE	n	Mean	SE	n
Sheep dipping	27.8	5.6	8	7.8	1.8	46
Bath cleaning	11.2	3.1	11	10.7	2.4	43
Use of pesticides	11.3	4.8	11	10.6	2.2	43
Contact with animals after pesticides	19.8	8.6	7	9.4	1.9	47

Table 4.7 **Linear Regression results showing the estimated coefficients after fitting the total number of concentrate handling events (CONC). Standard errors are in parenthesis.**

Data	Reason for Omission	n	intercept	CONC	R^2
All cases	-	42	6.41 (3.81)	4.40 (0.61)	56%
omit 15/1	unobserved conc. contamination	41	5.26 (3.07)	4.13 (0.50)	64%
omit 10/2	highly influential point	40	6.34 (3.10)	3.51 (0.64)	44%

Table 4.8 **Linear regression results showing the estimated coefficients after fitting the time-weighted splash score for dip wash (DIP) using the subset of individuals who did not handle concentrate. Standard errors are in parenthesis.**

Data used	**Reason for Omission**	**n**	**intercept**	**DIP**	**R^2**
All cases	-	21	2.93 (3.99)	0.33 (0.15)	20%
omit 17/2, 23/1	high pre-dip DEP+DEPT	19	4.14 (3.55)	0.39 (0.14)	32%
omit 10/1	outlier	18	1.46 (2.54)	0.44 (0.10)	56%

Table 4.9 **Linear Regression results showing the estimated coefficients after fitting the number of concentrate handling events (CONC) and the time-weighted splash score (DIP) to the full data set. Standard errors are in parenthesis.**

Data used	n	intercept	CONC	DIP	R^2
All cases	42	-2.40 (5.14)	3.10 (0.79)	0.39 (0.16)	62%
omit 17/2, 23/1,15/1	39	3.01 (4.64)	3.56 (0.70)	0.15 (0.15)	65%
omit 10/2	38	4.25 (4.61)	2.90 (0.80)	0.15 (0.15)	45%

Table 4.10 Correlation Matrix of exposure indices for concentrate and dip wash

Concentrate Handled:								
Total	1.000							
No Gloves	0.353	1.000						
Poor/Fair Gloves	0.891	-0.040	1.000					
Good Gloves	0.328	-0.116	0.242	1.000				
Dip Wash Splash Score:								
Total	0.490	0.383	0.368	0.063	1.000			
No Clothing	0.086	0.180	0.037	-0.075	0.759	1.000		
Poor/Fair Clothing	0.393	0.317	0.288	-0.012	0.886	0.606	1.000	
Good Clothing	0.611	0.406	0.482	0.192	0.840	0.475	0.551	1.000

Table 4.11 **Comparison of the levels of urinary metabolites DEP+DEPT (nmol/mmol creatinine) between the present study and the earlier first (Niven *et al*, 1993) and second (Niven *et al*, 1996) studies. SD denotes the standard deviation and Q1 and Q3 the first and third quartiles respectively. Principal tasks are represented by P (Paddler), C (Chucker) and H (Helper).**

	Present Study			First Study			Second Study		
	P	C	H	P	C	H	P	C	H
n	18	15	13	13	9	12	6	6	5
mean	42.7	6.2	5.3	17.2	36.2	6.5	39.5	47.8	14.2
median	36.8	6.7	0.9	13.0	16.0	5.5	17.5	14.8	9.0
SD	40.0	9.6	13.3	13.8	51.7	6.4	49.2	87.8	20.3
min	-6.4	-15.3	-14.2	0.0	4.0	-1.0	1.0	2.0	-4.5
max	127.6	21.7	38.6	48.0	146.0	16.0	137.5	226.5	49.0
Q1	10.3	0.0	0.0	9.5	6.0	0.0	12.5	7.2	1.5
Q3	75.1	13.9	11.4	26.0	60.5	12.0	64.8	71.3	29.5

Table 4.12 **Time-weighted Splash Scores for Dip wash showing the mean, standard deviation (in brackets) and number of observations (in italics) for each combination of principal task and bath type.**

Task	**Linear**	**Circular**	**Mobile**	**All Baths**
Paddler	68.2 (27.6) *8*	50.3 (10.5) *4*	47.1 (31.4) *5*	57.8 (26.5) *17*
Paddler/Chucker	49.6 (0.8) *2*	48.9 (*) *1*	* (*) *0*	49.4 (0.7) *3*
Chucker	53.3 (37.5) *4*	39.8 (19.5) *3*	* (*) *0*	47.5 (29.7) *7*
Chucker/Helper	43.1 (23.6) *6*	39.4 (1.3) *2*	15.4 (7.4) *3*	34.9 (21.2) *11*
Helper	17.0 (14.5) *8*	2.8 (3.3) *4*	4.6 (6.4) *6*	9.8 (12.1) *18*
All Tasks	44.7 (30.3) *28*	32.8 (22.3) *14*	22.1 (26.8) *14*	36.1 (28.8) *56*

Table 4.13 **Predicted means and 95% confidence intervals for time-weighted splash score after fitting additive model for principal task and bath type.**

	Linear		**Circular**		**Mobile**	
Paddler	66	(52, 81)	49	(35, 66)	39	(26, 55)
Chucker	44	(32, 57)	31	(19, 45)	23	(12, 36)
Helper	10	(5, 17)	4	(1, 11)	2	(0, 6)

Table 4.14 Mean number of concentrate handling events by principal task for all individuals and, separately, those with principal repsonsibility for handling concentrate at each farm

Task	All		Principal Handlers	
	Mean	n	Mean	n
Paddler	7.2	18	9.2	14
Paddler/Chucker	3.0	3	4.5	2
Chucker	1.1	7	7.0	1
Chucker/Helper	1.9	14	5.0	3
Helper	0.3	18	*	0
All	3.0	60	8.0	20

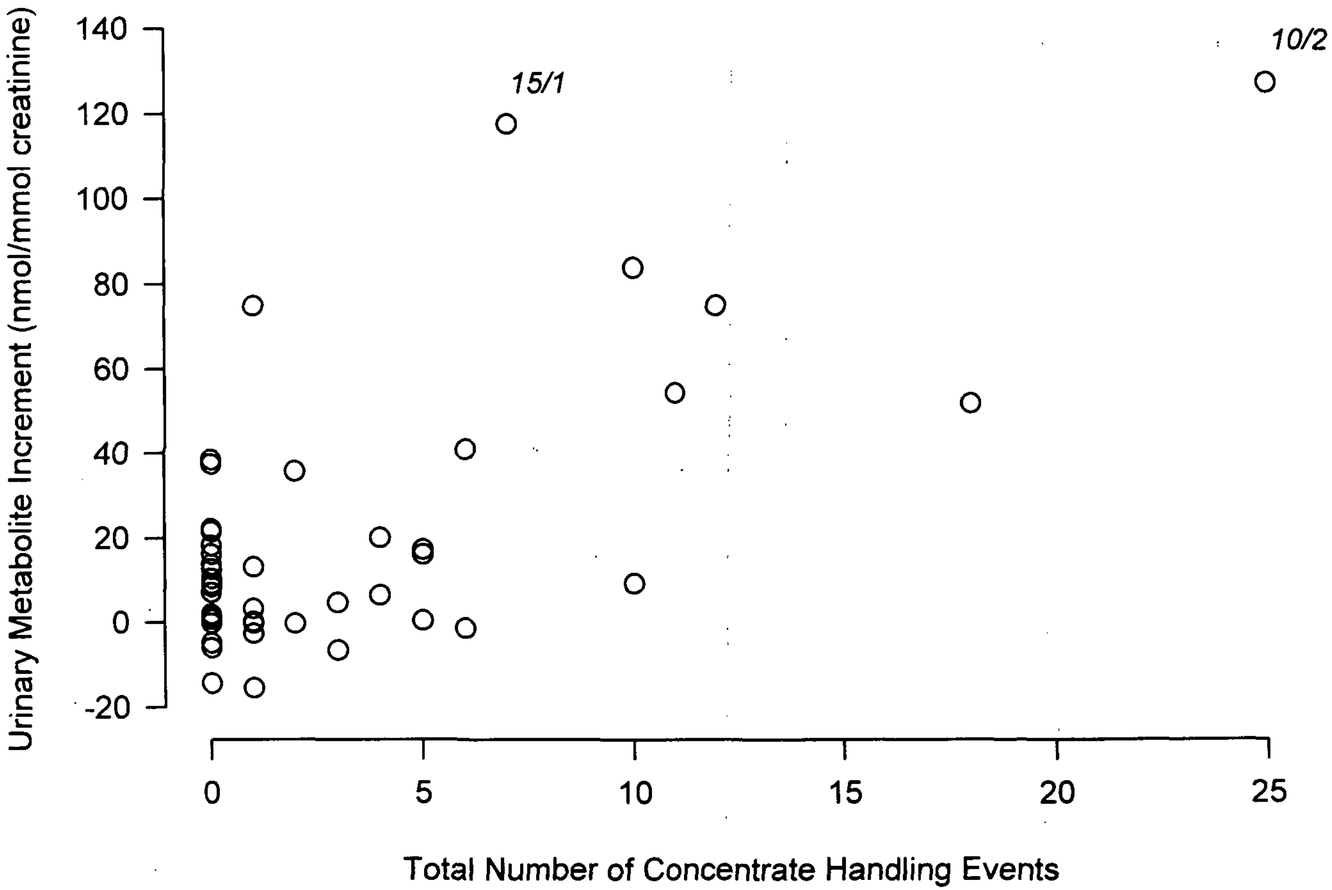


Figure 4.1 Scatterplot showing the relationship between uptake and number of times that concentrate was handled

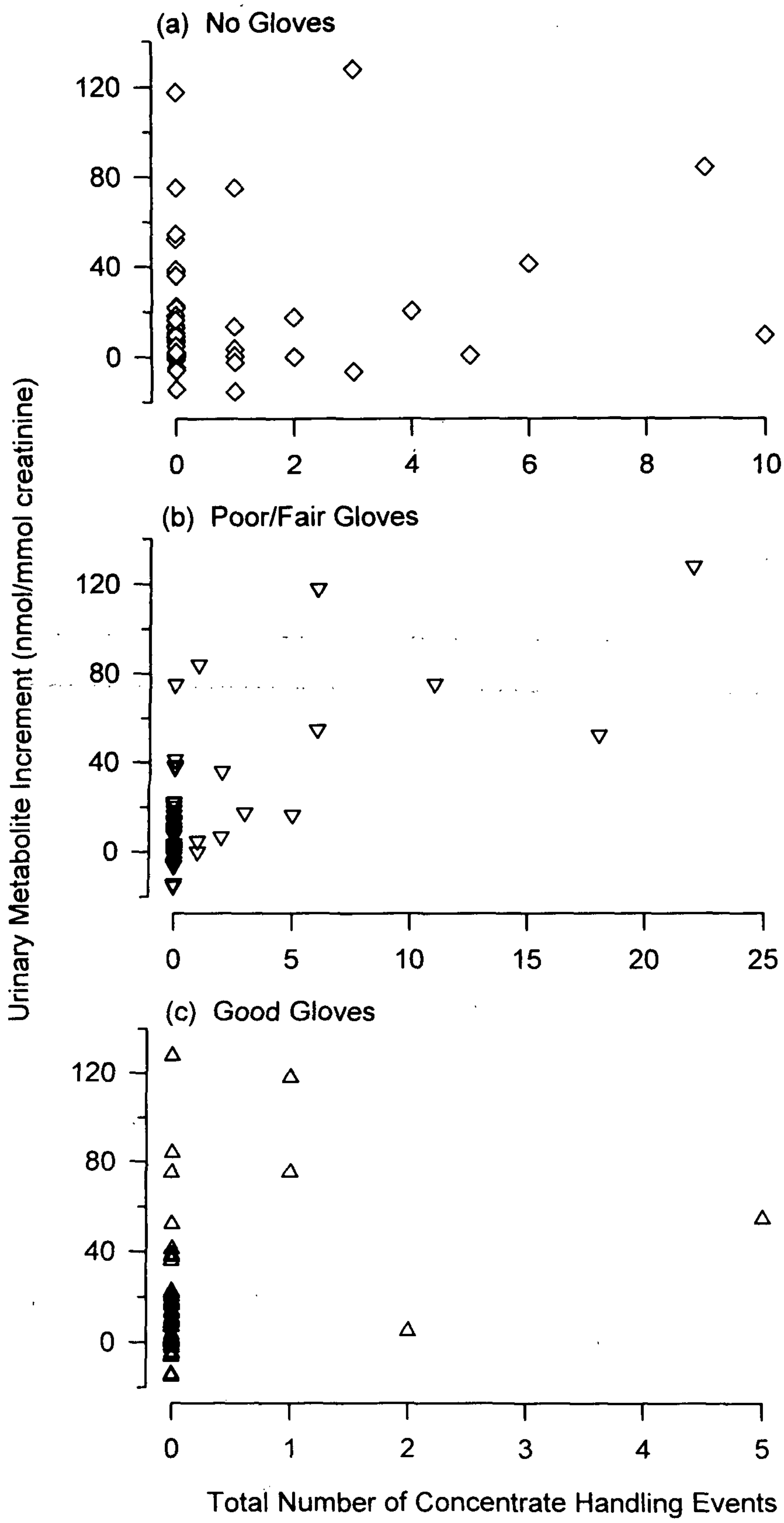


Figure 4.2 Scatterplots showing the relationship between uptake and number of concentrate handling events while wearing good and poor/fair quality gloves and no gloves

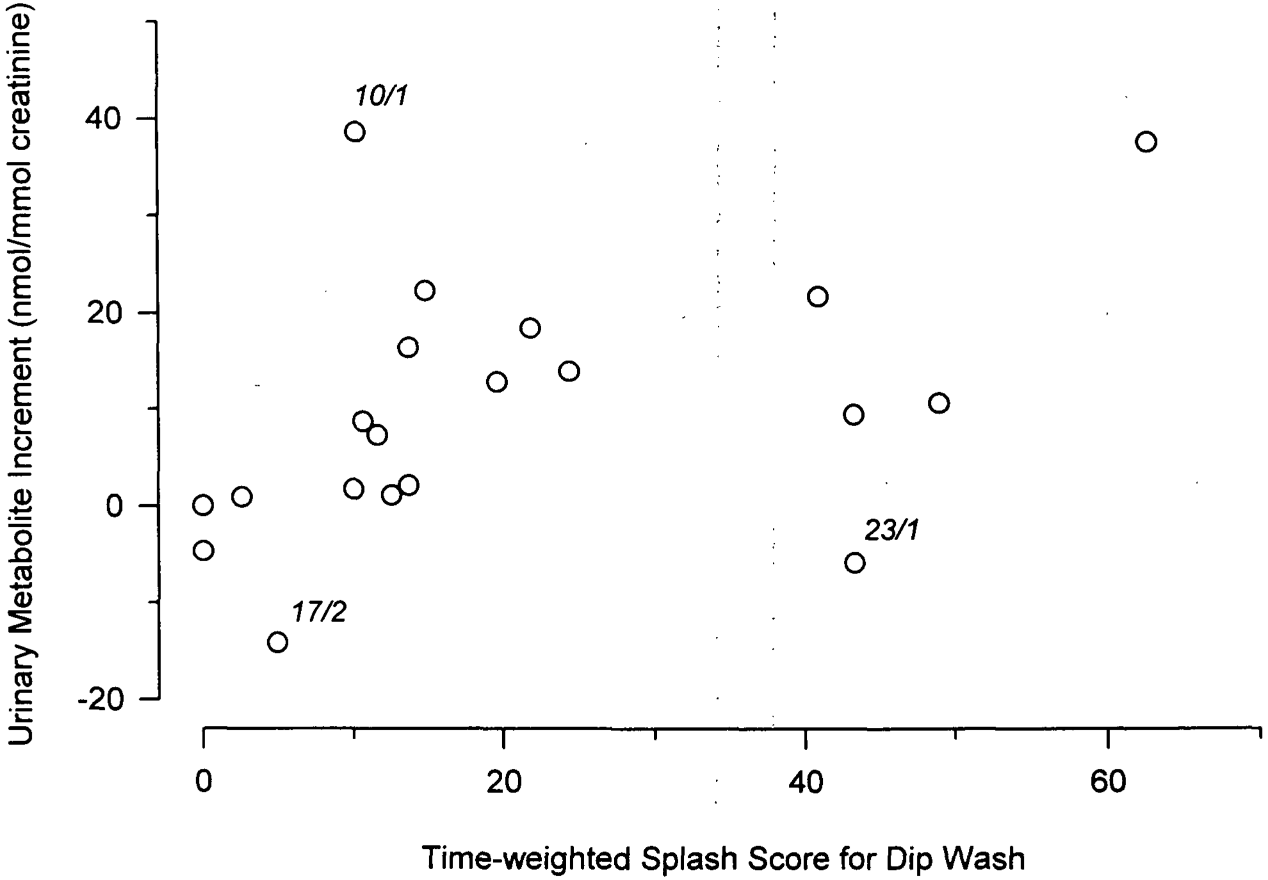


Figure 4.3 Scatterplot showing the relationship between uptake and time-weighted splash score for those who did not handl e concentrate.

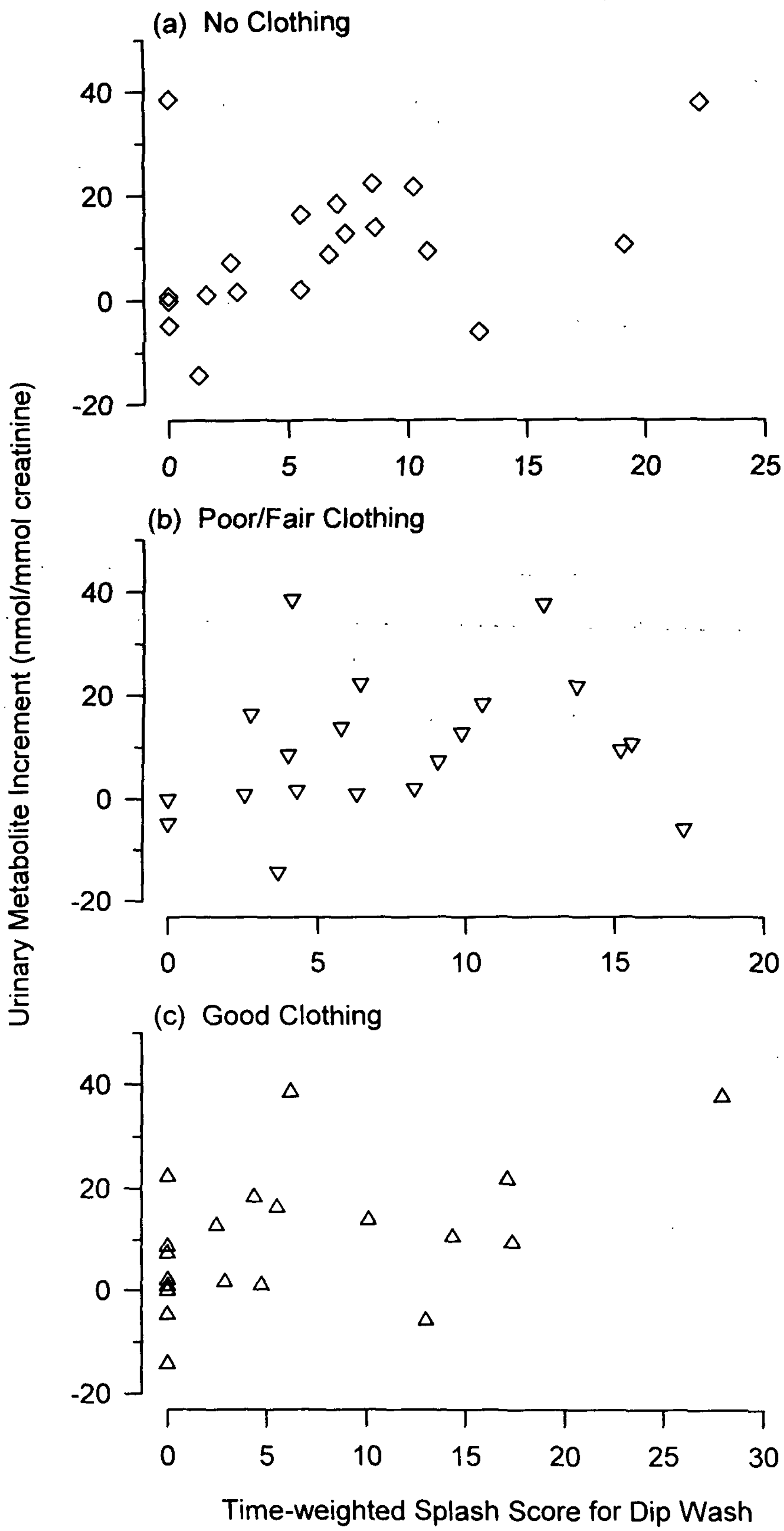


Figure 4.4 Scatterplots showing the relationship between uptake and time-weighted splash score for dilute dip wash summed across body regions protected by good and poor/fair quality clothing and no clothing.

