NIOSH HEALTH HAZARD EVALUATION REPORT

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The United States Department of Agriculture, Animal and Plant Health Inspection Service
Laredo, Texas

November 2007

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

PREFACE

The Hazard Evaluation and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employers or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Gregory A. Thomas, Lisa J. Delaney, Elena Page, and Charles Mueller of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Chad Dowell, Kevin Dunn, Max Kiefer, Deborah Sammons, and Barbara MacKenzie. Analytical support was provided by Deborah Sammons, Cynthia Striley, and John Snawder of the Division of Applied Research Technology (DART), DataChem Laboratories, Salt Lake City, Utah, and Pacific Toxicology Laboratories, Chatsworth, California. Desktop publishing was performed by Robin Smith. Editorial assistance was provided by Ellen Galloway.

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For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Highlights of the NIOSH Health Hazard Evaluation

On March 22, 2002, NIOSH received a request for a health hazard evaluation (HHE) from the Animal and Plant Health Inspection Service (APHIS), a division of the United States Department of Agriculture (USDA). The request was to determine if the cholinesterase monitoring program for animal health technicians was useful and to determine the feasibility of using field kit measurements of cholinesterase and urinary biomarkers of exposure. The primary organophosphate pesticide used was coumaphos. NIOSH conducted investigations in 2002 and 2005.

What NIOSH Did

- We observed the technicians doing their jobs.
- We asked technicians questions about coumaphos application history, health symptoms, general medical information, and use of personal protective equipment (PPE).
- We measured cholinesterase levels in blood before and after coumaphos use two ways – in a laboratory and with a field test kit.
- We measured urinary chlorferon (a metabolite of coumaphos) before and after coumaphos use.
- We took air samples for coumaphos in the breathing zone of the technicians.
- We tested clothing and hands of technicians for coumaphos.

What NIOSH Found

- We found that PPE use varied by technician.
- We did not find coumaphos in the air.
- We found coumaphos on almost every technician's hands, and on the clothing of most workers.
- Cholinesterase levels were within the normal range and correlated well between the two methods of testing.
- Urinary chlorferon levels rose significantly after application of coumaphos.

What USDA Managers Can Do

- Determine the appropriate PPE for the tasks performed by the animal health technicians and enforce its use.
- Consider discontinuing respirator use. If use is continued, establish a comprehensive respiratory protection program in accordance with the OSHA respiratory protection standard.
- Determine if urinary chlorferon can be used to monitor exposure to coumaphos.
- Continue cholinesterase monitoring, and consider use of field test kits.

What USDA Employees Can Do

- Wear appropriate PPE when applying pesticides.

CDC Workplace Safety and Health

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We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #2002-0203-3050

NIOSH

Health Hazard Evaluation Report 2002-0203-3050

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SUMMARY

On March 22, 2002, NIOSH received a request for a health hazard evaluation (HHE) from the Animal and Plant Health Inspection Service (APHIS), a division of the United States Department of Agriculture (USDA). The medical officer for APHIS was interested in determining if the current cholinesterase monitoring program for its animal health technicians in the tick eradication program was useful. In addition, APHIS had an interest in evaluating other methods for monitoring organophosphate (OP) exposure, including field test kit measurements of cholinesterase and urinary biomarkers. The primary OP used was coumaphos.

NIOSH investigators observed various coumaphos application tasks and administered questionnaires concerning coumaphos application history, health symptoms, and general medical information. Blood was collected by venipuncture for laboratory cholinesterase measurements using the Ellman method, and by fingerstick for cholinesterase measurements by field test kit at the start of the workday (prior to use of coumaphos) and again at the end of the workday. Urine was collected for measurement of a possible urinary biomarker of coumaphos, 3-chloro-4-methyl coumarin (chlorferon), at the same times. An additional urine sample was obtained the following day. Environmental sampling included personal air sampling, patch sampling on the surface of employees' clothing, and skin wipe sampling of hands. These were conducted at the end of one or more coumaphos application tasks.

All of the APHIS animal health technicians who met our criteria for participation agreed to participate in the evaluation, but only 15/59 met the criteria. Participants reported mixing coumaphos 8.5 days per month and spraying or dipping livestock 11 days per month, on average. Three reported being removed from working with coumaphos (one time each) in the past year due to low cholinesterase levels. Technicians were asked about symptoms consistent with OP poisoning experienced within 6 hours of coumaphos use in the past 3 months. Two each reported headache, weakness, and tearing eyes; and one each reported cough and nervousness. Reported personal protective equipment (PPE) use varied by task and type of PPE.

None of the technicians had plasma cholinesterase (PChE) or acetylcholinesterase (AChE) levels outside the laboratory's range of normal. Neither PChE nor AChE changed significantly from pre- to post-shift with the Ellman method or the field test kit. A significant positive correlation was found between PChE levels measured with the field test kit and by the Ellman method ($r=0.92$, $p<0.01$). A significant positive correlation was also found between AChE levels measured by the two different methods ($r=0.63$, $p<0.01$).