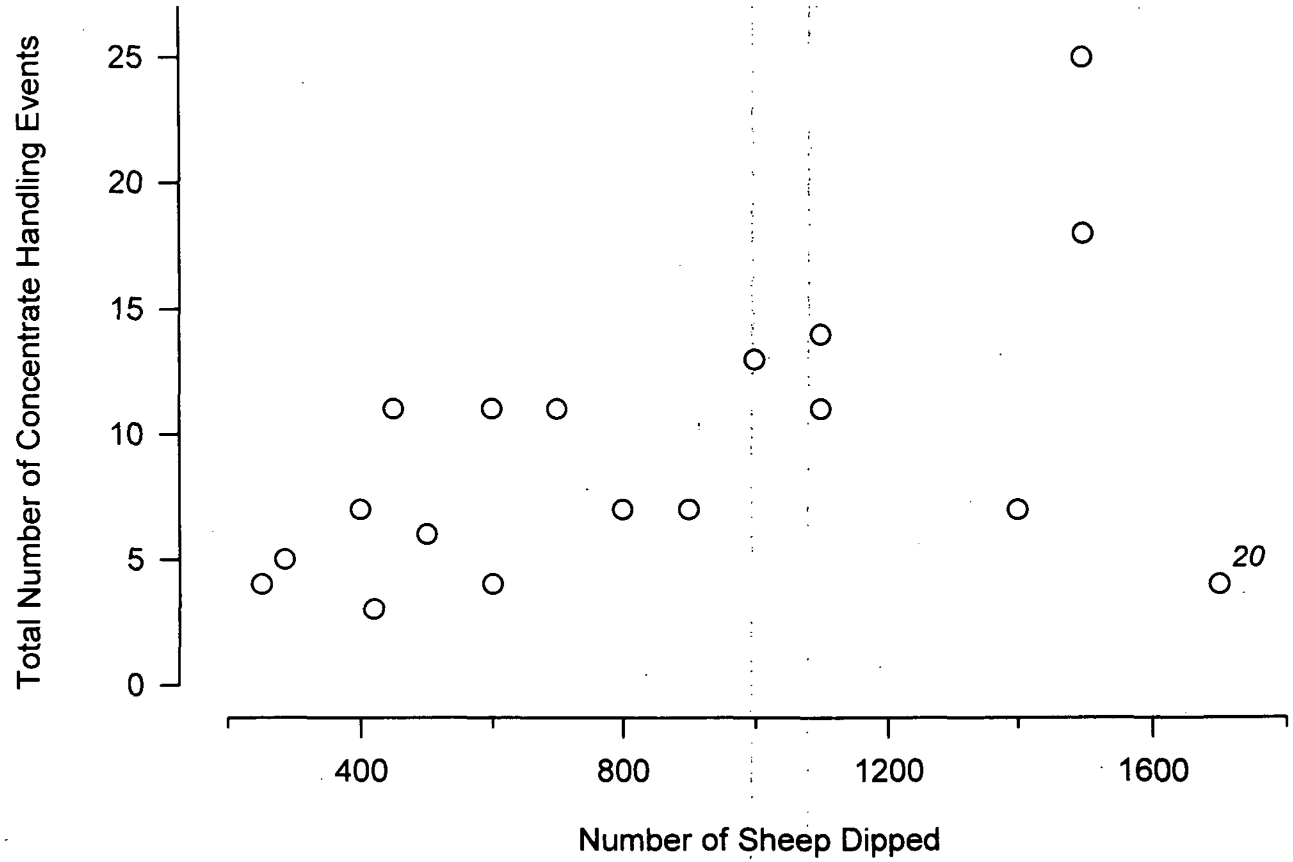


Figure 4.5 Scatterplot showing the relationship between total number of concentrate handling events at each farm and size of flock dipped.

APPENDIX 1

OP UPTAKE

FARM RECRUITMENT

CONTACT NAME	
FARM ADDRESS	**Telephone Number:**
Source	

INFORMATION

1. Does the farmer intend to dip in summer?	YES / NO
2. Product used for dipping	
3. Type of bath	
4. Likely number of consecutive days dipping	
5. Likely date of first day of dipping	
6. Number of people likely to be involved with dipping	
7. Is the farmer willing to participate in the study?	YES / NO

OTHER INFORMATION

DATE:
HYGIENIST: **SUITABLE/UNSUITABLE**

APPENDIX 1 (Cont.)

ARRANGEMENTS TO CONTACT FARMER

1. Follow-up letter	Date sent:	ACTIONED ....
2. Re-contact farmer 1 week prior to survey	Date:	ACTIONED ....
3. Contact farmer day before survey	Date:	ACTIONED ....

SURVEY DETAILS

Date of survey:	Anticipated start time:
Location / Directions:	
OTHER INFORMATION	

SUMMARY OF TELEPHONE CONVERSATIONS

DATE	CONTACT	SUMMARY	INITIALS

APPENDIX 2

Dear

Study of Sheep Dippers' Health

Thank you for agreeing to take part in our study of sheep dippers' health. The work is being carried out by the Institute of Occupational Medicine (IOM), an independent research charity based in Edinburgh, together with the Institute of Neurological Sciences (INS) in Glasgow. The study is supported by the Health and Safety Executive, the Ministry of Agriculture, Fisheries and Food and the Department of Health.

A colleague and I would like to visit your farm on a day when you are dipping sheep with an organophosphate dip. We would hope to spend the whole day with you, or at least while you are dipping. We will watch and make notes about the dipping process, and with your agreement take photographs and make a video recording. For your part, we would like you to follow your normal working procedures so that we can get a clear picture of sheep dipping practice.

When you have finished dipping for the day we will ask you some questions about the type of work you have been doing since leaving school or college, and in particular about sheep dipping.

Finally, we will ask each person involved in dipping to provide us with some urine samples both before and after dipping. We will provide containers for this.

I should mention that individual farms will not be identified in our report and all personal information will be treated with the utmost confidence.

I understand that you are likely to be dipping your sheep around *********. I will contact you by telephone about a week before this date to confirm arrangements for our visit. In the mean time if you have any questions about the study, or think that you may be dipping earlier than you first thought, please do not hesitate to telephone me at the IOM. The number is 0131 667 5131.

Thank you again for agreeing to take part in the study. I am sure it will provide some useful information on this important subject. I look forward to meeting you in the summer.

Yours sincerely

Christine Sewell
Occupational Hygienist

APPENDIX 3

INFORMATION FOR SHEEP DIPPERS ABOUT URINE SAMPLES

As part of our study of sheep dippers' health we would like you to provide us with some urine samples.

The samples are a very important part of our study because they tell us how much, if any, of the dip has been taken into your body on the day of our survey.

We would like you to provide **four** samples around the following times:

1) On the morning of our survey before any work with sheep dip is done.

2) The same day when all sheep dip work has finished.

3) First thing in the morning on the day after our survey.

4) The next day, first thing in the morning. (Approximately 24 hours after sample No.3)

You will have been provided with some containers in which to provide your samples. Additionally you should also have some polythene bags and labels.

Each time you provide a sample please record the following information on one of the labels provided:

- Your full name
- Your date of birth
- The date the sample was provided
- The time the sample was provided
- Whether the sample will be stored in the fridge

Next stick the label onto the container and place it into one of the bags provided.

If possible store the samples in a fridge. The samples will be collected by someone from the IOM. Please remember to leave them at the place agreed with the survey team.

Thank you for your help.

APPENDIX 4

Questionnaire to Determine Recent Exposure to OPs Prior to Farm Visit

IOM (12/7/96)

Farm code number ☐ 1

Individual's name and code ☐

The following questions are about the work you have been doing in the **three days** prior to our visit. It is important that you tell us all about this work because it may affect the urine samples you are providing. Remember these questions are only about the work you have being doing in the **three days** prior to our visit.

1. Have you been involved in sheep dipping prior to our visit? Y/N ☐

☞ *If no go on to question 7, if yes continue.*

2. Did the dipping take place on this farm? Y/N ☐

3. What task(s) did you perform? *(circle appropriate numbers)*

paddler	1
chucker	2
helper	3

4. Did you work with the concentrate? Y/N ☐

☞ *If no go on to question 6, if yes continue*

5. Did you wear protective gloves whilst working with the concentrate? Y/N ☐

6. Were you involved in any accidents or incidents involving concentrate dip or dip wash? Y/N ☐

If yes record what happened. Free text.

7. Have you been involved in cleaning or emptying the dipping bath or draining pens? Y/N ☐

APPENDIX 4 (Cont.)

8. Have you applied any pesticides to animals, crops, or buildings? Y/N ☐

If yes record proprietary name(s)

9. Have you been in contact with animals on the same day that they were treated with a pesticide? Y/N ☐

If yes record proprietary name(s).

The following questions are about the work you expect to be doing tomorow. It is important that you tell us about this work because it may affect the urine samples you are providing.

10. Will you be involved in dipping sheep tomorrow? Y/N ☐

11. Tomorrow, will you be involved in cleaning or emptying the dipping bath or draining pens? Y/N ☐

APPENDIX 5

OP Uptake Model
Form for Recording Information and Observations During Farm Visits
IOM (12/7/96)

Section 1: General Information

1.1 Farm number. [|]

1.2 Date of assessment (ddmmyy) [| |]

1.3 Assessor's names

Surname	Forename

1.4 Contact name

Surname	Forename

1.5 Telephone number (include code) [ ]

1.6 Farm name and address.

Post Code [ ]

Section 2: Information about dipping on the farm

2.1 Total number of dipping sessions during 1995 using (a) OP's [|]
(b) pyrethroids [|]

2.2 Total number of dipping days during this session [ ]

2.3 Number of dipping days already completed prior to visit [ ]

2.4 Proprietary product used for this dipping session

Name of Product	Batch Number	Date of Manufacture	Expiry Date

2.5 Date of last shearing (ddmmyy) [| |]

APPENDIX 5 (Cont.)

Farm number: [|]

For completion at the end of the dipping session

2.6 Total quantity of concentrate used (mls) [| | | |]

2.7 Approximate number of sheep dipped during the visit [| | |]

2.8 Duration of dipping session. *(Include all activities)* (mins) [| |]

APPENDIX 5 (Cont.)

Section 3: Dipping facilities, methods and conditions

Farm number. [|]

Facilities

3.1 Type of bath: *(circle one number)*

long swim	1
short swim	2
circular with island	3
circular without island	4
mobile	5
other (specify).	6

[ ]

3.2 Date bath was last cleaned (ddmmyy) [| |]

3.3 Volume of bath (litres) [| | |]

3.4 Location of bath: *(circle one number)*

outside /exposed	1
outside / sheltered	2
covered (open sides)	3
within building	4
within trailer	5
other (specify)	6

[ ]

3.5 Method of entry into bath: *(circle one number)*

manual	1
side entry (slip way)	2
slope	3
other (specify)	4

[ ]

3.6 Meter systems used to transfer concentrate from the container into the bath? Y/N. [ ]

3.7 Race to guide sheep to the bath? Y/N [ ]

3.8 Screen across dip entry slope to deflect splashes? Y/N/D(*=does not apply)* [ ]

3.9 Waist height splashboards alongside bath? Y/N. [ ]

3.10 High sided screens at the exit from the bath? Y/N. [ ]

APPENDIX 5 (Cont.)

Farm number.

3.11 Type of crook handle: *(circle one number)*

metal	1
wooden	2
rubber	3
other(specify)	4

3.12 Draining pens away from the workers? Y/N.

3.13 Remotely operated draining pen gates? Y/N.

3.14 Piped supply of clean water? Y/N.

Methods

3.15 Description of how the product is added to the bath. (Free text)

3.16 Bath replenishment: *(circle one number)*

manual	1
automatic	2
other (specify)	3

3.17 Description of how the bath is replenished. (Free text)

APPENDIX 5 (Cont.)

Farm number. [|]

Weather Conditions

3.18 Predominant weather condition: *(circle one number)*

dry - sunny	1
overcast	2
damp	3
drizzle	4

3.19 Wind condition: *(circle one number)*

still	1
breezy	2
gusting	3

3.20 Air temperature: Dry bulb (°C) [| •]

Wet bulb (°C) [| •]

3.21 Relative humidity (%) [|]

APPENDIX 5 (Cont.)

Section 4: Individuals involved in dipping

Farm number: | 1 |

4.1 Individuals taking part in dipping during the visit.

(Record name and principal job title(s), i.e. paddler, chucker, helper. In addition record any subsidiary jobs carried out for 0.5 hour or more. Tick appropriate boxes.)

Name and Forename	Code Num	Principal Jobs			Subsidiary Jobs		
		P	C	H	P	C	H
	1						
	2						
	3						
	4						

APPENDIX 5 (Cont.)

Section 5: Contact with concentrate

*Section 5 must be completed for **all** individuals who handle the concentrate and **each time** handling occurs.*

5.1 Farm and Individual's code number

Time of Handling *(24 hour clock)*

5.2 Reason for handling concentrate: *(circle up to two numbers)*

preparation of dipping bath	1
replenishment of dipping bath	2
storage of concentrate at end of dipping session	3
cleaning up spillage,	4
accidental contact,	5
other (specify)	6

5.3 Contamination with concentrate caused by: *(circle appropriate numbers)*

no contamination	0
spills	1
splashing	2
contact with contaminated container	3
contact with other contaminated implement(s)	4
face wiping	5
other (specify)	6

5.4 Information about contact with concentrate:

	HANDS	FACE	HAIR	TORSO (F)	TORSO (B)	ARMS (L)	ARMS (U)	LEGS (L)	LEGS (U)	FEET
Protection offered by own clothing (0-not worn, 1-poor, 2-fair, 3-good										
Protection offered by protective clothing (0-not worn, 1-poor, 2-fair, 3-good)										
Extent of contamination with concentrate dip (0-dry, 1-splashed, 2-soaked)										
Skin washed before continuing work (y-yes, n-no)										

APPENDIX 5 (Cont.)

Section 6: Routes of Ingestion

6.1 Farm and Individual's code number

6.2 Information about eating, drinking and smoking during observation

Time	Event: E-eating D-drinking S-smoking	Contact with C-conc. D- dip	Washes Hands Y-yes N-no
| | |			
| | |			
| | |			
| | |			
| | |			
| | |			
| | |			
| | |			
| | |			
| | |			

APPENDIX 5 (Cont.)

Section 7: Contact with dip wash

7.1 Farm and Individual's code number

7.2 Information about contact with dip wash:

Middle of morning session Session started at:

	HANDS	FACE	HAIR	TORSO (F)	TORSO (B)	ARMS (L)	ARMS (U)	LEGS (L)	LEGS (U)	FEET
Protection offered by own clothing (0-not worn, 1-poor, 2-fair, 3-good										
Protection offered by protective clothing (0-not worn, 1-poor, 2-fair, 3-good)										
Extent of contamination middle of morning session (0-dry, 1-splashed, 2-soaked)										

End of morning session Session ended at:

Protection offered by own clothing (0-not worn, 1-poor, 2-fair, 3-good										
Protection offered by protective clothing (0-not worn, 1-poor, 2-fair, 3-good)										
Extent of contamination end of morning session (0-dry, 1-splashed, 2-soaked)										

Middle of afternoon session Session started at:

Protection offered by own clothing (0-not worn, 1-poor, 2-fair, 3-good										
Protection offered by protective clothing (0-not worn, 1-poor, 2-fair, 3-good)										
Extent of contamination middle of afternoon session (0-dry, 1-splashed, 2-soaked)										

End of afternoon session Session ended at:

Protection offered by own clothing (0-not worn, 1-poor, 2-fair, 3-good										
Protection offered by protective clothing (0-not worn, 1-poor, 2-fair, 3-good)										
Extent of contamination end of afternoon session (0-dry, 1-splashed, 2-soaked)										

APPENDIX 5 (Cont.)

Section 8: Post dipping activities

8.1 Farm and Individual's code number

8.2 Activities: *(circle appropriate numbers)*

none	0
cleaning/emptying bath	1
cleaning drainage area	2
contact with treated sheep	3
other (specify)	4

8.3 Information about contact with dip during post dipping activities:

	HANDS	FACE	HAIR	TORSO (F)	TORSO (B)	ARMS (L)	ARMS (U)	LEGS (L)	LEGS (U)	FEET
Protection offered by own clothing (0-not worn, 1-poor, 2-fair, 3-good										
Protection offered by protective clothing (0-not worn, 1-poor, 2-fair, 3-good)										
Extent of contamination at end of tasks session (0-dry, 1-splashed, 2-soaked)										

8.4 **End of post-dipping activities** Time:

8.5 Information about washing at end of observation period

	HANDS	FACE	HAIR	TORSO (F)	TORSO (B)	ARMS (L)	ARMS (U)	LEGS (L)	LEGS (U)	FEET
Protective clothing washed/removed before continuing other work (y-yes, n-no,x-not/appl.)										
Own clothing next to skin removed (y-yes, n-no, x-not appplicable)										
Skin washed after work complete (within ½ hr) (y-yes, n-no)										

Now return and make entries for 2.6, 2.7, and 2.8

APPENDIX 5 (Cont.)

Section 9: Incidents

9.1 Farm number

9.2 Events affecting contact with concentrate or dip not otherwise described

Time	C / D	Pers. Code	Details

APPENDIX 5 (Cont.)

Section 10: Filling and Replenishment of Bath

Complete this section if un-metered filling or replenishment of dipping bath takes place

10.1 Farm number

10.2 Does the bath contain dipwash from previous dipping? Y/N

10.3 Filling or replenishment of bath

Time	Concentrate added (mls)	water added (litres)
| | |	| | |	| | |
| | |	| | |	| | |
| | |	| | |	| | |
| | |	| | |	| | |
| | |	| | |	| | |
| | |	| | |	| | |
| | |	| | |	| | |
| | |	| | |	| | |
| | |	| | |	| | |
| | |	| | |	| | |
| | |	| | |	| | |
| | |	| | |	| | |
| | |	| | |	| | |
| | |	| | |	| | |
| | |	| | |	| | |

10.4 Is water added to bath continuously? Y/N

10.5 Other substances added to bath

Time	Details
| | |	
| | |	

APPENDIX 6

OP Uptake Model

Protocol for completion of proforma for recording information and observations during farm visits

This protocol provides detailed information for the completion of the proforma designed for use in the field surveys.

Section 1: General information

Where possible this section should be completed prior to the site survey.

1.1 Farm number: Insert the number that has been assigned to this farm. (See list of participating farms). Each box should be filled eg. Farm 3 should be recorded as 03. The farm number should be inserted on each page of the proforma.

1.2 Date of assessment: Each box should be filled eg. 7 July 1996 should be recorded as 070796.

1.3 Assessor's names: The names of the members of the survey team.

1.4 Contact name: The main contact person at the survey site.

1.5 Telephone number: The telephone number of the contact person.

1.6 Farm name and address: The location of the survey site.

Section 2: Information about dipping on the farm

The information for completion of this section should be obtained through discussions with the farmer or person in charge of dipping.

All of the following questions refer specifically to the activities of the farm where the survey is being conducted. Most have been included to demonstrate representativeness.

2.1 Total number of dipping sessions during 1995: A dipping session may take place over several days within a dipping season e.g. spring, summer or autumn, and during the session there may be days when no sheep are dipped. Therefore, if dipping took place in summer only, record 1, if dipping took place in summer and autumn record 2 and so on.

2.2 Total number of dipping days during this session: A dipping session is defined in 2.1 above, only record those days within a session when sheep are dipped.

2.3 Number of dipping days already completed prior to visit: This refers to the current session only.

APPENDIX 6 (Cont.)

2.4 Proprietary name of product used for this dipping session: The brand name of the sheep dip eg. Coopers All Season Fly and Scab Dip. Also record batch number, date of manufacture and expiry date. If this information is not available clearly write NA in the boxes provided.

2.5 Date of last shearing: This is required to assess the potential degree of spray and the relative amount of dip that will be used. Dates may differ within the flock, if so record the date for the majority of sheep dipped at the time of the survey. Lambs may not have been sheared at all, if they form the majority record; OOOOOO. Full dates should be entered if possible. If months only are available the following format should be adopted eg. For May 1996, the record should be 000596.

The next three questions should be completed at the end of the session

2.6 Total quantity of concentrate used: Record the quantity in mls.

2.7 Approximate number of sheep dipped during the visit Remember each box should be filled eg. 563 sheep dipped would be recorded as 0563.

2.8 Duration of dipping session: Record in minutes the duration of the session. Include all activities eg cleaning / emptying bath, exclude lunch breaks.

Section 3: Dipping facilities, methods and conditions

Information for this section should be gathered through discussions with the farmer and direct observation.

Facilities

3.1 Type of bath: Record bath type in accordance with the following:

Short swim: A rectangular bath, plunge or walk-through. Most types are shorter than approximately 4m (including the ramp in and out). There may be a pit at the side for the operator. usually the operator puts the sheep in, but the bath may have a slide entry, located at the side of the bath. Sheep usually walk out of the bath to an adjacent draining area which should drain back into the bath.

Long swim: Rectangular swim-through type. They are usually longer than about 4m and can be up to 20m. they generally have straight walk-through entries but occasionally they may have side, slide entries. Usually have adjacent draining areas.

Circular: A round or hexagonal bath made of glass reinforced plastic or concrete. they usually have slide entries and ramps out to draining areas.

Circular with island: Similar to the circular type but with an island for the operator to stand on, located in the centre of the bath.

Mobile: A mobile dipping bath which may be square, rectangular or circular.

APPENDIX 6 (Cont.)

3.2 Date bath was last cleaned: If bath was not cleaned record the date when bath was last emptied. Full dates should be entered if possible. If months only are available the following format should be adopted eg. For May 1996, the record should be 000596.

3.3 Volume of bath: Record the approximate bath volume in litres. This can be obtained from the farmer, however, care should be taken to clarify whether litres or gallons are being specified. To convert from gallons to litres multiply by 4.55.

3.4 Location of bath: Outside/exposed means without shelter possibly on a hillside. Sheltered means sheltered by a hedge, walls or trees etc. Other locations are covered (open sites), within building, within trailer, other (specify).

3.5 Method of entry into bath : Manual means sheep are lifted/thrown into the bath. Other options are; side entry (slip way), slope, other (specify).

3.6 to 3.14 These questions are self explanatory. They have been included to provide some information about control measures in place at the study sites. Questions 3.10, 3.12 and 3.13 should be answered in accordance with the following:

3.10 High sided screens at the exit from the bath: Answer yes if the screens are one metre or more high, otherwise answer no.

3.12 Draining pens away from workers: Answer yes if droplets of dip are unlikely to reach any of the workers if the fleece is shaken after dipping, otherwise answer no.

3.13 Remotely operated draining pen gates: Answer yes if a system is in place (usually a rope and pulley) which allows gates to be opened without entering or working adjacent to the draining pens, otherwise answer no.

Methods

3.15 Description of how the product is added to the bath: Include in the free text description comments on the following; containers, handling, measuring out, addition to bath, mixing and implements used. Remember to observe and record what happens to the concentrate once bath preparation is complete.

3.16 Bath replenishment: Automatic systems mix concentrate with water, the dip wash is then piped into the bath. Other options are manual, other (specify).

3.17 Description of how the bath is replenished: Include in the free text description comments on the following; containers, handling, measuring out, addition to bath, mixing and implements used. Remember to observe and record what happens to the concentrate once bath replenishment is complete.

APPENDIX 6 (Cont.)

Weather Conditions

3.18 Predominant weather conditions: The weather may be changeable during the day, therefore record the predominant condition during the dipping session. Use the following as a guide:

Dry sunny/overcast	No precipitation, ground dry
Damp	No precipitation, ground wet
Drizzle	Very light rainfall only

3.19 Wind conditions: Record the predominant conditions. Use the following as a guide:

Still	Smoke rises vertically
Breezy	Raises dust and paper
Gusting	Inconvenience felt when walking

3.20 Air temperature: The air temperature should be measured at the end of the morning session close to the dipping facility. A sling hygrometer or assman psychrometer should be used and both dry bulb and aspirated wet bulb temperatures recorded. Record results to the nearest 0.5 degree centigrade.

3.21 Relative humidity: Use a psychrometric to derive the relative humidity. Record to the nearest whole number (%).

Section 4: Individuals involved in dipping

4.1 Individuals taking part in dipping during the visit: Record the full name of each individual. At some sites father and son may have the same name, under these circumstances record senior and junior as appropriate.

Record the principal (job done for most of the time during dipping that day)job title in accordance with the following:

Paddler	The worker who actually plunges the sheep under the dip
Chucker	The worker who feeds the sheep into the dipping bath
Helper	The worker who herds the sheep ready to go into the bath

It is possible that work is planned for some team members to change jobs during dipping. Where team members spend about equal amounts of time in two or more jobs for the majority of dipping that day all relevant job titles should be recorded as principal jobs. Any additional jobs that are carried out for more than half an hour in total should be recorded as subsidiary jobs.

APPENDIX 6 (Cont.)

Section 5: Contact with concentrate

All of the remaining sections should be completed by observation.

This section should be completed **each time** an individual handles the concentrate dip or accidental contact with the concentrate occurs.

5.1 Farm and individual's code number: This code is made up from the farm code (section 1) and the individual's code (section 4).
Time of handling: Should be recorded in 24 hour clock.

5.2 and 5.3 These are designed to investigate how skin contamination occurs. Multiple answers are allowed. The questions are self explanatory.

5.4 Information about contact with concentrate: This matrix has been designed to record the extent of contamination for individual body sections. The matrix should be completed for each individual, each time the concentrate is handled (regardless of whether any contamination was observed) or there is accidental contact with concentrate. Each cell in the matrix should be completed by assigning an appropriate score in accordance with the following:

Own Clothing refers to clothing worn by the individual other than those items of protective clothing listed below. Examples include:

Jacket or anorak (except PVC or nitrile)
Gloves (except PVC or nitrile heavy duty)
Boilersuit eg poly / cotton or cotton
Trousers eg jeans
Hat or hood attached to jacket
Woollen jumpers, sweatshirts, shirts, t-shirts and vests
Body warmers
Shoes or boots

The protection offered by own clothing will depend on the material, it's condition and how it is worn.

Protective clothing refers, on the whole, to personal protective equipment (PPE) recommended by the Health and Safety Executive (HSE) in their guidance booklet AS29 entitled Sheep Dipping. In this study PPE includes the following:

Face shield
Bib apron (over boiler suit or equivalent) or waterproof coat (PVC or nitrile)
Gloves (PVC or nitrile)
Waterproof legging / trousers (PVC or nitrile)
Wellington boots

APPENDIX 6 (Cont.)

In the field it may be difficult to determine whether protective clothing is made of PVC or nitrile. Under these circumstances any gloves, leggings, aprons or coats which have a rubbery or plastic appearance should be assumed to be protective clothing and an assessment of the protection afforded recorded on this basis.

Respirators may be worn at some farms. Although these do not appear in the HSE's list of protective clothing the protection afforded should be recorded under protective clothing. REMEMBER ONLY PROTECTION AFFORDED AGAINST SKIN CONTACT SHOULD BE CONSIDERED IN THE ASSESSMENT.

The protection offered by protective clothing will depend on condition (wear and tear, and cleanliness) and how it is worn.

Protection offered by own clothing:

Good Clothing offers adequate protection, it prevents concentrate from coming into contact with the skin. The material is clean and shows no visible signs of tears, cracks or wear, eg. Barbour type jacket

Fair Clothing offers some degree of protection, but for a short period only. Generally, this will be two layers of own clothing (or a single layer of double lined or quilted clothing) covering the body part in question. Or clothing that would normally be classified as good, and which is showing no visible signs of tears or cracks, but is showing a degree of wear or showing visible signs of concentrate residue, eg. Well worn Barbour jacket.

Poor Clothing offers little or no protection. Generally, this will be a single layer of own clothing over the body part in question. Or clothing that would normally be classified as fair or even good, but which is showing signs of tears or cracks, eg. T-shirt, woollen jumper

Protection offered by protective clothing:

Good Showing no visible signs of concentrate residue, tears, cracks or wear. It should also fit correctly and be worn correctly eg. Overall sleeves inside gloves

Fair No visible signs of tears or cracks, but showing a degree of wear or showing visible signs of concentrate residue. In some cases the protective clothing may not be worn correctly, but still offer fair protection eg. Trousers inside Wellington boots.

Poor Clothing with tears or cracks, or clothing that cannot be fastened correctly, or is not properly worn. The clothing may be contaminated with concentrate residue that is likely to come into contact with the skin, eg. contaminated gloves.

APPENDIX 6 (Cont.)

Extent of contamination with concentrate dip:

Dry	No visible sign of contamination with concentrate on skin or clothing
Splashed	One or more small droplets of concentrate visible on skin or own clothing. Or minor contamination due to direct contact with container or other contaminated item
Soaked	More significant contamination than above (areas of wetness as opposed to droplets) visible on skin or clothing.

Skin washed before continuing work:

It is important to answer this question regardless of whether any skin contamination was observed.

Answer yes if body sections were washed or rinsed in clean water. Otherwise answer no.

Section 6: Routes of ingestion

This section should be completed once only for each individual taking part in the study.

6.1 Farm and individual's code number: This code is made up from the farm code (section 1) and the individual's code (section 4).

6.2 Information about eating, drinking and smoking during observation: This table has been designed to record potential routes of ingestion of the concentrate dip and dip wash during the survey. Each time an individual is observed eating, drinking or smoking one row in the table should be filled.

Time: Use the 24 hour clock.

Event: Record the appropriate letter according to the event.

Contact: Record the appropriate letter depending on whether the event took place immediately after work with concentrate dip or dip wash.

Washes hands: Answer yes if hands were washed or rinsed in clean water. Otherwise answer no.

Section 7: Contact with dip wash

This section should be completed once only for each individual taking part in the study.

7.1 Farm and individual's code number: This code is made up from the farm code (section 1) and the individual's code (section 4).

APPENDIX 6 (Cont.)

7.2 Information about contact with dip wash: This matrix has been designed to record the extent of contamination for individual body sections. It has been divided into four observational periods. If there are natural breaks during dipping in the morning and afternoon sessions observations on the extent of contamination should be recorded at the start of these breaks. Otherwise record observations at the middle and end of both morning and evening sessions. If a member of the dipping team leaves the dipper to do work unrelated to dipping for more than half an hour an assessment for this person should be made before he/she leaves. Remember to record the time of the assessment.

Observations pertaining to the whole all of observation period should be recorded. Each cell in the matrix should be completed by assigning an appropriate score in accordance with the following:

For definitions of own clothing and protective clothing see Section 5.4

Protection offered by own clothing:

Good Clothing offers adequate protection, it prevents dip wash from coming into contact with the skin. The material is clean and shows no visible signs of tears, cracks or wear, eg. Barbour type jacket.

Fair Clothing offers some degree of protection, but for a short period only. Generally, this will be two layers of own clothing (or a single layer of double lined or quilted clothing) covering the body part in question. Or clothing that would normally br classified as good, and which is showing no visible signs of tears or cracks, but is showing a degree of wear or showing signs of significant contamination with dip wash eg. old Barbour jacket.

Poor Clothing offers little or no protection. Generally, this will be a single layer of own clothing over the body part in question. Or clothing that would normally be classified as fair or even good, but which is showing signs of tears or cracks, eg. T-shirt, woollen jumper.

Protection offered by protective clothing:

Good Showing no visible signs of tears, cracks or wear. (May show signs of dip wash residue). It should also fit correctly and be worn correctly eg. Overall sleeves inside gloves.

Fair No visible signs of tears or cracks, but showing a degree of wear or showing visible signs of concentrate residue. In some cases the protective clothing may not be worn correctly, but still offer fair protection eg. Trousers inside Wellington boots.

APPENDIX 6 (Cont.)

Poor Clothing with tears or cracks or clothing that cannot be fastened correctly, or is not properly worn. The clothing may be contaminated with concentrate or dip wash residue that is likely to come into contact with the skin, eg contaminated gloves.

For both own clothing and protective clothing all items worn for the **majority** of the observation period should be included in the assessment of the protection offered.

<u>Extent of contamination with dip wash</u>:

Dry No visible sign of contamination with dip wash on skin or clothing

Splashed Areas of wetness which are discrete droplet size visible on skin or own clothing

Soaked More significant indirect contamination than above, areas of splashing that have merged together visible on skin or own clothing or total submergence of skin or clothing

<u>Session started at etc.</u>:Record the time (24 hour clock) each observation period began and ended.

Section 8: Post dipping activities

This section should be completed when all the sheep have been dipped. It should be completed once only for each individual taking part in the study.

8.1 <u>Farm and individual's code number</u>: This code is made up from the farm code (section 1) and the individual's code (section 4).

8.2 <u>Activities</u>: Self explanatory. Multiple answer options allowed.

8.3 <u>Information about contact with dip after dipping completed</u>: This matrix has been designed to record the extent of contamination for individual body sections. Each cell in the matrix should be completed by assigning an appropriate score in accordance with the following:

For definitions of own clothing and protective clothing see Section 5.4

<u>Protection offered by own clothing</u>:

Good Clothing offers adequate protection, it prevents dip wash from coming into contact with the skin. The material is clean and shows no visible signs of tears, cracks or wear, eg. Barbour type jacket.

APPENDIX 6 (Cont.)

Fair Clothing offers some degree of protection, but for a short period only. Generally, this will be two layers of own clothing (or a single layer of double lined or quilted clothing) covering the body part in question. Or clothing that would normally br classified as good, and which is showing no visible signs of tears or cracks, but is showing a degree of wear or showing signs of significant contamination with dip wash, eg. old Barbour jacket.

Poor Clothing offers little or no protection. Generally, this will be a single layer of own clothing over the body part in question. Or clothing that would normally be classified as fair or even good, but which is showing signs of tears or cracks, eg. T-shirt, woollen jumper.

Protection offered by protective clothing:

Good Showing no visible signs of tears, cracks or wear. (May show signs of dip wash residue). It should also fit correctly and be worn correctly eg. Overall sleeves inside gloves.

Fair No visible signs of tears or cracks, but showing a degree of wear or showing visible signs of concentrate residue. In some cases the protective clothing may not be worn correctly, but still offer fair protection eg. Trousers inside Wellington boots.

Poor Clothing with tears or cracks or clothing that cannot be fastened correctly, or is not properly worn. The clothing may be contaminated with concentrate or dip wash residue that is likely to come into contact with the skin, eg contaminated gloves.

For both own clothing and protective clothing all items that were worn for the **majority** of the observation period should be included in the assessment of the protection offered.

Extent of contamination with working strength dip:

Dry No visible sign of contamination with dip wash on skin or clothing

Splashed Areas of wetness which are discrete droplet size visible on skin or own clothing

Soaked More significant indirect contamination than above, areas of splashing that have merged together visible on skin or clothing or total submergence of skin or clothing

8.4 End of post-dipping activities: Record the time all activities ended, use 24 hour clock. If no post dipping activities record time dipping ended.

APPENDIX 6 (Cont.)

8.5 Information about washing at the end of the observation period: The design of this matrix is similar to others used in the proforma, however, the purpose is to record what happens at the end of all dipping activities. There should be an entry in each cell in accordance with the following:

Protective clothing washed or removed before continuing other work: Answer yes if protective clothing is washed or rinsed in clean water, or removed, otherwise answer no. If wellingtons are removed for a short, but are then put back on answer no. If no protective clothing was worn the answer option not applicable should be selected.

Own clothing next to skin remove: Answer yes if clothing removed, otherwise answer no. If no clothing was worn over the particular body section the answer option not applicable should be selected.

Skin washed after work complete: Answer yes if skin washed within half an hour of dipping activities ending, otherwise answer no.

Remember to return and make entries for 2.6, 2.7 and 2.8

Section 9: Incidents

9.1 Farm number: Insert the number that has been assigned to this farm (See section 1.1).

9.2 Events affecting contact with concentrate or dip wash not otherwise described: Use this table to record novel events which may influence exposure, but which have not been recorded elsewhere in the form. Always record the following: time in 24 hour clock; whether the event involved dip wash or concentrate; the person(s) involved; and a brief, but precise description of the event.

Section 10: Filling and replenishment of the bath

This section has been included to keep a record of the concentration of the dip wash throughout the period of dipping. This will used to correct splash scores.

10.1 Farm number: Insert the number that has been assigned to this farm (See section 1.1).

10.2 Does the bath contain dip wash from previous dipping: If the bath contains dip that has been used previously (which makes an estimate of bath concentration difficult) answer yes, otherwise answer no.

10.3 Filling and replenishment of bath: Each time concentrate is added to the bath for filling or replenishment purposes the following information should be recorded: time in 24 hour clock; the quantity of concentrate dip added (in mls) and the quantity of top-up water used (litres). This will be an estimate only, but knowledge of the capacity of the bath and the level of the dip wash in the bath should allow a reasonable estimate to be made.

APPENDIX 6 (Cont.)

10.4 Is water added to the bath continuously: Answer yes if a piped supply of clean water is used continuously to keep the bath topped up, otherwise answer no.

10.5 Other substances added to the bath: Record any other substances that are added to the bath. Remember to record the time in 24 hour clock.

APPENDIX 7

Inter-Assay results for DEP, DEPT and Creatinine

	DEP	DETP	Creatinine
Limit of detection (μmole/litre)	0.03	0.03	NA
Inter-assay CV (%)	6.0	12.3	0.1

NA - Not applicable

APPENDIX 8

STANDARD OPERATING PROCEDURE (SOP) FOR COMPUTER BACK-UP AND RECOVERY FOR DATA ARISING FROM RESEARCH PROJECTS
(Other than projects under the scope of GLP)

1. THE SCOPE OF THIS SOP

1.1 IOM Computing Platforms

This SOP aims to provide guidelines for the back-up and recovery of programs and datasets held on IOM computing platforms and systems used on research projects. It applies to those projects which are not within the GLP procedures. However, it is cognate with the SOP authorised under GLP. Hardware and software to be used will be suitable for both back-up and recovery.

The IOM currently uses two generic computing platform types for the processing and analysis of project data.

(a) PCs running the DOS operating system are used on an individual (i.e. non-networked) basis for data transcription, manipulation and transformations and analysis. Windows may or may not be used as an operating environment running on this platform.

(b) The Prime running the PRIMOS operating system provides a central multi-processing facility on a timesharing basis for further data manipulation transformations and analysis.

In the procedures given below the basic strategies for back-up and recovery for the two platform types are the same but some of the practical details are different. The operational procedures for each is therefore detailed separately below, making it easier to refer to the methods for each type when required.

The person responsible for ensuring back-up will be the responsible person designated as day-to-day system administrator on the Computing Platform Definition Form.

2. THE BACK-UP OF PERSONAL COMPUTERS (PCs)

2.1 Incremental Back-up

On a daily basis, for each PC-based computing platform used on a project (where indeed that PC has been used and project files updated on that day) an incremental back-up of the updated project files will be made. The files will be backed-up to portable back-up media. The media will be clearly labelled with the following information:

(a) project ID
(b) IOM PC ID
(c) Date and time of back-up
(d) Person carrying out the back-up
(e) Back-up type

APPENDIX 8 (Cont.)

The back-up media will then be stored in an environment in accord with the guidelines of the back-up media manufacturer. The media should be securely stored in a locked cabinet to which only authorised personnel have access. The locked cabinet should be sited physically remote from the source computing platform. This measure will help avoid physical threat to both original and back-up at the same time (for example through fire).

2.2 Checkpoint Back-up

Once each week, on the same day each week, (where that PC had been used and project files updated since the same time the previous week) a full checkpoint back-up of all the project files, in all the project directories, will be made. The files will be backed-up to portable magnetic media. The media will be clearly labelled with the following information:

(a) project ID
(b) IOM PC ID
(c) Date and time of back-up
(d) Person carrying out the back-up
(e) Back-up type

The back-up media will then be securely stored in the same manner as that detailed above for the incremental back-up.

2.3 Checkpoint Back-up Cycling and History Back-up

Four sets of media will be used for the checkpoint back-up. These will be cycled on a four-weekly basis so maintaining a maximum four-week back-up recall period. The media will be numbered and colour coded so that the use of the media will follow a pre-set four-weekly cycle. This pattern must be adhered to: week 1 - red; week 2 - green; week 3 - blue; week 4 - yellow. Each fourth week will be removed from the cycle for a history type - see and borrow from Prime SEUFF.

3. BACK-UP OF THE IOM PRIME 2850

3.1 Daily Back-up

The back-up of project data on the Prime follows the same routine back-up procedure carried out for all IOM projects, programs and data that are stored on the Prime.

On four working days of each week, Monday to Thursday, a full back-up of all project files and directories will be made using an Exabyte tape back-up device. This back-up will include all directories, data files and programs on the Prime at the time.

The tape produced will be held securely, separate from the site of the Prime, and in environmental conditions recommended by the manufacturer of the tape.

APPENDIX 8 (Cont.)

Four separate Exabyte tapes labelled "Monday" to "Thursday" will be used, one for each day respectively.

A complete list of the files backed-up will be made and stored on the Prime until the next day's back-up is successfully completed.

3.2 Weekly Back-up and History Back-up

Once each week, after normal working hours on a Friday, a full back-up of all project files and directories will be made using Exabyte tape back-up device. This back-up will include all directories, data files and programs on the Prime at the time.

A complete list of the files backed-up each week will be made and stored on the Prime until the next back-up is taken. A hard copy of this will be retained.

The tape produced will be held securely, separate from the site of the Prime 2850, and in environmental conditions recommended by the manufacturer of the tape.

Four separate tapes will be used for the weekly back-up. The first three of these will be cycled on a four-weekly basis. These three tapes will be labelled and colour coded as follows: week 1 - red; week 2 - green; week 3 - blue. Each fourth week the weekly back-up is superseded by a history back-up. This history tape will be removed from the cycle and held in perpetuity. A new tape will be used for each history back-up.

4. REPLACEMENT OF BACK-UP MEDIA

Back-up media will be maintained and replaced at intervals according to the manufacturers' instructions, guidelines and recommendations, or other authoritative third party documentation which may be available from time to time. Each new item of media entering a /IOM back-up cycle will be labelled with the date on which they entered the cycle.

4.1 The Refreshing of Magnetic Media

From time to time, according to manufacturers' instructions/guidelines from third party, it will be necessary to refresh back-up media before any potential decay of the back-up media can occur. This will be accomplished as follows:-

Back-up media will be read (with verification onto an IOM computing platform - Prime or PC. After verification the data will be written to new back-up media and labelled in the same way as the earlier details but clearly marked as a "refresh" tape in addition.

APPENDIX 8 (Cont.)

5. CARE OF BACK-UP DEVICES

Back-up devices will be cleaned and maintained in accordance with the manufacturers' instructions, guidelines and recommendations. Hardware manuals and cleaning instructions will be stored available for QA inspection when required. Cleaning tapes will be clearly marked with dates of usage, and discarded after the recommended number of uses.

6. RECOVERY

Back-ups taken by the methods above can be used for recovery in the event of accidental or deliberate loss of project data or programs. Recovery of the files, either to the original or to a replacement computing platform, would also need to be undertaken in the event of any of the following:

(a) In the event that files are lost from, or corrupted on, the source computing platform.
(b) In the event that the source computing platform itself becomes inaccessible (through theft etc) or inoperable (and subsequently is either replaced by another equivalent machine or is repaired).

The back-up and restore software will be used in conjunction with the latest backup copies of the data to recover the project data as far as is practicable.

(12 July 1994)
(Revised May 1996)

APPENDIX 8 (Cont.)

STANDARD OPERATING PROCEDURE (SOP) FOR THE SECURITY AND PROTECTION OF COMPUTER SYSTEMS AND DATA ON RESEARCH PROJECTS
(Other than projects under the scope of GLP)

1. THE SCOPE OF THIS SOP

This SOP provides guidelines for the establishment and use of security and protection procedures for IOM computing platforms and systems used on research projects. It applies to those projects which are not within the GLP procedures. However, it is cognate with the SOP authorised under GLP. It involves the overall protection of hardware, software and data from unauthorised or accidental modification, destruction or disclosure.

Back-up and recovery are also aspects of security. The need for them will be emphasised following a breakdown or lapse in security. However that subject is dealt with in the SOP for Computer Back-up and Recovery.

The prevention of deliberate system damage, loss or disruption of data or programs by malicious programs (viruses, trojan horses, worms etc) is covered in the present SOP.

Although the main features of security procedures are shared by the two generic computing platforms currently used by the IOM for processing project data there are some important distinctions. The procedures for each are detailed separately below for ease of reference and updating. Changes in security measures in relation to the networking of PCs may substantially alter standard operational procedures in future and they will be updated as appropriate.

Physical security refers to the way a user gains access to the actual computer hardware and other measures taken to maintain the physical integrity of the system.
Logical security refers to the way a user gains access to the computing system, the application software and the data.

1.1 IOM Computing Platforms

With respect to computer systems and computerised data the IOM currently uses two computing platform types for the capture, processing and analysis of project data:

(a) The Prime 2850 running the PRIMOS operating system (see 2.3 and 3.4) provides a central multi-processing facility on a timesharing basis for further data processing, manipulation transformations and analysis. This is run as a central IOM computing service staffed by Computing Section within the Data Sciences Group.

(b) PCs running the DOS operating system (namely version 3.3, 5 and 6) are (currently) used on stand-alone (i.e. non-networked) basis for data transcription, processing, manipulation and transformations and analysis. MS Windows may be used as an operating environment running on this platform.

APPENDIX 8 (Cont.)

2. SECURITY ON THE IOM PRIME 2850

The standard operating procedures with respect to security on the Prime are alréady a *de facto* standard within the IOM, they are set out below.

2.1 Project Directory and Authorised Personnel

Persons authorised to use the Prime 2850 for the purposes of data capture, processing or analysis on a particular project will be identified by the project leader.This information will be transmitted to and acted upon by the Prime System Manager or nominated deputy from the systems or operations staff. These three roles are hereafter referred to as system administrators.

In general systems administrators will create a suitable working directory structure for the project and will create suitable accounts for the project personnel (where not already extant). This structure may be updated from time to time.

2.2 Physical Security of System

(a) The Prime is located in a secure temperature and humidity controlled environment with access available only to systems administrators and other nominated operations staff.

(b) From time to time controlled access will be available to authorised manufacturers' field service staff.

(c) Access will be controlled by door locks and a combination-lock door security system. Keys and combinations will be available only to authorised system administrators and other nominated operations staff.

(d) The environment will be air conditioned to maintain temperature and humidity within tolerable levels as recommended by the manufacturers. The service records of the air conditioning system will be maintained. These records or authorised copies of them will be archived where appropriate. The temperature and humidity will be recorded at the start of each working day on appropriate records.

(d) Service records for maintenance by authorised Prime engineers will be maintained. These records or authorised copies of them will be archived where appropriate.

2.3 Logical Security of System

On the Prime logical access can be restricted at three possible levels: (a) user accounts; (b) project directories and files; (c) application software.

(a) User accounts:

i) Access to the system by authorised users will be by way of a user account ID and a password to the account.

APPENDIX 8 (Cont.)

ii) All passwords will be encrypted on the system and unalterable by anyone other than the user (although systems administrators may have to intervene when necessary). The password lifetime is set to 30 days.

iii) Nominated personnel will take steps to maintain the integrity of their password, following the usual procedures to prevent disclosure, make "unbreakable", and alter regularly.

(b) Project directories and files:

i) Access to project data and programs will be controlled at the directory, sub-directory and or individual file levels through the use of File Access Control Lists.

ii) Systems administrators will assign read-only, or read-and-write access for different users and different files within a project, as appropriate to the needs of that project, and according to the discretion of the designated study member with responsibility for systems and computing.

(c) Application software:

i) In certain software packages (in some databases, SIR on the Prime for example) it is possible to define user access very precisely, for read and write access, down to the individual variable level if desired.

ii) This security will be imposed by systems administrators, database administrator, or nominated persons responsible for this software application for the project.

3. SECURITY ON IOM PC-BASED COMPUTING PLATFORMS

3.1 Project Directory and Authorised Personnel

Persons authorised to use each PC-based computing platform for the purposes of data capture, processing or analysis on a project will be identified by the project leader. This information will be transmitted to and acted upon by the PC System Administrator or authorised nominated deputy for the purposes of computing on the project in question. These two persons are referred to as system administrators.

In general systems administrators will create a suitable working directory structure for the project. This structure may be updated from time to time.

Systems administrators will arrange for the distribution of any keys or hardware and security information required by authorised users to access this PC platform.

APPENDIX 8 (Cont.)

3.2 **Physical Security of System**

(a) The PC will be located in a suitable environment that will:

i) Aim to to prevent theft of or unauthorised access to the PC as far as is practicable.

ii) Maintain physical conditions within the guidelines recommended by the equipment manufacturer.

(b) Where available physical security devices may limit access to PCs.

(c) Any service records for maintenance by authorised equipment engineers will be maintained. These records or authorised copies of them may be archived where appropriate.

3.3 **Logical Security of System**

On PC-based platforms logical access may be restricted at three possible levels: (a) user authorisation (passwording) for the whole system; (b) third party software security packages restricting access to applications software and data to a variable extent; (c) applications software itself.

(a) User authorisation:

i) Where available, hardware, software or firmware on the PC will be implemented to provide passworded access to the platform as a whole. The named platform system administrator will be responsible for implementing this procedure.

ii) All passwords will be encrypted on the system and unalterable by anyone other than the platform system administrator.

iii) The system administrator will take steps to maintain the integrity of the password although it is acknowledged that it may have to be shared where there are multiple users on the same PC platform for project(s).

iv) Where available, logging audit software will be used to record who uses which for what.

(b) Third party software security packages:

i) Such packages may be implemented at the discretion of the project leader and system administratior where judged warranted. Functionality will be variable.

APPENDIX 8 (Cont.)

(c) Application Software:

i) In certain software packages (in some databases, SIR or Paradox on the PC for example) it is possible to define user access very precisely, for read and write access, down to individual record or variable level if desired. This security will be imposed by, and at levels decided by systems administrators, database administrator, or nominated persons responsible for this software application for the project.

3.4 **Virus Prevention and Eradication on Pcs**

For the purposes of this SOP, the use of "virus" refers to maliciously programmed software that is intended to bring about the loss or damage to programs and data.

The IOM has a policy and procedures for detection and prevention of PC viruses (ref FH, 28/06/93). The policy and procedures are adopted here although they are reworded for SOP purposes. Currently viruses may only enter the IOM via magnetic floppy diskettes (3.5 or 5.75 inch) from external sources or on portable or notebook computers used for data recording on a site external to the IOM. There are not at present direct or modem links to bulletin boards or third party networks that would provide further routes for virus infection. In time this may change, in which case the anti-virus strategy and procedures will be updated to take account of this and any other new potential mode of infection.

Because the IOM is based on several physical sites it is necessary to clarify what is meant by "external". The use of external in this context includes all diskettes originating elsewhere and brought in for use on PCs in any part of the IOM. The separate sites of the IOM are regarded as external to each other. Thus, for example, the City Hospital site is external to the Roxburgh Place HQ and *vice versa*; transfers of data on diskette from one to the other will then be regarded as a disk coming from an external source.

a) Two anti-virus packages will be used. This will increase the potential for detection and prevention cover. Both packages will be installed on one PC on each IOM site. The second package will be installed on every PC in the IOM.

(b) The anti-virus packages will have three modes of operation: (1) memory resident, to monitor and alert for suspicious memory activity during operation; (2) to scan, to check the contents of floppy disks and hard disks for virus software; (3) eradication of virus software.

(c) Respectively, the two packages currently used by the IOM are: Doctor Solomon's Anti-Virus Toolkit, from S&S International Ltd. ; F-Prot, from Portcullis Software. The software chosen is subject to periodic review as part of IOM computing policy. It will be the responsibility of IOM Computing Service to continue this review and inform PC users of any changes in packages to be used (including updating this SOP).

(d) Both software packages are regularly updated by the software producers in order to keep up with the development and spread of viruses. Updates will be received centrally by Computing Service who will install and distribute updates to end-users.

APPENDIX 8 (Cont.)

(e) All PCs will have the chosen anti-virus software for general use installed and loaded on start-up.

(f) Both anti-virus packages will be used on a centrally administered PC on each IOM site to "scan" all incoming disks from external sources. Scanning will be carried out by a trained nominated person for each site.

(g) Each incoming disk must be presented for scanning by the person responsible for importing itto the IOM.

(h) Both anti-virus software packages will be used to scan incoming disks.

(i) The detection of a virus must be immediately reported to Computing Service. Detection will be recorded and documented.

(j) Scanning to be carried out via clean boot disk and scanning software on floppy and according to guidelines issued by IOM Computing to those responsible for scanning.

(j) Notebook and laptop computers entering the IOM following external use (eg . by members of staff at home, or at other sites) will require their hard discs to be scanned in the same manner as incoming floppy discs.

4. **DATA PROTECTION LEGISLATION**

(a) All projects will be subject to the Data Protection Act (1984) under which the IOM is registered. Any records which pertain to personal information will conform to the conditions of our registration.

(b) Where necessary, or where doubt exists, the IOM data protection officer will be consulted for advice on compliance to the act.

(c) The IOM data protection officer will amend the conditions under which the IOM is registered under the act if and when the need arises.

(July 1994)
(Revised May 1996)

APPENDIX 9

1. General Characteristics of Dipping Sessions

Excluding stoppages for lunch, dipping times ranged from 155 minutes (farm 07) to 491 minutes (farm 15). At some farms all sheep were gathered prior to the start of the work which enabled continuous dipping throughout the session. At some one or more individuals left the dipping facility to gather more sheep while others remained behind to continue the work. At other farms dipping was intermittent throughout the session as all those involved helped to gather sheep, dip and return them to the fields.

The number of sheep dipped during the surveys ranged from 285 (farm 11) to 1700 (farm 20). Nearly all farms dipped ewes, lambs and tups (rams). At farm 15, however, ewes and lambs were separated and only the lambs and tups dipped, while a pyrethroid pour-on was applied to the ewes. Depending on the size of the flock and the work rate, some farms dipped all their sheep on the day of the survey. Five farms (13, 14, 23, 24, 25) had carried out dipping at sometime in the three days prior to the survey and some farms intended to dip the day after, weather permitting.

During all the surveys the weather was predominantly dry except at farms 05 and 18 where it was damp. The wind condition was recorded as 'breezy' at the majority of farms, although at farm 06 it was recorded as 'gusting' and farms 15 and 25 'still'. Dry bulb air temperature ranged from 10.5°C (farm 25) to 22°C (farm 04) and relative humidity from 48% (farm 04) to 85% (farms 03, 13, 22, 24).

2. Dipping Facilities

A range of dipping facilities were included in the study, from traditional to modern types (Photographs 1 and 2). Most were well maintained and in good working order, but some were in poor condition and in need of repair. All of the dipping baths were located outside, although at two farms (17 and 25) sheep were fed into the bath from a small barn.

All commonly used dipping bath types were included. The baths studied were; four short swim (farms 01, 03, 06, 25), six long swim (farms 05, 15, 20, 22, 23,24,), one circular (farm 21), four circular with island (farms 04, 14, 17, 18) and five mobile (farms 07, 08, 10, 11, 13). These were constructed of a variety of materials including stone, brick, mild steel and glass reinforced plastic. The capacity of the baths ranged from 800 litres (farm 15) to 4000 litres (farm 05).

Gathering pens and races were also constructed from a variety of different materials including; stone, brick, wood and galvanised metal. Layouts varied, some facilities incorporated races to lead sheep to the bath, while others utilized pens and relied on manual labour to carry sheep forward. All baths had adjoining draining pens.

APPENDIX 9 (Cont.)

3. Organophosphate Dips used and Containers

The study protocol stipulated only farms using sheep dips containing the organophosphate diazinon be included. The products studied were as follows; Diazadip All Seasons Scab Approved Dip (formerly known as Diazadip All Purpose Scab Approved Sheep Dip)(eight farms), Coopers All Seasons Fly and Scab Dip (five farms), Neocidol Winter Dip (three farms), Deosan Diazinon Sheep Dip (three farms), and Paracide Plus (one farm).

The quantity of concentrate dip used ranged from 1.64 litres (farm 17) to 9.70 litres (farm 05). One farm (10) used dip that was out with the expiry date.

Concentrate dip was supplied in metal containers, most were 5 litre capacity, except for Paracide Plus which was supplied in a 10 litre container and Coopers All Seasons Fly and Scab Dip which was supplied in 20 litre containers at three of the five farms using this product. Table 4.2 provides a summary of the main characteristics of each container type encountered.

Containers were representative of all designs normally used to supply sheep dips. In general, containers were either rectangular or cylindrical in shape with a screw cap or ring pull opening, carrying handle and some form of pouring spout located on the upper horizontal surface (Photographs 3 and 4). This surface was encircled by a lip of a few millimetres in height and proved to act as a reservoir for concentrate inevitably remaining after, or spilt during pouring.

Neocidol and Coopers (5 litre) containers, used at farms 05, 11, 15, 17, 21, were fitted with a secondary metal cap below the uppermost screw cap. This provided an additional seal and was removed and discarded when the container was first opened. Removal of this seal caused problems at some farms. The seal is intended to be levered off with the help of a screw driver or other similar tool, rather like opening a can of paint, however, several individuals chose to puncture the seal with a sharp knife or similar and remove the cap in this way. Splashing of concentrate often occurred and on occasions gloves were removed to carry out this task (Photograph 5).

Containers with metal screw caps (Coopers (5 litre), Neocidol, Paracide Plus) were usually supplied with a pouring spout. Made of plastic the spout was simply a shaped, shallow trough which clipped onto the neck of the opening and forced the liquid to flow in the right direction. After pouring any residual concentrate left on the spout trickled down the channel and collected around the neck of the opening (Photograph 6).

The Paracide Plus container, used at farm 20, was fitted with a plastic cylindrical shaped spout which protruded vertically from the container once in position. This spout was pulled into position by the individual inserting their fingers into the container. Residual concentrate was visible on the surface of this container after pouring (Photograph 7).

Diazadip, Deosan and Coopers (20 litre) containers, used at farms 01, 03, 04, 06,07, 8,10,13, 14, 18, 22, 23, 24 and 25 were fitted with a different opening and pouring mechanism to those described above. A plastic screw cap with two relatively large plastic

APPENDIX 9 (Cont.)

ring pulls was utilized. The cap was attached to a cylindrical plastic spout which could be pulled into place, prior to the removal of the cap. At some farms, however, individuals poured out the concentrate with the spout still inside the container (Photograph 8) or pulled out the spout incorrectly (Photograph 9) and at one farm (04) an individual pulled the spout into position by inserting her fingers into the container after removing the cap. Although the pouring spout usually reduced the amount of residual concentrate on the surface of the container after pouring, small quantities of the liquid were usually visible.

Most containers were fitted with a carrying handle in the form of an arched metal bar fixed at both ends. On larger containers (10 and 20 litres) there was an indentation on the surface of the container to allow more room for a hand to be slipped around the bar. As expected, residual concentrate on the surface of the container collected in the area of the indentation to form a source of contamination (Photograph 10). Older batches of Diazadip were fitted with a flexible plastic handle.

All of the containers encountered were intact, although some were showing signs of rusting on the upper surface. The majority were opened for the first time during the survey.

At four of the dipping sessions additional substances were added to the bath. Two farms added substances containing phenols; Bayer Phenolic Disinfectant was added at farm 03 and Bayer Bactericide at farm 10. The remaining two farms added substances for cosmetic purposes; natural clay and Deosan Purl Dip were added at farms 17 and 24 respectively.

4. Dipping Methods

Several dipping practices were observed during the course of the field surveys. However, the method by which sheep entered the bath and the method employed to submerge sheep below the dip wash were the two most important sources of variation. Table 4.3 highlights the different methods employed by each farm.

Ten farms (04, 05, 07, 08, 10, 11, 17, 20, 21, 23) used a side entry slip way to manoeuvre sheep into the bath (Photograph 11). Sheep were usually fed through a race which guided them onto the slipway from where they slid or were pulled with a paddle into the bath. At eight farms (01, 03, 06, 14,15,18, 22, 25) sheep were gathered in a pen adjacent to the bath then lifted, turned and placed in the bath. At farm 24 a slope was used which sheep were encouraged to walk down, but invariably they leapt off the slope and usually fell into the bath causing considerable splashing (Photograph 12). Finally, at farm 13 where the 'Mobidip,' was used, sheep were simply walked in and out of the bath. Dip wash was pumped into the bath after the sheep had entered and drained away before the sheep were allowed to walk out of the unit.

Once in the bath, sheep were submerged below the dip wash to ensure complete coverage of the insecticide. The most common method of submergence utilized a paddle or dipping stick (farms 01, 04, 05, 07, 08, 10, 11, 13, 14, 15, 17, 18, 20, 21, 22, 23, 24, 25). The paddle usually had a metal (crook type) head and a long wooden or metal handle. One handle was covered with a PVC sheath (farm 05) (Photograph 13).

APPENDIX 9 (Cont.)

At two farms (03, 06) sheep were submerged by hand. This is a more traditional method of dipping which has been largely superseded by the paddle method. At both farms the workers responsible for this task stood in a pit adjacent to the bath. Their unprotected hands and forearms were often submerged in the dip wash (Photograph 14).

In the majority of cases sheep left the bath via a ramp and were gathered in adjacent draining pens.

Preparation of the dipping bath was similar at all farms. The bath was initially filled with water and then concentrate dip was added. The water was supplied from either a piped source, a tanker or large (200 litre) drums. In general concentrate was poured directly from the container in which it was supplied into a measuring jug (usually plastic) and then transferred into the bath. Next the liquid was mixed with a paddle or sweeping brush. The same procedure was usually followed for replenishment of the bath. The exception to this method was the 'mobidip,' (farm 13) where concentrate was poured onto the floor of the empty bath and automatically mixed with water / dip wash when it was pumped back into the unit. For replenishments the concentrate was decanted into a graduated 1 litre container from where it was transferred to the bath as required.

Non-manual systems for preparation or replenishment of the bath were not encountered during the surveys.

5. Job Titles

At the majority of farms three individuals were principally involved in the dipping session, although others may have helped to gather sheep. There were two farms (11, 21) with only two people involved and two farms (20, 22) with four people involved.

Individuals were assigned to one or more of the following job categories on the basis of tasks performed; paddler, chucker, or helper. Exactly half of the study population were assigned one job only. Eighteen of the sixty individuals studied were assigned two principal job categories, ie. they spent an equivalent amount time doing two tasks, usually chucking and helping, and eleven individuals were assigned a principal job and a secondary job, ie. a job in which they spent more than half an hour. The most common secondary job was helper. One individual had two principal jobs; paddler and chucker and also a secondary job as helper.

In general the job descriptions set out in the protocol matched the nature of the work encountered, however, at farm 15 the chucker also submerged sheep with his booted feet prior to them being submerged by the paddler (Photograph 15).

Every farm had a paddler, although at farm 21 this job was carried out in conjunction with chucking. All, except two farms, had a chucker (Photograph 16). Both these farms (10, 13) used a contractor. At farm 10 two individuals encouraged sheep to move along an ascending race to the bath, and as both were working well away from the bath they were categorised as helpers. At farm 13 a 'mobidip' was used. Sheep were simply walked in and out of the unit and so a chucker was not required. Every farm had at least one helper.

APPENDIX 9 (Cont.)

At sixteen of the twenty farms the paddler or paddler/chucker was also the individual who most often filled and replenished the bath with concentrate dip.

6. Engineering Control Measures

Engineering control measures in the form of screens, splash boards and remotely operated gates were encountered at several farms. A summary of these by farm is provided in Table 4.3. Seven farms (04, 05, 10, 17, 20, 21, 25) had screens across the entry to the bath to deflect splashes, three farms (04, 08, 10) had waist height splashboards around the side of the bath and four farms (04, 07, 08, 18) had high sided screens at the exit to the bath. All except farm 10 had draining pens which were away from the workers and ten farms (01, 04, 07, 08, 10, 13, 14, 17, 18, 21) had remotely operated draining pen gates (Photographs 17 and 18).

Only one permanent dipping facility (farm 04) had all of the above mentioned measures in place. As might be expected this was one of the newest facilities included in the study. Other recently constructed dippers lacked some of the basic controls (farms 20, 21).

7. Protective Clothing

A variety of protective clothing was encountered during the study. The extent and condition of clothing varied between farms and also between individuals at farms. This is summarised in Table 4.4.

Wellington boots and waterproof leggings were the items worn most often (Photograph 19). Wellington boots were worn by forty eight individuals in total, although two individuals were wearing boots with holes in them and two replaced their boots with shoes part way through the session. Leggings were worn by forty six individuals. Eighteen pairs were assessed as affording only fair or poor protection because that they were dirty, damaged, or only partially covered the lower body and legs.

Use of protective clothing on the upper body was less common. Waterproof jackets and bib aprons were worn at some farms. Sixteen individuals wore some form of protection on the upper body, however, some items were assessed as affording only fair or poor protection for similar reasons to those described above. Misuse of protective clothing was also observed, for example waterproof jackets were left open or incorrectly fastened.

Very few individuals wore hair/head or face protection.

Gloves were worn by eleven individuals whilst dipping, all except one were paddlers. The type of gloves worn varied and included; rubber, nitrile, PVC, and vinyl; these were usually medium to heavy duty. Wrist length PVC gloves with knitted wrist band were encountered, as well as mid-length and gauntlet styles. Only one pair were assessed as affording good protection throughout the dipping session as others were dirty and/or contaminated, became damaged or were simply unsuitable for the work (Photograph 20).

APPENDIX 9 (Cont.)

Gloves were worn by fourteen of the thirty three individuals who handled concentrate dip. (No information was available for one individual). Glove types were similar to those described above except at one farm (04/2) a pair of light duty domestic type gloves were worn and at another a pair of surgical gloves (20/4). No gloves were assessed as affording good protection every time concentrate was handled. One important reason for this was that individuals never routinely washed their gloves after handling the concentrate dip. Therefore, it was considered that concentrate may have permeated through the gloves to the skin or that gloves may have become contaminated internally when being put on or removed. The use of phenols at two farms (03, 10) may have resulted in more significant damage to gloves and may have also promoted uptake of OP through the skin. Gloves were also found to be dirty and damaged, and misuse was encountered as contaminated gloves were incorrectly removed (15/1) (Photographs 21 and 22).

8. Pre and Post Dipping Activities

Before the dipping session began individuals were asked whether they had been involved in any activities associated with sheep dipping or the application of pesticides in the three days (72 hours) prior to the survey. 57% of individuals, had not carried out any activities. The remainder, however, had been involved in up to three different activities as follows:

Task(s) and individuals

Dipped (23/1, 25/2)
Cleaned bath (06/2, 06/3, 17/3, 18/2, 18/3, 24/2)
Worked with other pesticides (03/1, 06/2, 17/3, 18/2, 18/3, 24/2)

Dipped and cleaned bath (23/3, 24/1, 25/1)
Dipped and had contact with recently treated animals (01/3, 14/3, 23/2)
Worked with pesticides and had contact with recently treated animals (01/1, 10/1, 22/2)
Cleaned bath and worked with pesticides (15/1, 15/3)
Cleaned bath and had contact with recently treated animals (05/2)

Dipped, worked with pesticides and had contact with recently treated animals (14/1,14/2)

Post dipping activities were carried out at five farms and only involved eight individuals. Four (03/1, 05/2, 07/1, 18/2) were involved in emptying or cleaning the bath, two (13/1, 13/3) dismantled the 'mobidip', one individual (05/1) cleaned the drainage area and one (05/3) sprayed dip wash onto nearby fields with a slurry tanker.

At the majority of farms the dip wash was left in the bath as dipping was planned to continue the next day, or because it was normal practice to leave the wash a few days before draining and cleaning was carried out.

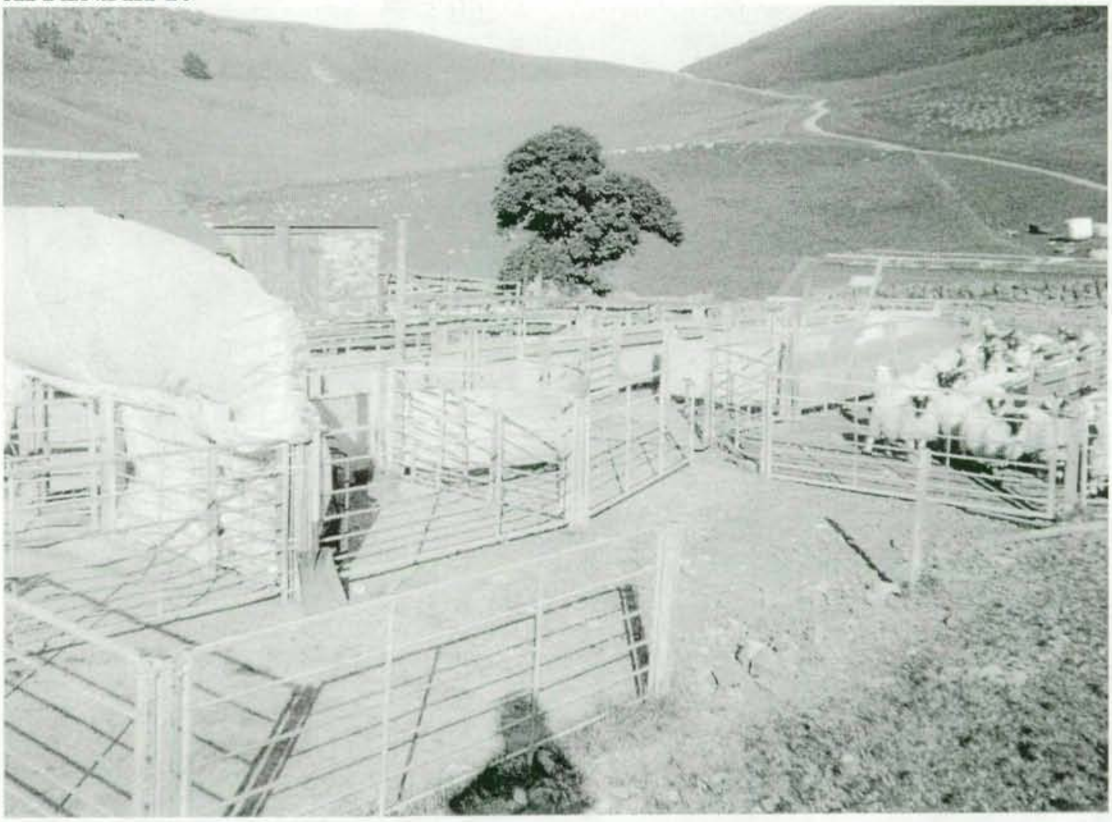
When all dipping activities were complete forty three individuals washed their hands within 30 minutes of finishing work, twenty seven also washed their faces. Only seven (01/3, 06/1, 06/2, 15/3, 17/1, 21/1, 22/1) individuals took a shower or bath on completion of the dipping session.

APPENDIX 9 (Cont.)

9. Ingestion Events

A record was kept of all events which may have led to the ingestion of concentrate dip or dip wash. These included eating, drinking and smoking. Almost all individuals had at least one ingestion event. The maximum number of events recorded was thirteen, for an individual (04/3) who ate, drank and smoked. In most, but not all cases eating and drinking took place during breaks and individuals tended to wash their hands beforehand. However, individuals who smoked usually continued to do so whilst dipping was in progress and did not wash their hands.

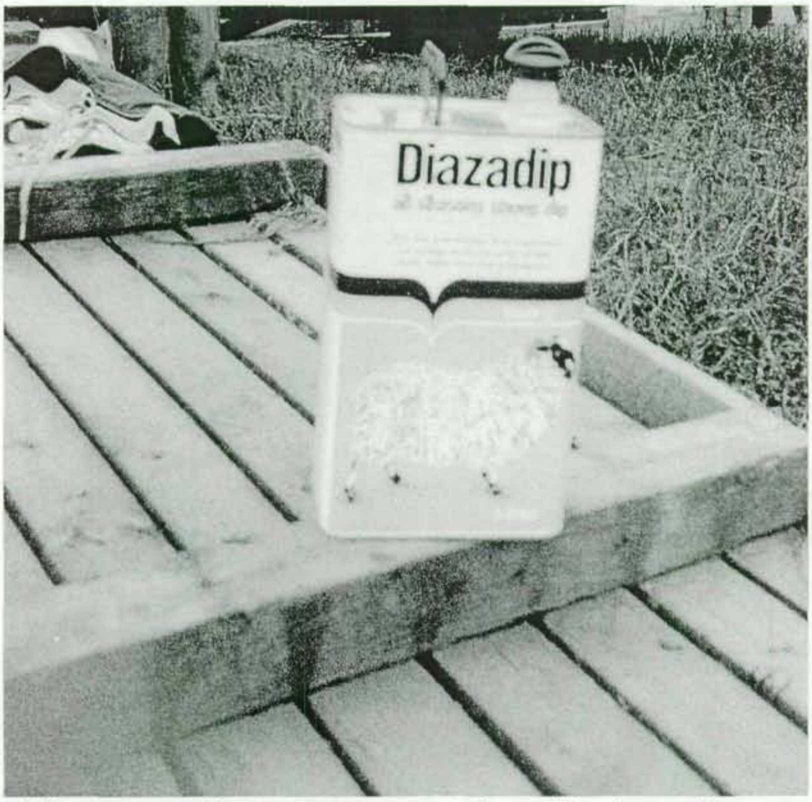
APPENDIX 10



Photograph 1: A modern dipping facility, with galvanised metal gathering pens and gates (FO4).

Photograph 2: A more traditional dipping facility with post and rail fencing and gates. Stone walls surround the dipping bath (F22)

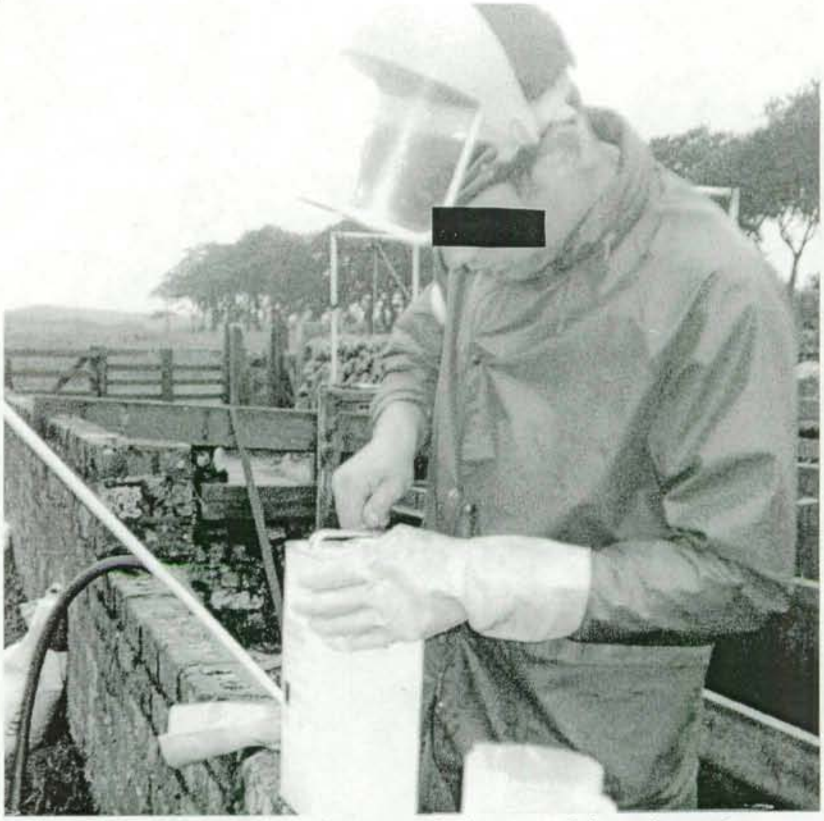
APPENDIX 10 (Cont.)



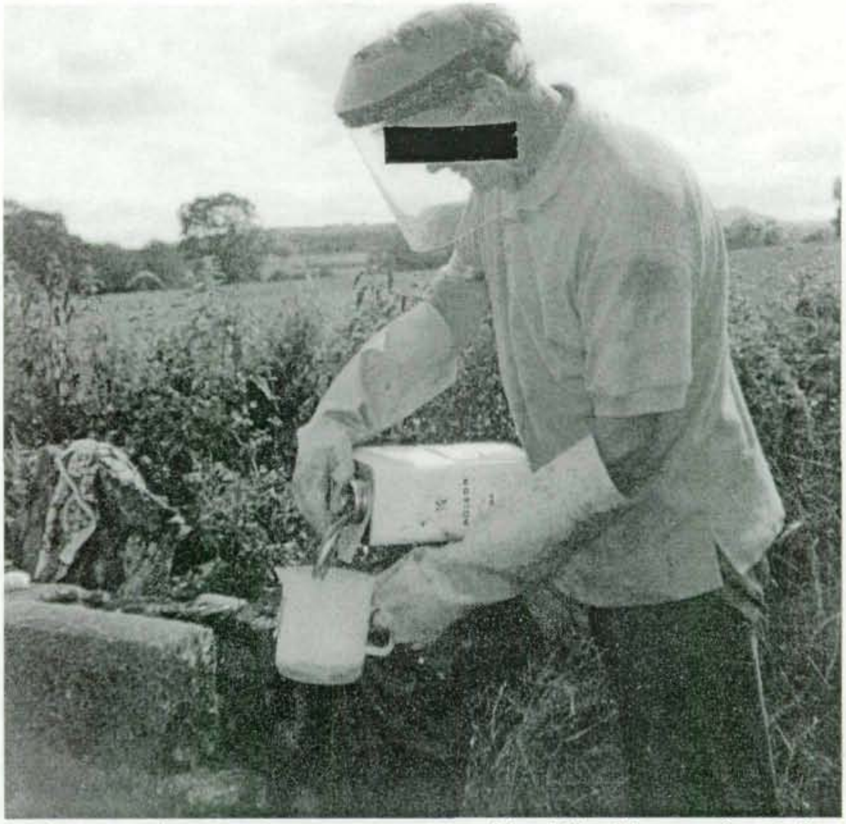
Photograph 3: A 5 litre rectangular concentrate container with ring-pull cap and plastic pouring spout (FO6).

Photograph 4: A 5 litre cylindrical container with metal screw cap and pouring trough (F11).

APPENDIX 10 (Cont.)



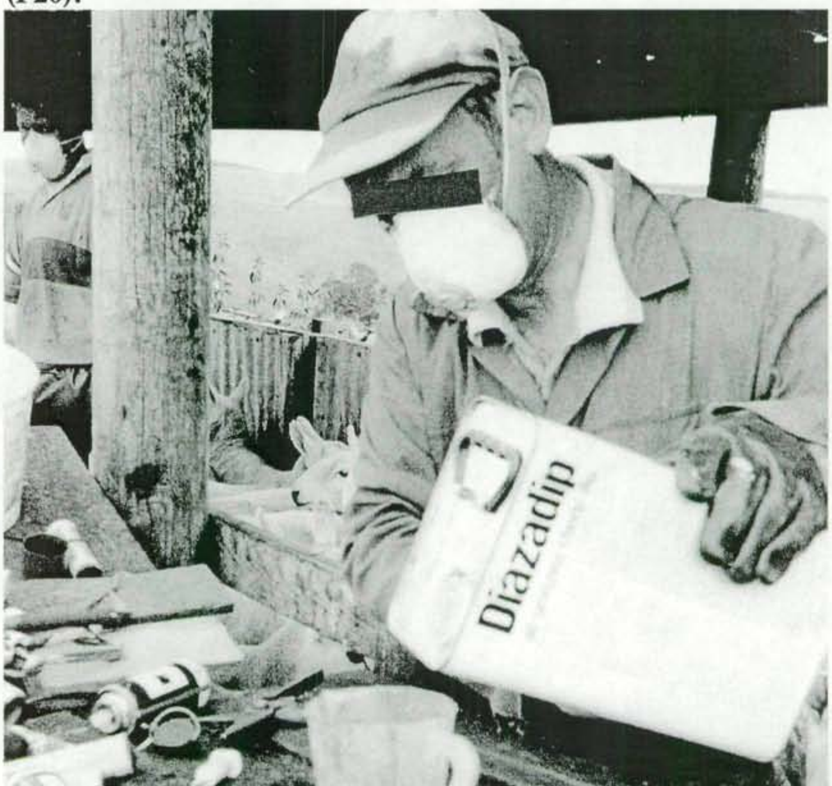
Photograph 5: A Neocidol dip container is opened. A screwdriver is used to lever off the secondary seal. One glove has been removed (FO5).



Photograph 6: After pouring out the concentrate residual liquid was often left around the neck of the container (F15).

APPENDIX 10 (Cont.)

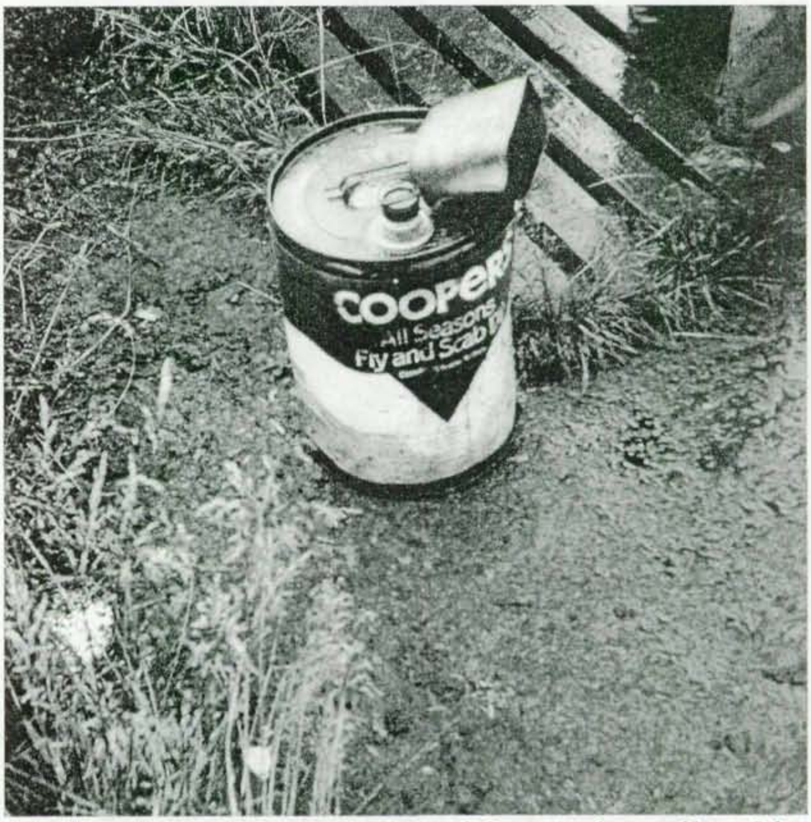
Photograph 7: **Paracide Plus containers. The pouring spout was pulled into position by individuals inserting their fingers into the container (F20).**



Photograph 8: **Pouring out concentrate with the plastic pouring spout still inserted in the container**

APPENDIX 10 (Cont.)

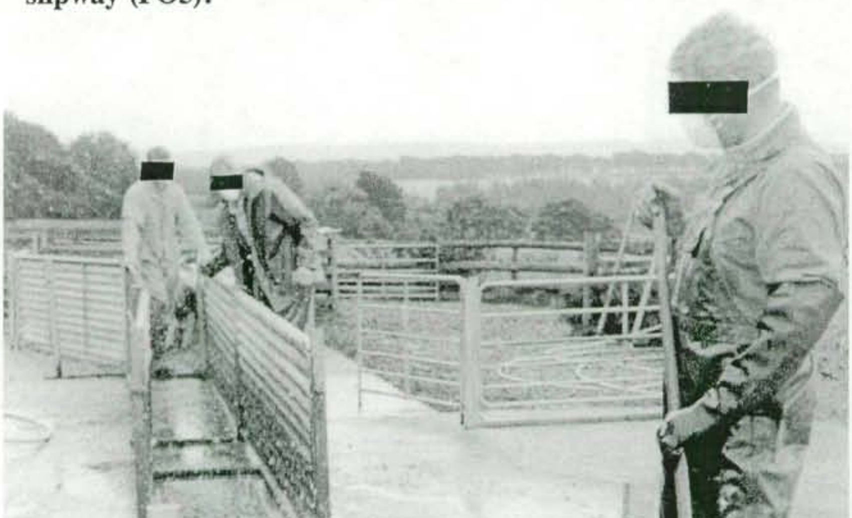
Photograph 9: **The ring-pull cap has been removed and a screwdriver is used to lever the plastic spout out of the container (F24).**



Photograph 10: **Residual concentrate on the surface of the container collected in the indentation below the carrying handle. This acted as source of contamination (FO1).**

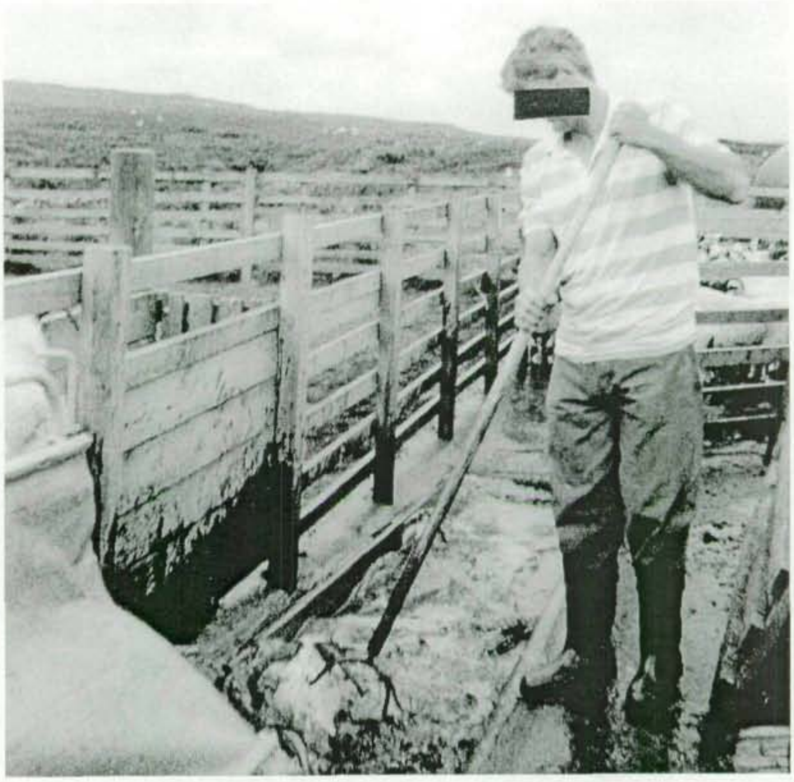
APPENDIX 10 (Cont.)

Photograph 11: Sheep were often manoeuvred into the bath using a side entry slipway (FO5).

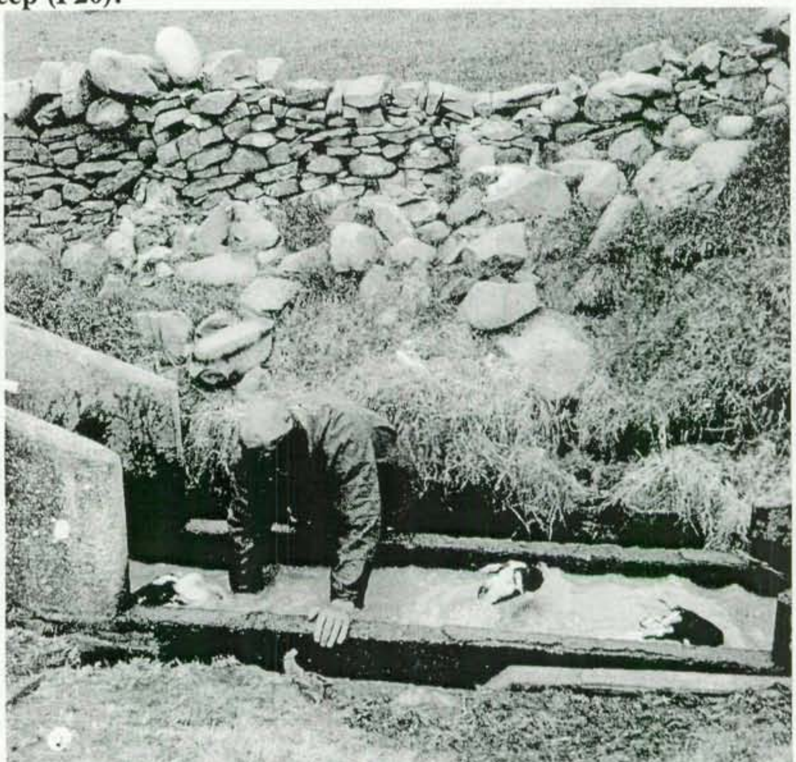


Photograph 12: Splashing caused as sheep leapt off the bath entry slope (F24).

APPENDIX 10 (Cont.)

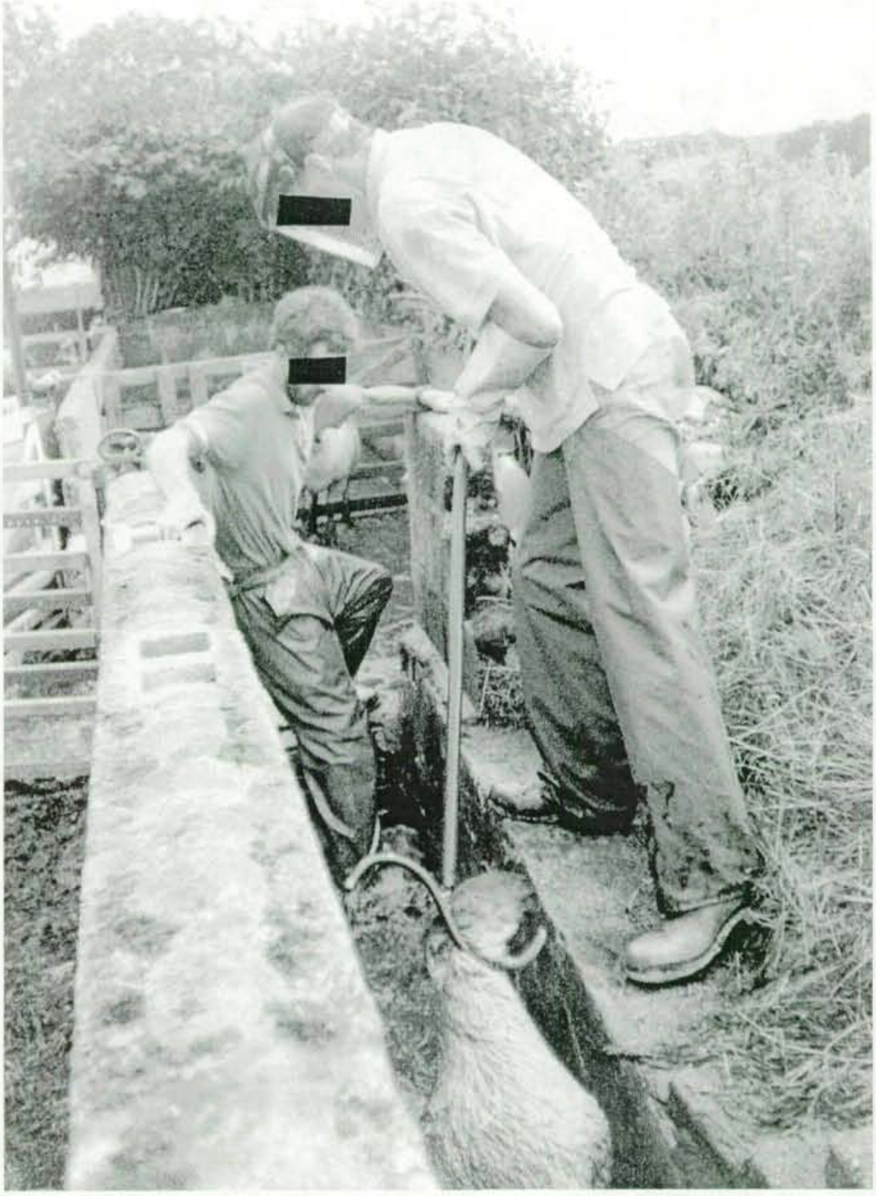


Photograph 13: A dipping stick or paddle was most commonly used to submerge sheep (F20).



Photograph 14: At two farms sheep were submerged by hand (FO6).

APPENDIX 10 (Cont.)



Photograph 15: **The paddler uses a dipping stick to submerge the sheep while the chucker submerges them with his foot (F15).**

APPENDIX 10 (Cont.)

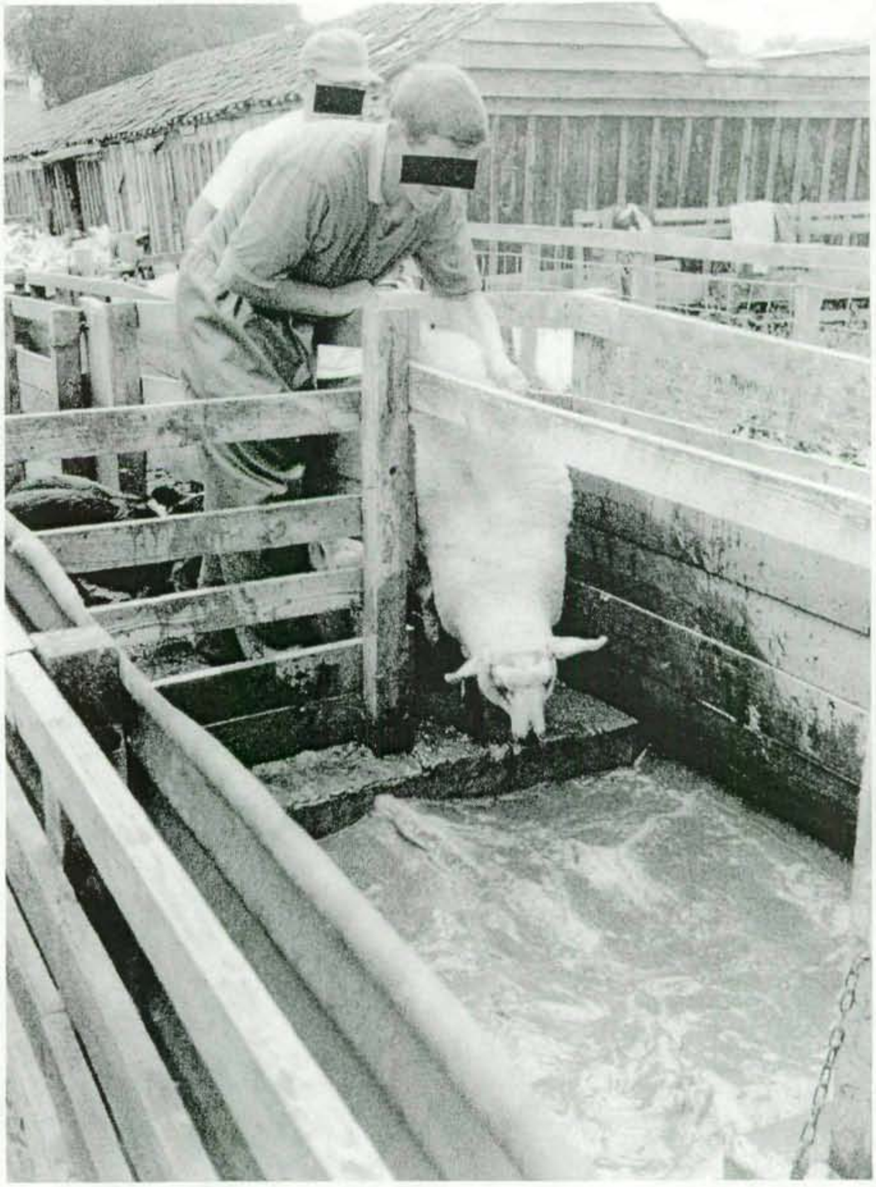
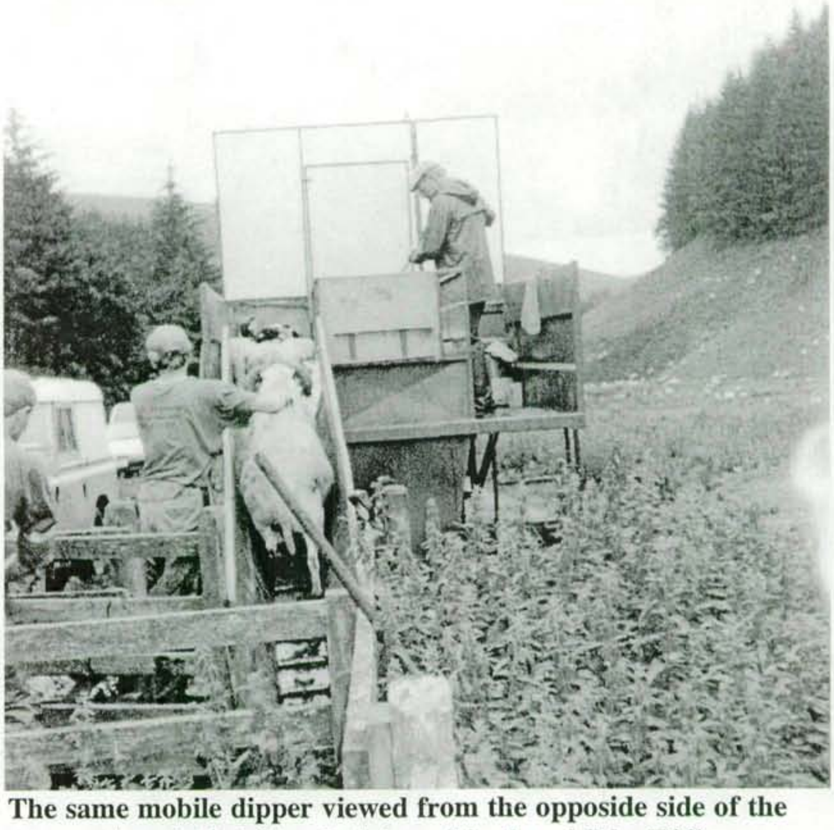


Figure 16: **The responsibility of the chucker was to manoeuvre sheep into the dipping bath (F23).**

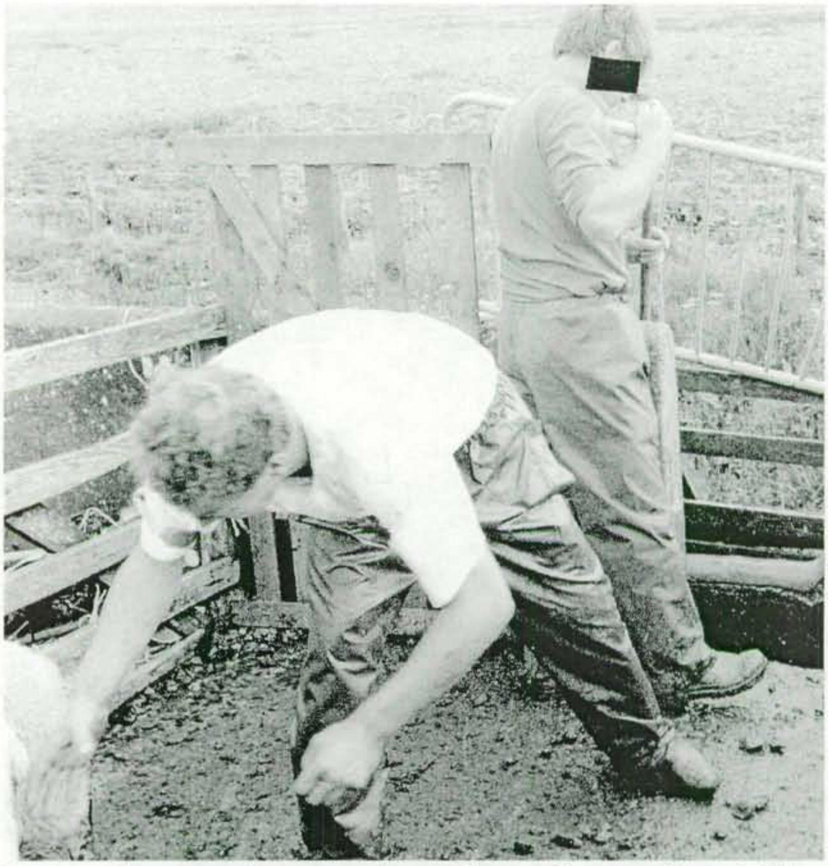
APPENDIX 10 (Cont.)

Photograph 17: **A mobile dipper with high sided screen and remotely operated draining pen gate to reduce splashing and contact with dipped sheep (FO8)**



Photograph 18: **The same mobile dipper viewed from the opposide side of the screen. A waist height splash board is also visible (F08).**

APPENDIX 10 (Cont.)



Photograph 19: **The most commonly encountered items of protective clothing were waterproof leggings and wellington boots (F22).**

Photograph 20: **During dipping gloves became contaminated with dip wash and some were damaged (F10).**

APPENDIX 10 (Cont.)

Photograph 21: **Gloves used to handle concentrate left on the surface of the concentrate container where further contamination could occur (F08).**

Photograph 22: **Some gloves used were inappropriate for the work. The gloves above had a knitted fabric wrist band. Once this fabric was contaminated it could act as a wick holding concentrate dip against the skin (F07).**

APPENDIX 11

Farm Visit Reports

Farm 01

Farm 01 formed part of a large estate in Northumberland. The farm is managed by an estate manager and is run on a day to day basis by a shepherd and farm workers.

The shepherd and farm worker from this farm, plus the shepherd from the adjacent farm on the estate carried out the dipping. The shepherd (1) and farm worker (2) from this farm had not been involved in dipping within the previous three days. However, the shepherd (3) from the adjacent farm had carried out dipping at his own facility three days prior to the survey and had already taken part in this project (Farm 14).

The dipping facility was sited close to one of the farm worker's cottages, in a relatively sheltered position. The dipping bath was a Cooper's hill-sheep short swim bath with a slip-way. Wooden draining boards were positioned alongside the bath. Sheep were held in pens constructed from wooden posts with wooden fencing and sheet metal. Similar waist-height sheet metal screens were positioned between the bath and collecting pen. The draining pens were sited away from the workers. There was a piped supply of clean water.

During the survey the weather was dry and breezy, with an overcast sky.

The dipping session lasted for 5½ hours in total. Approximately 1000 sheep (ewes, lambs and tups) were dipped with Cooper's All Seasons Fly and Scab Dip, which was supplied in a 20 litre cylindrical container. In total, approximately 9650 ml of concentrate dip was used.

The paddler (1) prepared the bath and was generally the person who replenished it with concentrate dip and water, although, the others both handled the concentrate dip during replenishment.

To prepare the bath, the concentrate dip (2 litres) was poured from the container into a 1 litre plastic jug and emptied into the bath containing about 820 litres of water which had been added previously. A brush was then used to mix the bath. Finally, the jug was rinsed out in the dip wash. To replenish the bath, water (228 litres) was emptied from a metal barrel into the bath. The concentrate dip (850 ml) was poured from the container into the jug and emptied into the bath. The bath was mixed with a brush. Similarly, the jug was rinsed out in the dip wash.

Sheep were gathered into a circular collecting pen adjacent to the bath. Wooden swing gates were used to move the sheep closer to the bath. The shepherd (3) from Farm 14 and farm worker (2) both acted as chucker/helpers. The sheep were moved backwards through a gate and entered the bath down the slipway. Once in the bath, the sheep were turned and then plunged in the dip wash by the shepherd (1) who used a paddle with a wooden handle. After dipping, the sheep entered a draining pen where they were held until it was full, and were subsequently released into the surrounding grassland.

APPENDIX 11 (Cont.)

Some protective clothing was worn by all three workers. The paddler (1) wore Wellington boots, waterproof leggings and a waterproof jacket. However, both the jacket and leggings were torn. The chucker/helpers both wore Wellington boots and waterproof leggings. One of the chucker/helper's (3) Wellington boots and leggings were torn and by the end of the dipping session his jeans were saturated with dip wash.

No post dipping activities were carried out. The concentrate container and jug were left near the dipping bath. Further dipping was planned for the following day.

Farm 03

Farm 03 was a family owned farm located in the Borders Region.

Three people were involved in dipping on the day of the visit, the farmer and two farm workers. The farmer and one of the farm workers had worked with pesticides within the previous three days the other farm worker had not.

The dipping facility, one of two on the farm, was sited away from the farm steading on an exposed hillside. Although the majority of sheep pens were open to the elements, some immediately adjacent to the dipping barn were sheltered by a corrugated metal roof. The facility was of a traditional design, the pens were formed from post and rail fending. The barn was a concrete lined short swim type, and the paddler worked from within an adjacent pit. Although the facility was not new it was in fair condition. The drain pens were located away from the workers.

During the survey the weather was dry, but overcast and breezy.

The dipping session lasted for about four and a quarter hours. Approximately 600 sheep (ewes and lambs) were dipped with Bayer's Diazadip All Season Sheep Dip, which was supplied in 5 litre containers (slender type). Bayer's phenolic disinfectant was also added to the bath at the start of dipping. In total, approximately 2300 ml of concentrate dip was used. The replenishment of the bath was conducted manually by pouring concentrate sheep dip directly into a measuring jug and then into the bath. Water was added simultaneously using a bucket from a pre-filled drum. The pull out spout on the concentrate container was not used for pouring the dip, it was left pushed down inside the container.

The farmer acted as the paddler (1) throughout the session. He used his hands to plunge the sheep below the surface of the dip wash. Two farm employees shared the work of the helper and chucker. They gathered sheep in the adjacent collecting pen 5, them manually lifted and turned each animal and put it into the bath.

The farm workers filled and replenished the dipping bath with concentrate dip. The farmer was not involved in this, however he did wash out the concentrate containers at the end of the session.

APPENDIX 11 (Cont.)

Personal protective clothing was worn by all three workers. Farm workers wore disposable respirators, waterproof leggings and Wellington boots whilst dipping. In addition wrist length, heavy duty PVC gloves were worn whilst handling concentrate dip. The gloves appeared worn and during the course of the survey became contaminated with concentrate.

The farmer was dressed in waterproof leggings and a coat (worn back to front). He also wore Wellington boots, and a respirator. No gloves were worn whilst dipping or washing out the concentrate container.

On the day of the visit the three workers were also tubing ewes, which meant that dipping stopped for approximately three and a half hours. This work was carried out at the dipping facility.

The bath was emptied at the end of the session.

The survey team were unable to observe the preparation of the dipping bath and part of the dipping session because the farmer began dipping earlier than he had anticipated. Discussions with those involved enabled a summary of the activities not observed, to be recorded.

Farm 04

Farm 04 was a privately owned hill sheep farm near Penicuik. The farm is family run, and employs a shepherd.

The farmer, the farmer's wife and the shepherd carried out the dipping. They had not been involved in dipping within the three days prior to the visit.

The dipping facility was sited close to the farm steading, in an exposed position. The dipping bath was a modern circular bath with island, and a slipway. Sheet metal screens, just below waist-height, were positioned alongside the bath. On the island there was a metal frame within which the plunger stood. Sheep were held in various pens constructed from metal railings. The draining pens were sited away from the workers, screened off by tarpaulin sheeting. There was a piped supply of clean water.

During the survey the weather was dry and sunny with a breeze.

The dipping session lasted for 5½ hours in total, spread over a period of around 8 hours. Other activities were carried out on the day of the survey, e.g. stacking hay bales. Approximately 900 sheep (ewes, lambs and tups) were dipped with Diazadip All Seasons Sheep Dip, which was supplied in a 5 litre rectangular container. In total, approximately 4500 ml of concentrate dip was used.

The chucker (2) prepared and replenished the bath on each occasion. The paddler (1) and helper (3) did not handle concentrate dip during the survey.

APPENDIX 11 (Cont.)

To prepare the bath, the concentrate dip (1.5 litres) was poured from the container into a 1 litre plastic jug and emptied into the bath containing about 2200 litres of water which had been added previously. Difficulty was experienced in retrieving the pouring nozzle from the container resulting in contamination of the worker's hands with concentrate dip. A brush was then used to mix the bath. Finally, the jug was rinsed under running water from a tap which was used to provide a continuous supply of water to the bath. To replenish the bath, concentrate dip (500 ml) was poured from the container into the jug and emptied into the bath. The bath was mixed with a brush or paddle. The jug was either washed under the running tap, or rinsed out in the dip wash.

Sheep were gathered into collecting pens adjacent to the bath. Metal swing gates were used to move the sheep closer to the bath and into a race which guided them into the bath. The shepherd acted as a helper (3), and the farmer's wife acted as a chucker (2), ensuring the sheep moved along the race and entered the bath sideways down the slipway through a bath entry screen. Several sheep were used as a decoy across the slipway. Once in the bath, the sheep were plunged by the farmer (1) who used a paddle with a metal handle. After dipping, the sheep entered a draining pen where they were held until it was full, and were subsequently released into the surrounding grassland.

Some protective clothing was worn by the paddler (1) and chucker (2). The paddler wore Wellington boots and waterproof leggings, both in good condition. The chucker wore Wellington boots, and waterproof leggings in fair condition, which were worn for only part of the time. Light/medium weight domestic rubber gloves were worn by the chucker when handling the concentrate dip and these were generally rinsed under the running water each time the concentrate was handled. The helper (3) did not wear personal protective equipment.

No post dipping activities were carried out at this farm. Further dipping was planned for the following day.

Farm 05

Farm 05 was a family owned farm located in West Lothian.

The farmer and his two sons carried out the dipping. Other family members also helped to gather sheep, but remained at a distance from the dipper. One of the sons (2) had been involved in cleaning the dipping bath and had contact with recently treated animals within the previous three days. The farmer and other son had done no work associated with dipping during this time.

The dipping facility was sited away from the farm in an exposed field. The sheep pens were of a traditional design and were formed from stone walls and post and rail fences. The dipping bath was a long swim type, with walls lined with concrete blocks. Entry to the bath was from one side via a slip way which was particularly effective. A screen (rubber mat) positioned across the slip way. Low level rubber matting (about knee height) was also positioned vertically around the edge of the bath. Several collecting pens were sited adjacent to the dipper. The draining pens were located away from the workers and there was a piped

APPENDIX 11 (Cont.)

supply of clean water. The facility was obviously several years old, but generally appeared to be in good working order.

During the survey the weather was damp and breezy.

The dipping session lasted for 6 hours. Approximately 1500 sheep were dipped (ewes, lambs and tups) with CIBA Agriculture's Neocidol Winter dip (supplied in 5 litre containers). In total 9700 ml of dip was used. To prepare and replenish the bath, concentrate dip was poured from the container into a measuring jug. Next it was poured into the bath and mixed with the paddle. Top-up water was added when required from a tanker via a hose pipe.

Sheep were gathered in a large pen and then in batches moved into smaller pens adjacent to the dipper. A small number of decoy sheep located at one side of the slip way were used to encourage other sheep to step onto the slope. For most of the time the younger son (3) worked close to the dipper encouraging sheep onto the slip way, while the farmer (1) filled the collecting pens behind. For shorter periods these two exchanged tasks. The eldest son (2) acted as the paddler throughout the session. He used a metal paddle with a PVC sheath to plunge the sheep below the surface of the dip wash..

The eldest son (2)also filled and replenished the bath with concentrate dip and was the only one to handle the concentrate during the survey. He had difficulty removing the metal cap on the concentrate container and removed a glove to perform this task.

Personal protective clothing was worn by all three workers. The paddler (2) wore waterproof leggings and coat, although the upper part of the leggings were showing signs of wear. In addition he wore Wellington boots and nitrile gloves, the gloves were also showing signs of wear and became contaminated with concentrate dip as the session went on. Finally he wore a visor which remained in the up position whilst dipping, but which was usually pulled down over his face for handling concentrate.

The chucker (3) wore Wellington boots, waterproof leggings and coat throughout the session. One Wellington boot was noted to be slit across the foot.

Finally, the helper (1) wore the same protective clothing as the chucker, however the coat was showing signs of wear and not always fastened at the front. Surprisingly, one of the helpers Wellington boots was also slit across the foot.

At the end of the dipping session emptying of the bath and cleaning the draining pens was observed. The farmer And one son (2) drained and cleaned the dipping facility, while the other son (3) disposed of the dip wash.

Farm 06

Farm 06 was a privately owned farm located in the Scottish Borders.

APPENDIX 11 (Cont.)

Dipping was carried out by three individuals; the farmer (3), his uncle (2) and a farm worker (1). The farmer and his uncle had been involved in cleaning out the dipping bath up to three days prior to the visit. The farm worker had not been involved in any activities associated with dipping during this time.

The dipping facility was sited away from the farm steading, but close to two farm workers cottages in an exposed position. The dipping bath, which was constructed of concrete blocks, was a short swim type. There was an adjacent pit along the length and to one side of the bath from where the paddler worked. Several collecting pens of various sizes surrounded the bath, these were constructed from either stone walls or post and rail fencing. Immediately adjacent to the bath was a circular pen where sheep were gathered just before being put into the dipper. The draining pens were sited away from the workers and there was a piped supply of clean water close-by. The facility was several years old, but was in reasonable repair.

During the survey the sky was predominantly overcast, but the weather stayed dry. There was a gusting wind.

The dipping session lasted for about 6 hours. Approximately 1400 sheep (ewes, lambs and tups) were dipped with Bayer's Diazadip All Season Sheep Dip, which was supplied in 5 litre (slender type) containers with a ring pull cap. In total about 2380 mls of dip was used. To make up the bath the concentrate dip was poured into a measuring jug and then into a bucket containing water. This was then emptied into the bath which had been filled previously with water. To replenish the bath the concentrate dip was poured into the measuring jug and then into the bucket. This was then topped up with water and emptied into the bath. The dip wash was mixed with a shovel. Top up water was supplied by a tanker which was located adjacent to the facility.

Sheep were gathered in the circular collecting pen adjacent to the bath. Swing gates were used to move the sheep closer together and then each animal was turned and lifted into the dipping bath. The farmer (3) and farm worker (1) acted as chucker and helper in turn. The farmer's uncle (3) plunged each sheep below the dip wash using his hands.

The farmer and farm worker were the only two individuals who handled the concentrate. They filled and replenished the dipping bath with concentrate dip.

Some protective clothing was worn by all three workers. The chucker/helpers wore Wellington boots and waterproof leggings, although the farm worker's leggings appeared to be well worn. The plunger wore waterproof leggings and Wellington boots, he also wore a Barbour jacket and waterproof hat. By the end of the dipping session, dip wash had passed through his leggings and soaked his own trousers below. The inside of his hat was also contaminated with dip wash because on several occasions it had been used to wipe splashes off his face.

There were no post dipping activities at this farm on the day of the visit. It was planned to clean out the bath within the next few days.

APPENDIX 11 (Cont.)

Farm 07

Farm 07 was a family owned farm located in the Scottish Borders and operated as part a group of farms also owned by the family.

Six people were involved in dipping, however, three were only involved in gathering sheep and worked well away from the dipping bath, for this reason they were not included in the survey. The remaining three, the farmer and two of his farm workers were included. None of the individuals included in the study had been involved in any activities associated with dipping in the three days prior to the survey.

During the survey the weather was dry although it was overcast and breezy.

Dipping took place at the farm in a sheltered location using a mobile dipper. Collecting pens and a race, temporarily located in the farm yard, were used to guide sheep to the dipper and a ramp led them to the bath. The mobile dipper was constructed from sheet metal. The bath was a small circular type without an island. Entry into the bath was via a side entry slipway. High sided screens were fixed at the exit to the bath although there was no screening around the bath to protect the paddler. The draining pens, which had remotely operated gates, were away from the workers. The dipper was only a few years old and was in good working order.

The dipping session lasted for just over two and a half hours. Approximately 700 sheep (ewes, lambs and tups) were dipped with Bayer's Diazadip All Seasons Sheep Dip, which was supplied in 5 litre (slender type) containers with a ring pull cap. In total about 3200 mls of dip was used. To fill and replenish the bath concentrate was poured into a measuring jug and then into the bath. The jug was washed in the bath and the concentrate was mixed with the paddle. Water was added when required from a tanker.

The farmer (1) was the only individual to handle the concentrate dip. It was noted that the pull out spout on the concentrate container was not used for pouring the dip, instead it was left pushed down inside the container. As a result, a large amount of concentrate was spilt when first pouring which contaminated the outer surfaces of the container.

The farmer (1) acted as the paddler, he used a metal handle paddle to plunge each sheep below the surface of the dip wash. One farm worker (3) stood at the entrance to the bath forcing sheep up the last part of the ramp, and onto the slipway. This worker was classified as the chucker.

Finally the second farm worker stood further down the race and encouraged sheep to run forward onto the lower part of the ramp. This worker was classified as the helper (2). The chucker spent some time doing the same work as the helper.

Two of the three workers wore some protective clothing whilst dipping. The paddler (1) wore a face shield, heavy duty PVC wrist length gloves (with knitted wrists), waterproof leggings and Wellington boots. He also wore a disposable respirator. The helper (2) wore waterproof Wellingtons only. The chucker (3) wore no protective clothing.

APPENDIX 11 (Cont.)

The dipping session was completed by lunch time. Although the paddler informed us that he may empty and/or clean the bath later that day this was not observed. The chucker and helper had no further contact with the sheep dip and did not carry out any further dipping activities.

Farm 08

This survey was carried out at a farm in Heriot where dipping was carried out by a contractor using a mobile dipping facility.

The contractor, the contractor's father and the contractor's brother carried out the dipping. They had not been involved in dipping within the three days prior to the visit.

The mobile dipping facility was remote from the farm steading, in an exposed location. The dipping bath, constructed from steel sheeting, was well kept and in good condition. Waist-height screens were positioned alongside the bath. Sheep were held in nearby pens constructed from wooden post and rail fencing. The draining pen, which forms part of the mobile dipping facility, was sited away from the workers, screened off by a perspex panel. There was a piped supply of clean water.

During the survey the weather was dry and breezy, with an overcast sky.

The dipping session lasted for just over 2½ hours in total, and was carried out in a morning. Approximately 500 sheep (ewes and tups) were dipped with Coopers All Season Fly and Scab Dip, which was supplied in a 20 litre cylindrical container. In total, approximately 5220 ml of concentrate dip was used.

The paddler (1) prepared and replenished the bath on each occasion.

The bath was prepared and dipping had just started before the survey team arrived on site. It is understood that to prepare the bath, the concentrate dip (2.5 litres) was poured from the container into a 2 litre plastic jug and emptied into the bath containing 1138 litres of water which had been added previously. To replenish the bath, concentrate dip (680 ml) was poured from the container into the jug and emptied into the bath. Water (182 litres) was subsequently emptied from a 200 litre plastic barrel into the bath.

Sheep were gathered into collecting pens adjacent to the bath. Wooden swing gates were used to move the sheep closer to the mobile dipping facility and into a ramped race which guided them into the bath. The contactor (3) and his brother (2) both acted as chucker/helpers. The sheep entered the bath head-first down the slipway. Several sheep were used as a decoy across the slipway. Once in the bath, the sheep were plunged by the contractor's father (1) who used a paddle with a metal handle. After dipping, the sheep were held in a draining pen where they were held until it was full, and were subsequently released into the surrounding grassland.

APPENDIX 11 (Cont.)

Some protective clothing was worn by all three workers. The paddler (1) wore Wellington boots, waterproof leggings and a waterproof jacket, all in good condition. One chucker/helper (2) wore Wellington boots and waterproof leggings, both in good condition. The other chucker/helper (3) wore waterproof chaps which offered some protection. Gloves were sometimes worn by the paddler (1) when handling the concentrate dip. However, these were well worn and showing signs of contamination with concentrate dip.

No post dipping activities were carried out at this farm. At the end of the session, the concentrate container and jug were packed in the contractor's land rover by the contractor (3). No further dipping was planned for the following day.

Farm 10

Farm 10 was a privately owned farm located in the Scottish Borders. Dipping was carried out by a contractor who used a mobile dipping bath.

Three people were involved in dipping, the contractor (2), the farmer (1) and a neighbour (3). The neighbour left about 4pm, although dipping continued until after 7.30pm. Three of the farmer's children helped out in the afternoon. The farmer had been involved in work with pesticides and had contact with recently treated animals up to three days prior to the survey. The contractor and neighbour had no involvement in dipping activities during this period.

The mobile dipper was sited away from the farm steading in an exposed position in the corner of a field. Collecting pens and a race were used to guide sheep to the dipper, and a ramp was used to lead them up to the bath. The bath was a short swim type, formed from sheet metal. Entry to the bath was via a side entry slip way which had a screen across the entry. Remotely operated draining pen gates were fitted to the dipper, however, the contractor who responsible for plunging the sheep was not segregated from draining sheep. The dipper itself was several years old, but in good working order.

During the survey the weather was dry, although it was overcast and breezy.

The dipping session lasted for just over eight hours. Approximately 1500 sheep (ewes, lambs and tubs) were dipped with Bayer's Diazadip All Seasons Sheep Dip. This was supplied in both 5 litre (slender type) and 2.5 litre containers. The larger container had a ring pull cap and a pull out pouring spout, whilst the smaller container, which seemed to be of an older design, had a plastic pouring lip attached to the opening of the container. In total approximately 5150 mls of concentrate dip was used. A phenol based bactericide was also added to the bath in the morning. To fill and replenish the bath, concentrate was poured from the container into a measuring jug and then into the bath containing water/dip wash. The wash was then mixed with a brush. Water was added from a larger 200 l drum adjacent to the bath. This was filled from a large mobile tanker.

APPENDIX 11 (Cont.)

The contractor (2), acted as the paddler, while the farmer (1) and his neighbour (3) both acted as helpers. Sheep were collected in a large pen and then transferred to smaller pens until finally they were moved into the race. The main duties of the helper and chucker were to encourage sheep to run along the race and up the ramp to the bath. Only the contractor handled the concentrate dip, whilst replenishing the bath, a task which was carried out many times.

All of the three workers wore some form of protective clothing. The neighbour (3) wore waterproof leggings and Wellington boots, although the leggings were removed around mid morning, and in the afternoon the Wellington boots were replaced by stout shoes. The farmer (1) wore waterproof chaps and stout shoes. Finally, the contractor wore waterproof leggings, Wellington boots and nitrile gloves in accordance with the recommendations for protective equipment . During the course of the day, however, the gloves became badly torn and offered no protection from either concentrate or dip wash.

There were no post dipping activities at this site. It was intended to continue dipping the following day and therefore the dip wash was left in the bath at the end of the session.

Farm 11

Farm 11 was a privately owned small holding in Linlithgow. The holding is family run by the father and son, with help from the farmer's wife. Dipping was carried out using a mobile dipping facility owned by the farmer's son.

The farmer and farmer's son carried out the dipping, with some help from the farmer's wife who did not take part in the study. They had not been involved in dipping within three days prior to the visit.

The mobile dipping facility was located close to the farm steading, in an exposed location. The dipping bath, constructed from steel sheeting, was in good condition. Screens, just below above knee height, were positioned alongside the bath. Sheep were held in a nearby pen constructed from metal railings and wooden post and fencing. The draining pen, which forms part of the mobile dipping facility, was sited away from the workers. There was a piped supply of clean water.

During the survey the weather was dry and sunny with a breeze.

The dipping session lasted for just under 3 hours in total. Approximately 285 sheep (ewes, lambs and tups) were dipped with Coopers All Season Fly and Scab Dip, which was supplied in a 5 litre cylindrical container. In total, approximately 4990 ml of concentrate dip was used.

The paddler (1) prepared and replenished the bath on each occasion.

To prepare the bath, the concentrate dip (2.5 litres) was poured from the container into a 500 ml plastic jug and emptied into the bath containing 900 litres of water which had been added

APPENDIX 11 (Cont.)

previously. The paddle was then used to mix the bath vigorously. To replenish the bath, water (136-182 litres) was added from a storage tank into the bath via a hose. The concentrate dip (900 ml) was poured from the container into the jug and emptied into the bath. The jug was then rinsed out in the dip wash. The bath was mixed with the paddle.

Sheep were gathered into a collecting pen adjacent to the bath. The sheep were moved into a ramped race which guided them into the bath. The farmer (2) and his wife both acted as helpers. The farmer also spent some time acting as chucker, particularly for pet lambs which were dipped at the end of the dipping session. The sheep entered the bath sideways down the slipway. One sheep was used as a decoy across the slipway. Once in the bath, the sheep were plunged by the farmer's son (1) who used a paddle with a wooden handle. After dipping, the sheep entered a draining pen where they were held until it was full, and were subsequently released into the surrounding grassland.

The helper generally stood downwind of the dipping facility, and would most likely have been exposed to an aerosol of dip wash.

Some protective clothing was worn by the paddler (1) and helper (2). The paddler wore Wellington boots, waterproof leggings and a waterproof jacket. However, the leggings and jacket were both holed. The helper wore Wellington boots. Heavy duty PVC gauntlets were worn by the paddler when handling the concentrate dip. However, these were holed. The paddler generally rinsed the gloves in dip wash each time he handled the concentrate dip.

No post dipping activities were carried out at this farm. No further dipping was planned for the following day, although the paddler (1) thought that he would probably clean the dipping facility. At the end of the session, the concentrate dip and jug were stored in a shed.

Farm 13

On this occasion dipping took place at two adjacent farms in Angus. The same mobile dipper and workers were involved at each location.

Three people were involved in dipping; a contractor (1), the farmer (2) and his father (3). In the afternoon the farmer left to other work away from the farm and so his wife took over and helped to gather sheep. None of the individuals were involved in any tasks associated with sheep dipping up to three days prior to the survey.

The dipper used was a 'Mobi Dip' type. With this system sheep (in batches of about ten) were herded into an enclosed area and hydraulically operated gates were lowered in front and behind them. The area then filled with dip wash from an adjacent tanker. When the depth of the wash was sufficient, the paddler plunged each sheep individually. Next the dip wash was drained back into the holding tank and the gates lifted. The dipped sheep were moved to the draining area, still within the trailer and another batch were moved forward to be dipped. The draining area was away from the workers and had remotely operated gates. The dipper was in good working order.

APPENDIX 11 (Cont.)

On the day of the survey the weather remained dry, although it was overcast and breezy. The dipping session lasted for just less than two and a half hours. In total about 1100 sheep (ewes, lambs and tubs) were dipped with Bayer's Diazadip All Seasons Sheep Dip, supplied in 5 litre containers (slender type). The containers were fitted with a ring pull and pull out pouring spout which was used correctly to transfer the liquid. Approximately 7000 mls of dip was used in total. To prepare the dip wash the contractor poured concentrate dip from the container into a plastic measuring jug and then onto the mesh floor of the dipper. Water was then pumped from the tank into the dipper in an enclosed system. To replenish the dipping bath, concentrate was decanted from the container to a smaller 1 litre graduated plastic bottle, held at the side of the dipping bath. The concentrate was poured from this container onto the mesh floor and introduced to the dip wash when the bath was next filled.

The contractor (1) acted as the paddler throughout the day. The farmer (2) and his father (3) worked as helpers. They gathered sheep from surrounding collecting pens and moved batches up to the dipper. The nature of the facility meant that the two helpers worked away from sources of dip wash.

Only the contractor handled the concentrate during preparation and replenishment of the dip wash, although both the farmer and his father handled the concentrate container to transfer it from one location to another during the course of the day.

Two of the three men wore some form of protective clothing, although the farmer (2) wore Wellington boots only. The contractor wore waterproof leggings and an apron. Additionally he wore heavy duty PVC gauntlets whilst handling the concentrate dip. These became contaminated with concentrate as the container was repeatedly handled.

At the end of the dipping session the Mobi dip was dismantled as all dipping had been completed. The dip wash was removed from the farm in the trailer.

Farm 14

Farm 14 formed part of a large estate in Northumberland. The farm is managed by an estate manager and is run on a day to day basis by a shepherd and farm workers.

The shepherd and two farm workers carried out the dipping. All three had been involved in dipping within the three days prior to the visit. The shepherd (1) and one of the farm workers (2) had used pesticides within the previous three days.

The dipping facility was sited remote from the shepherd and farm worker's houses, in an exposed location. The dipping bath was a relatively modern circular bath with island. There was a redundant slipway. On the island there was a metal frame within which the plunger stood. Sheep were held in various pens constructed from wooden post and rail fencing and wooden fencing. The draining pens were sited away from the workers. There was a piped supply of clean water.

During the survey the weather was dry and sunny with a breeze.

APPENDIX 11 (Cont.)

The dipping session lasted for just over 3½ hours in total. Approximately 800 sheep (ewes, lambs and tups) were dipped with Coopers All Season Fly and Scab Dip, which was supplied in 20 litre cylindrical container. In total, approximately 3750 ml concentrate dip was used.

The paddler (2) replenished the bath on each occasion. The others did not handle the concentrate during the survey, except the shepherd (1) who stored the concentrate dip and jug in a nearby shed at the end of the session.

The bath was prepared on previous day. It is understood that to prepare the bath, the concentrate dip (5 litres) was added to the bath containing 2228 litres of water. To replenish the bath, water (159-228 litres) was emptied from a plastic barrel into the bath. The concentrate dip (550-1000 ml) was poured from the container into a 1 litre plastic jug and emptied into the bath. The bath was mixed with a wooden stick.

Sheep were gathered into a circular collecting pen adjacent to the bath. A revolving metal gate was used to move the sheep closer to the bath. The shepherd (1) and one of the farm workers (3) acted as chucker/helpers. The sheep were moved backwards into the bath. Once in the bath, the sheep were plunged in the dip wash by the other farm worker (2) who used a paddle with a wooden handle. After dipping, the sheep entered a draining pen where they were held until it was full, and were subsequently released into the surrounding grassland.

Some protective clothing was worn by all three workers. The paddler (2) wore Wellington boots, and waterproof leggings. However, the leggings were torn. One chucker/helper (1) wore Wellington boots and waterproof leggings, both of which were torn. The other chucker/helper (3) wore Wellington boots and waterproof leggings, both in good condition.

No post dipping activities were carried out at this farm. At the end of the session, the concentrate dip and jug were stored in a shed by the shepherd (1). No further dipping was planned for the following day.

Farm 15

Farm 15 was a tenanted farm located in the Dumfries and Galloway area.

The farmer (1), his wife (2) and a farm worker (3) were involved in the dipping session. The farmer and the farm worker were involved in cleaning the dipping bath and work with other pesticides up to thee days prior to the survey. The farmer's wife was not involved in any work associated with sheep dipping during this time.

Dipping took place at the farm steading, in a sheltered location. The dipping bath , which was constructed of concrete blocks and bricks was a short swim type. Collecting pens were situated around the dipper, to enable sheep to be gathered prior to dipping. The draining pens were located away from the farm workers and there was a piped supply of clean water. The facility was several years old and in need of some repairs. A large amount of empty dip containers were also lying around in the area.

APPENDIX 11 (Cont.)

During the survey the weather remained dry, although the sky was overcast for most of the day. The wind was still.

The dipping session lasted for just over eight hours. Approximately 400 sheep (lambs and tubs) were dipped with Neocidol Winter Dip, which was supplied in 5 litre containers. In total about 1.8 litres of concentrate dip were used. To make up the bath the concentrate dip was poured into a measuring jug (with a handle) and then into the bath which already contained water. The jug was washed out with water from the bath and the concentrate and water were mixed with a long handled sweeping brush. The bath was replenished in a similar manner.

Sheep were gathered in a rectangular pen adjacent the bath. The farm worker (3) lifted each animal in turn into the bath, and used his foot to submerge each one. In doing this the farm worker's lower leg and foot were submerged in the dip wash. The farmer (1) then

submerged each sheep once again with a metal paddle. The farmer's wife (2) generally helped to gather sheep and return them to the fields after dipping.
Only the farmer handled the concentrate to fill and replenish the dipping bath. The other individuals had no contact with the concentrate dip.

Some protective clothing was worn by all three workers. The farmer wore waterproof chaps, a long apron, Wellington boots, nitrile rubber gauntlets and a face shield. During the course of the day however, he removed his apron and face shield his gloves became contaminated with both concentrate and dip wash and it was noted that when removing his gloves he also contaminated his hands.

At the start of dipping, the farm worker wore waterproof trousers, Wellington boots and a face shield. The waterproof trousers were showing some signs of wear and tear. The face shield was not worn during the afternoon session.

The farmer's wife wore waterproof shoes only.

Throughout the day sheep dipping was intermittent. Dipping stopped whilst sheep were returned to fields and another batch gathered. Once back at the farm steading ewes and lambs were separated (shed). Ewes were not dipped but treated with a pyrethroid pour-on instead, applied from a knapsack applicator. Lambs were then dipped as described above.

No post dipping activities were carried out at the end of the dipping session as the farmer intended to continue dipping the next day, the dip wash was left in the bath.

Farm 17

Farm 17 was a tenanted sheep farm in Galashiels. The farm is family run by the farmer and his son.

APPENDIX 11 (Cont.)

The farmer, the farmer's son and a family friend carried out the dipping. They had not been involved in dipping within the three days prior to the visit. One individual (3) had cleaned the bath within the previous three days.

The dipping facility was sited near the farm steading, in a sheltered position. The dipping bath was a circular bath with island, and a slipway. The bath itself was relatively new, however, the dipping facility was old and worn. Sheep were held inside a farm building in pens constructed from wooden post and rail fencing. The draining pens were sited away from the workers. There was a piped supply of clean water.

During the survey the weather was dry and breezy, with an overcast sky.

The dipping session lasted for almost 5 hours in total. Approximately 295 sheep (ewes and lambs) were dipped with Neocidal Winter Dip, which was supplied in a 5 litre container. In total, approximately 1640 ml of concentrate dip was used.

The paddler (1) prepared the bath and replenished it on each occasion. The concentrate was measured out in a nearby shed where it was stored along with other agricultural medicines. The chucker (3) and helper (2) did not handle the concentrate dip during the survey.

To prepare the bath, the concentrate dip (1250 ml) was poured from the container into a 1 litre plastic jug and emptied into the bath containing 2500 litres of water which had been added previously. Natural clay had also been added to the bath for cosmetic reasons. A paddle was then used to mix the bath. To replenish the bath, water (182-455 litres) was added to the bath via a plastic hose from a storage tank held on a trailer next to the bath. Concentrate dip (95-195 ml) was poured from the container into the jug and emptied into the bath. The bath was mixed with the paddle. The jug was then rinsed out in the dip wash, or under the running tap.

Sheep were gathered into collecting pens inside the farm building adjacent to the bath. Wooden swing gates were used to move the sheep closer to the bath and into a race at the exit from the building which guided them into the bath. The farmer acted as the helper (2) inside the farm building, ensuring the sheep entered the race and the family friend acted as a chucker (3) ensuring that the sheep entered the bath. The sheep moved along the race and entered the bath sideways down a slipway through a bath entry screen. Several sheep were used as a decoy across the slipway. Once in the bath, the sheep were plunged by the farmer's son (1) who used a paddle with a metal handle. A lighter paddle with a wooden handle was also used to plunge lambs. After dipping, the sheep entered a draining pen where they were held until it was full, and were subsequently released into the surrounding grassland.

Some protective clothing was worn by the paddler (1) and chucker (3). The paddler wore Wellington boots, waterproof leggings, and an airfed helmet fitted with a particulate (P2) filter. The waterproof trousers were holed and were generally worn well below the waist. The chucker (3) wore Wellington boots. Heavy duty PVC gloves (with flock lining) were also worn by the paddler when handling the concentrate. However, these were showing signs of wear and tear and on close inspection were found to be holed. The helper (2) did not wear personal protective equipment.

APPENDIX 11 (Cont.)

No post dipping activities were carried out at this farm. The concentrate container and jug were left in the nearby shed. Further dipping was planned for the following day.

Farm 18

Farm 18 was a privately owned sheep farm in Galashiels. The farm is family run by two brothers, and employs a farm worker.

Both brothers and the farm worker carried out the dipping. They had not been involved in dipping within the three days prior to the visit. However, one of the brothers (paddler), and the farm worker (helper) had been involved with cleaning the bath on the previous day.

The dipping facility was remote from the farm steading, in an exposed location. The dipping bath was a circular bath with island and a slipway, constructed from fibreglass. The bath itself was relatively new, however, the dipping facility was old and worn. Sheep were held in various pens constructed from wooden post and rail fencing, and wooden panels. The draining pens were sited away from the workers. There was a piped supply of clean water.

During the survey the weather was damp and breezy, with an overcast sky.

The dipping session lasted for just over 3 hours in total. Approximately 450 sheep (ewes, lambs and tups) were dipped with Diazadip All Seasons Sheep Dip, which was supplied in a 5 litre container. In total, approximately 3200 ml of concentrate dip was used.

The paddler (2) prepared the bath and replenished it on each occasion. The chucker (1) and helper (3) did not handle the concentrate dip during the survey.

To prepare the bath, the concentrate dip (1200 ml) was poured from the container into a 1 litre plastic jug and emptied into the bath containing 1820 litres of water which had been added previously. The jug was rinsed out in the dip wash. A brush was then used to mix the bath. To replenish the bath, concentrate dip (200 ml) was poured from the container into the jug and emptied into the bath. The bath was mixed with a brush. Similarly, the jug was rinsed out in the dip wash, or under the running tap which provided a continuous supply of water to the bath.

Sheep were gathered into a circular collecting pen constructed from metal railing adjacent to the bath. Revolving metal swing gates were used to move the sheep closer to the bath. The farm worker acted as a helper (3). The sheep were moved into the bath by one of the brothers who acted as a chucker (1). The sheep entered the bath sideways down the slipway. Several sheep were used as a decoy across the slipway. Once in the bath, the sheep were plunged by the other brother (2) who used a paddle with a metal handle. After dipping, the sheep entered a draining pen where they were held until it was full, and were subsequently released into the surrounding grassland.

All three workers gathered sheep during the survey.

APPENDIX 11 (Cont.)

Some protective clothing was worn by all three workers. The paddler (2) wore Wellington boots, waterproof leggings, a waterproof jacket and medium weight nitrile gauntlets. These were in good condition. However, the waterproof jacket provided limited protection on the lower arms due to its design. The chucker (1) wore Wellington boots and waterproof leggings, both in good condition. The helper (3) wore Wellington boots, waterproof leggings and a waterproof jacket. These were in good condition, however, the jacket was worn with its front unzipped. The paddler (2), who wore protective gloves throughout the survey generally rinsed the gloves in water each time he handled concentrate dip.

Post dipping activities were carried out by the paddler (2) at this farm. The post dipping session lasted for about an hour. The bath was emptied using a gulley sucker. While the bath was being emptied, the paddler stood on the island in the centre of the bath or in the bath (once it was nearly empty) and brushed the sludge at the bottom of the bath to ensure it was removed by the gulley sucker.

At the end of the dipping session, the concentrate dip and jug were left at the side of the bath. Further dipping was planned for the following day.

Farm 20

Farm 20 was a privately owned farm located in the Dumfries and Galloway area.

Four people were involved in dipping, the farmer (1), his two sons (2 and 3) and a family friend (4). The younger son (3) had been involved in work with pesticides at sometime during the three days prior to the survey. The other individuals had not been involved with any work associated with sheep dipping during this period.

Dipping was carried out away from the farm on an extremely exposed hillside. Collecting pens and a race formed from post and rail fencing were used to guide sheep to the dipping bath. The bath itself was a long swim type, lined with concrete. Entry to the bath was via a side entry slipway, with a screen across to deflect splashes. Draining pens were located away from the workers. The facilities had been purpose built just a few years ago and were in good working order.

During the survey the weather was dry, although it was overcast and breezy.

The dipping session lasted for just a little under 5 hours. Approximately 1700 sheep (ewes, lambs, tups) were dipped with Paracide Plus, manufactured by Battle, Hayward and Bower Ltd and supplied in 10 litre cylindrical containers. In total about 8700 mls were used. To fill the bath, concentrate was poured from the container into a plastic measuring jug (with handle) and then into the bath. The pouring spout was pulled into place by inserting fingers into the container. The jug was rinsed in the bath and a brush was used to mix up the dip wash. The bath was replenished in a similar manner to that described above and water was added from a nearby tanker when required.

The farmer (1) gathered sheep and moved them forward through a series of pens to the start of the race from where the chucker took over. For the majority of the time the two sons

APPENDIX 11 (Cont.)

acted as plunger and chucker in turn. The friend (4) helped out generally by gathering and moving sheep in the pens and for a short time, took over as plunger while one of the sons helped to move sheep.

A wooden handled paddle was used to plunge the sheep below the surface of the dip wash. The paddler stood opposite the side entry slip way and plunged each sheep in turn. The chuckers' job was to encourage sheep to move up the race to the bath, and to man-handle awkward sheep into the bath.

The younger son (3) handled the concentrate most often to fill and replenish the dipping bath. The friend (4) also handled the container once to carry out one replenishment. The remaining individuals had no contact with the concentrate dip.

Three of the workers wore some protective clothing. The older son (2) wore Wellington boots only, while the younger son (3) wore Wellington boots and a pair of waterproof chaps. No additional protective clothing was worn whilst handling concentrate. Finally, the friend wore Wellington boots sometimes waterproof leggings and a coat. Whilst handling concentrate he wore all of the above plus some surgical type gloves.

No post dipping activities were carried out at the end of the dipping session. The farmer intended to continue dipping the following day and therefore the dip wash was left in the bath.

Farm 21

Farm 21 was a privately owned farm located in the Dumfries and Galloway area.

Two people only were involved in the dipping session; the farmer (1) and a farm worker (2). Neither individual carried out any tasks associated with dipping up to three days prior to our visit.

Dipping took place away from the farm steading at an exposed, but low level site close by. A series of collecting pens and a race were used to guide the sheep to the dipping bath. These were formed from galvanised fences gates and screens. The bath itself was a small circular swim type, without an island and was lined with concrete. The whole facility was encircled by a post and rail fence. Entry into the bath was via a side entry slip way which had a galvanised screen across to deflect splashes. The draining pens which had remotely operated gates were located away from the workers. There was a piped supply of clean water at the site. Beyond the dipping bath was a large foot bath which sheep were moved through once they had been dipped. The facility was just a few years old and in good working order.

During the survey the weather was dry although it was overcast and breezy.

The dipping session lasted for just less than four and a half hours. Approximately 500 sheep (ewes, lambs and tubs) were dipped, with Coopers All Season Fly and Scab Dip. This product was supplied in 5 litre cylindrical containers. In total about 7000 mls were used.

APPENDIX 11 (Cont.)

To fill and replenish the bath, concentrate was poured from the container into a measuring jug (with handle) and then into the bath. The jug was rinsed in the bath and a paddle was used to stir the dip wash. Water was added when required from a piped supply.

The farmer (1) acted as chucker and plunger by firstly pushing the sheep forward onto the slipway and then dipping them using a wooden handled paddle. The farm worker (2) gathered sheep from the collecting pens and moved them forward to the dipper.

Only the farmer handled the concentrate dip mostly this was to replenish the bath although on one occasion he poured concentrate directly onto a sheep's foot which had become infested with maggots.

The farmer (1) wore Wellington boots and a long PVC apron for both dipping and working with concentrate. The farm worker wore no personal protective clothing.

There was no stoppage for lunch and all sheep had been dipped by early afternoon. There were no post dipping activities as the farmer intended to leave the dip wash in situ for a few days before draining and cleaning the facility.

Farm 22

Farm 22 was a privately owned sheep and cattle farm in Midlothian. The farm is family run, and employs a shepherd and farm worker.

The farmer, the farmer's wife, the shepherd and farm worker carried out the dipping. The farmer's wife and shepherd were present for only part of the dipping session. They had not been involved in dipping within the three days prior to the survey.

The dipping facility was remote from the farm steading, in an exposed location. The dipping bath was a long swim bath. The dipping facility was old and in poor condition, with make-shift gates. Originally sheep would have been dipped in this bath by a paddler using his hands, standing in a pit alongside the bath. However, in more recent years dipping with the hands has ceased and the paddler stands on the opposite of the bath from the pit and uses a plunger to the dip the sheep. Sheep were held in various pens constructed from wooden post and rail fencing. The draining pens were sited away from the workers. There was a piped supply of clean water.

During the survey the weather was dry and breezy, with an overcast sky.

The dipping session lasted for almost 4 hours in total. Approximately 600 sheep (ewes, lambs and tups) were dipped with Deosan Diazinon Dip, which was supplied in a 5 litre container. In total approximately 2300 ml of concentrate dip was used.

One of the helpers (4) prepared the bath. The paddler (1) and other helper (3) replenished the bath.

APPENDIX 11 (Cont.)

To prepare the bath, the concentrate dip (1200 ml) was poured from the container into a 2 litre plastic jug and emptied into the bath containing 1820 litres of water which had been added previously. A brush was then used to mix the bath. To replenish the bath, water (910 litres) was added via a hose from a nearby storage tank. The concentrate dip (500-600 ml) was poured into the jug and emptied into the bath. The jug was then rinsed out in the dip wash. Similarly, the bath was mixed with a brush.

Sheep were gathered into a collecting pen at the side of the bath. The sheep were moved head-first into the bath by the shepherd or farm worker who acted as chucker (2) and helper (3), respectively. Once in the bath, the sheep were plunged by the farmer (1) who stood alongside the bath in the collecting pen, using a plunger with a wooden handle. After dipping, the sheep entered a draining pen where they were held until it was full, and were subsequently released into the surrounding grassland.

All four workers gathered sheep during the survey.

Some protective clothing was worn by all workers. The paddler (1) wore Wellington boots and waterproof leggings, in good condition. The chucker (2) wore waterproof leggings which were in poor condition and heavily ripped. The helper (3) wore Wellington boots and waterproof leggings, in good condition. The farmer's wife (4), who helped out for part of the session, wore Wellington boots and waterproof leggings, also in good condition. In addition, she wore a waterproof jacket, a visor and heavy duty PVC gauntlets when handling the concentrate. The PVC gauntlets were also worn by the paddler (1) when handling the concentrate dip.

No post dipping activities were carried out at this farm. The concentrate container and jug were left near the dipping bath, however, it is understood that the paddler (1) planned to move them into a nearby shed later on. Further dipping was planned for the following day.

Farm 23

Farm 23 was a privately owned sheep and cattle farm near Gifford. The farm is family run by the farmer and his son and employs a farm worker.

The farmer, the farmer's son and the farm worker carried out the dipping. All three had been involved in dipping within the three days prior to the visit, and the farmer worker (3) had cleaned the bath within the previous three days.

The dipping facility was sited near to the farm steading, in an relatively sheltered location. The dipping bath was a long swim bath with a race. The dipping facility was old and showing signs of wear and tear. Wooden post and rail fencing and wooden fencing was positioned alongside the bath. However, some of the fencing had been removed at the bottom to allow the sheepdogs to chase the sheep along the race. Corrugated steel screens were positioned alongside the bath, below waist-height, between the paddler and the dipping bath. The draining pens were sited away from the workers. There was a piped supply of clean water.

APPENDIX 11 (Cont.)

During the survey the weather was dry and breezy, with an overcast sky.

The dipping session lasted for around 4½ hours in total. Approximately 250 sheep (lambs, ewes and tups) were dipped with Deosan Diazinon Dip, which was supplied in a 5 litre rectangular container. In total, approximately 2750 ml of concentrate was used.

The chucker/helper (2) replenished the bath on each occasion. The others did not handle the concentrate during the survey.

The bath was prepared on the previous day. It is understood that concentrate dip was poured from the container into a 1 litre plastic jug and emptied into the bath containing 2730 litres of water which had been added previously. The bath was mixed with a brush. To replenish the bath, the concentrate dip (500-750 ml) was emptied from the container into the jug and emptied into the bath. The bath was mixed with a brush. Water was added to the bath continuously via a hose.

Sheep were gathered into collecting pens at the foot of the bath. The farm worker acted as a helper (3) and the farmer's son acted as the chucker/helper (2), ensuring that the sheep moved along the race and entered the bath head-first down the slipway. They were assisted by the sheepdogs who encouraged the sheep to move along the race and into the bath. One sheep was used as a decoy across the slipway. Once in the bath, the sheep were plunged by the farmer (1) who used a paddle with a metal handle. After dipping, the sheep entered a draining pen where they were held until it was full, and were subsequently released into the surrounding grassland.

Wellington boots and waterproof leggings were worn by all three workers. The leggings worn by the chucker/helper (2) were torn. The leggings wore by the others were in good condition.

No post dipping activities were carried out at this farm. The concentrate container and jug were left near the dipping bath. No further dipping was planned for the following day.

Farm 24

Farm 24 was a privately owned farm located in Midlothian.

Three individuals were involved in dipping; the farmer (1), his son (3) and a farm worker (2). The farmer had been involved in dipping and cleaning out the dipping bath up to three days prior to our visit. The farm worker had also been involved in cleaning the dipping bath during the same period, however, the farmer's son had not done any work associated with sheep dipping in this time period

Dipping was carried out at the farm steading in a sheltered position. A series of collecting pens and a race were used to guide sheep to the dipping bath. These were formed from galvanised fences, gates and corrugated metal screens. The bath was constructed of glass reinforced plastic and was a long swim type. Entry into and out of the bath was via ramps.

APPENDIX 11 (Cont.)

In theory the sheep were to walk down the ramp and into the bath. In practice, however, most tried to jump across to the exit ramp and caused a large amount of splashing as they fell into the dip wash, particularly because there was no screening around the edge of the bath. Draining pens were sited away from the workers and there was a piped supply of clean water close by. In general the dipping facility was clean and in good working order.

During the survey the weather was dry although it was overcast and breezy.

The dipping session lasted for about six and a quarter hours. Approximately 1100 sheep (ewes, lambs and tups) were dipped with Deosan Diazinon Dip, which was supplied in 5 litre containers. These containers have a pull up plastic pouring spout which the farmer found difficult to use during the session. To make-up and replenish the dipping bath concentrate dip was poured into a measuring jug (with handle) and then into the bath containing water/dip wash. Water was added when required from a large 200 litre plastic drum. A brush was used to mix concentrate with water/dip wash. Later in the day a hose was used to wash out the measuring jug. Deosan Purl, a cosmetic sheep dip, was also used in the bath on the day of the survey.

The farmer (1) acted as the paddler, he used a wooden handled paddle to plunge the sheep below the surface of the dip wash. During the course of the day the farmer was significantly splashed with dip wash as sheep went into the bath. For the majority of the time the farm worker (2) acted as the chucker, pushing sheep forward in the race toward the ramp and man-handling stubborn sheep directly into the bath. For shorter periods he also acted as a helper. The farmer's son spent almost all the time helping. This job involved gathering sheep in the collecting pens and driving them forward toward the race. In addition, he gathered and returned sheep to nearby fields.

The farmer filled and replenished the dipping bath each time with the concentrate. The farm worker handled a concentrate container once only, while washing it out. The farmer's son had no contact with the concentrated dip.

All three workers wore some form of protective clothing. The farmer wore Wellington boots, PVC waterproof trousers with a front bib, one rubber gauntlet style rubber glove and a disposable respirator whilst dipping and handling concentrate. During the course of the day the rubber glove was removed. The farm worker wore Wellington boots, a waterproof coat, which was open at the front, waterproof trousers and a disposable respirator. The son wore Wellington boots only.

Dipping continued for the whole day. At the end of the session there were no post dipping activities. The dip was left in the bath as it was intended to continue dipping the next day.

Farm 25

Farm 25 was a privately owned sheep farm in Hawick. The farm is family run by the farmer and his sons and employs a shepherd.

APPENDIX 11 (Cont.)

The farmer, one of the farmer's sons and the shepherd carried out the dipping. The farmer and shepherd had been involved in dipping within the three days prior to the visit.
The dipping facility was sited remote from the farmhouse, in a sheltered location. The shepherd's caravan was located nearby. The dipping bath was a Cooper's short swim bath. Sheep were held in pens constructed from wooden post and rail fencing adjacent to the dipping facility, and a pen inside the farm building next to the bath. The draining pens were sited away from the workers. There was a piped supply of clean water.

During the survey the weather was dry and still, with an overcast sky.

The dipping session lasted for around 2½ hours in total. Approximately 420 sheep (ewes, lambs and tups) were dipped with Diazadip All Seasons Sheep Dip, which was supplied in a 5 litre rectangular container. In total, approximately 1800 ml of concentrate dip was used.

The paddler (1) replenished the bath on each occasion. The concentrate was measured out inside the farm building. The chucker/helpers did not handle the concentrate dip during the survey.

The bath was prepared on the previous day. The bath had already been replenished once before the survey team arrived on site, however, dipping had not started. To replenish the bath, water (227-318 litres) was added to the bath via a plastic hose from a storage tank on a trailer next to the bath. Concentrate (500-700 ml) was poured from the container into a 1 litre plastic jug and emptied into the bath. The bath was mixed with a brush.

Sheep were gathered into a pen inside the farm building adjacent to the bath by the farmer (2) and the farmer's son (3) who both acted as a chucker/helpers. They moved the sheep into the bath. The sheep entered the bath backwards through a wooden gate which acted as an effective splash barrier at the entrance to the bath. Once in the bath, the sheep were turned and plunged in the dip wash by the shepherd (1) who used a paddle with a wooden handle. After dipping, the sheep entered a draining pen where they were held until it was full, and were subsequently released into an adjacent pen.

Some protective clothing was worn by the paddler (1) and one chucker/helper (3). The paddler (1) wore Wellington boots, waterproof leggings, heavy weight vinyl gloves (lined), goggles and a disposable nuisance dust mask. However, the leggings were torn and were generally worn well below the waist. One of the chucker/helpers (3) wore Wellington boots and waterproof chaps, which offered some protection. The farmer (2), who acted as the other chucker/helper did not wear personal protective equipment.

No post dipping activities were carried out. The concentrate container and jug were left in the farm building next to the dipping bath. No further dipping was planned for the following day.

APPENDIX 12: Estimated Protection offered by Protective Clothing (Range)

Farm & Ind. Code	Principal Job(s)	Subsidiary Job	Protection offered by protective clothing during work with dip wash										No. of Handling Events (Conc.)	Protection offered by protective clothing during work with concentrate									
			Hands	Face	Hair	Torso F	Torso B	Arms L	Arms U	Legs L	Legs U	Feet		Hands	Face	Hair	Torso F	Torso B	Arms L	Arms U	Legs L	Legs U	Feet
01/1	P	H	0	0	0	3-1	3	3	3	2	1	3	10	0	0	0	1-3	3	3	3	2	1	3
01/2	C & H	-	0	0	0	0	0	0	0	3	3	3	1	0	0	0	0	0	0	0	3	3	3
01/3	C & H	-	0	0	0	0	0	0	0	1	3	3	2	0	0	0	0	0	0	0	1	2-3	3
03/1	P	-	0	2	0	3	3	1	3	3	3	3	1	0	0	0	3	3	1	3	3	3	3
03/2	C & H	-	0	2	0	0	0	0	0	3	3	3	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
03/3	C & H	-	0	2	0	0	0	0	0	3	3	3	4	2	2	0	0	0	0	0	3	3	3
04/1	P	-	0	0	0	0	0	0	0	3	3	3	0	-	-	-	-	-	-	-	-	-	-
04/2	C	-	0	0	0	0	0	0	0	3	0-2	3	7	0	0	0	0	0	0	0	3	0-2	3
04/3	H	-	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
05/1	H	C	0	0	0	2-1	2	2	2	3	3	3	0	-	-	-	-	-	-	-	-	-	-
05/2	P	-	2-1	0-1	0	3	3	3	3	3	2	3	18	2-1	2-1	0	3	3	3	3	3	2	3
05/3	C	H	0	0	0	3	3	3	3	3	3	1	0	-	-	-	-	-	-	-	-	-	-
06/1	C & H	-	0	0	0	0	0	0	0	3	2	3	2	0	0	0	0	0	0	0	3	2	3
06/2	P	-	0	0	0	0	0	0	0	3	1	3	0	-	-	-	-	-	-	-	-	-	-
06/3	C & H	-	0	0	0	0	0	0	0	3	3	3	5	0	0	0	0	0	0	0	3	3	3
07/1	P	-	2	3	0	0	0	0	0	3	2	3	11	3-2	3	0	0	0	0	0	3	2	3
07/2	H	-	0	0	0	0	0	0	0	3	0	3	0	-	-	-	-	-	-	-	-	-	-
07/3	C & H	-	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
08/1	P	-	0	0	0	3	3	3	3	3	3	3	5	0-2	0	0	3	3	3	3	3	3	3
08/2	C & H	-	0	0	0	0	0	0	0	3	3	3	0	-	-	-	-	-	-	-	-	-	-
08/3	C & H	-	0	0	0	0	0	0	0	3	2	0	1	0	0	0	0	0	0	0	3	2	0

Codes: Task; P-Paddler, C - Chucker, H - Helper. Protective Clothing; 0 - Not worn, 1 - Poor, 2 - Fair, 3 - Good, N/A - Not Available.

HEAD OFFICE:

Research Avenue North,
Riccarton,
Edinburgh, EH14 4AP,
United Kingdom
Telephone: +44 (0)870 850 5131
Facsimile: +44 (0)870 850 5132

Tapton Park Innovation Centre,
Brimington Road, Tapton,
Chesterfield, Derbyshire, S41 0TZ,
United Kingdom
Telephone: +44 (0)1246 557866
Facsimile: +44 (0)1246 551212

Research House Business Centre,
Fraser Road,
Perivale, Middlesex, UB6 7AQ,
United Kingdom
Telephone: +44 (0)208 537 3491/2
Facsimile: +44 (0)208 537 3493

Brookside Business Park,
Cold Meece,
Stone, Staffs, ST15 0RZ,
United Kingdom
Telephone: +44 (0)1785 764810
Facsimile: +44 (0)1785 764811

Email: iom@iom-world.org