Chlorferon was detected in the urine of all animal health technicians after they used coumaphos. Urinary chlorferon levels were significantly higher 4-6 hours after use ($p<0.01$) and declined significantly by the next day ($p=0.01$). No coumaphos was detected in 8 of 9 personal breathing zone air samples. One showed trace amounts of coumaphos and represented a worst case scenario. The technician sprayed horses and dipped cattle for the entire day. Of the whole body patch samples, 58% detected measurable levels of coumaphos. Of handwipe sampling, 96% detected measurable amounts of coumaphos, indicating that the majority of exposures occur from hand contact with the pesticide.

A formal PPE program was not in place. No standard guidance for what type of PPE should be worn during specific tasks was available and use of PPE varied by employee. PPE was poorly maintained and dirty. Employees were observed incorrectly wearing respiratory protection.

A health hazard from dermal exposure to coumaphos existed for USDA APHIS animal health technicians. An inhalation hazard to the pesticide did not exist at the time of the NIOSH evaluation. Instituting a formal PPE program and requiring the use of PPE such as gloves and aprons during specific work tasks would lower dermal exposures.

Keywords: NAICS 926140 (Regulation of Agricultural Marketing and Commodities), organophosphates, coumaphos, chlorferon, cholinesterase, chlorpyrifos, personal protective equipment.

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INTRODUCTION

On March 22, 2002, NIOSH received a request for a health hazard evaluation (HHE) from the Animal and Plant Health Inspection Service (APHIS), a division of the United States Department of Agriculture (USDA). The medical officer for APHIS was interested in determining if the current cholinesterase monitoring program for its animal health technicians working in the tick eradication program was useful. In addition, APHIS had an interest in evaluating other methods for monitoring organophosphate (OP) exposure, including field test kit measurements of cholinesterase and possible measurement of urinary biomarkers of exposure. APHIS thought these alternative monitoring methods may be more convenient considering the erratic use of OP pesticides by APHIS employees, and the remote locations and harsh conditions under which they worked. The primary OP used was coumaphos.

In 2002, NIOSH staff made an initial site visit to the Laredo, Texas, location of the APHIS field office for the tick eradication program to learn more about the program. During that visit, various coumaphos application tasks were observed and photographed. On September 13, 2005, NIOSH staff returned to carry out a field investigation. An opening conference included Webb County APHIS employees, the APHIS field director, and the local union representative. Employees were represented by the American Federation of Government Employees Union, Local 3106. During this visit NIOSH staff administered questionnaires concerning coumaphos application history, health symptoms, and general medical information. Blood was collected by venipuncture for standard laboratory cholinesterase measurements, and by fingerstick for cholinesterase measurements by field test kit at the start of the workday (prior to use of coumaphos) and again at the end of the workday. Urine was collected for measurement of a possible urinary biomarker of coumaphos, 3-chloro-4-methyl coumarin (chlorferon) at the same times. An additional urinary collection was obtained the following day. Technicians were informed by letter of the results of their individual testing. The NIOSH industrial hygienists observed the coumaphos application tasks and conducted environmental sampling for coumaphos. The sampling included individual air sampling, patch sampling on the surface of clothing of employees and skin wipe sampling of hands. Sampling was conducted at the end of one or more coumaphos application tasks.

BACKGROUND

The U.S. initiated a tick eradication program in 1906 to control cattle fever, a disease that has historically decimated livestock populations. The program, managed by the USDA APHIS, successfully eradicated cattle fever ticks from the U.S. by 1961. However, 50% of cattle in Mexico are infested with the cattle fever tick, and many of these animals migrate across the border into the U.S. The migration of Mexican cattle produces sporadic infestations in U.S. livestock along the Texas border. To control these infestations, the USDA APHIS maintains a quarantine buffer zone along the Texas border with Mexico. Animal health technicians ("tick riders") are employees of the USDA APHIS who patrol and inspect cattle in and around the quarantine zone. Cattle found to carry the cattle fever tick are treated over periods of weeks to months with coumaphos, an OP pesticide.

The USDA APHIS employs 59 animal health technicians who typically work alone in rugged remote terrain, often on horseback. They apply coumaphos to cattle by using fixed or portable dipping vats that require the cattle to fully submerge in the OP mixture. They also utilize a single-cattle spray booth that sprays coumaphos on cattle. They hand spray their own horses and cattle, on a limited basis, by using low pressure spray wands. The technicians mix and dilute the coumaphos solution. Animal health technicians typically perform no more than one scheduled spraying or dipping operation per day. Technicians also conduct physical inspections of the cattle by touching areas of the cattle where ticks most likely attach. This activity is commonly referred to as "scratching." These operations begin in the morning and, depending on the total herd size, may last until early afternoon. In addition, the animal health technicians spray chlorpyrifos to disinfect infested materials in trailers, corrals, and barns. This occurs infrequently.

Each technician is issued personal protective equipment (PPE) including a half-facepiece respirator (Willson AR 700 or Norton 7500) and full-facepiece respirator (3M 6892) with particulate filter and organic vapor cartridges; apron; neoprene elbow length gloves; rain coat and pants; and rubber boots. They are required to wear goggles and rubber gloves when applying coumaphos. At their own discretion, the technicians wear a respirator equipped with dual high efficiency and organic vapor cartridges when spraying coumaphos in windy conditions.

For many years, the USDA APHIS has maintained a coumaphos exposure monitoring program for the animal health technicians. This program consists of establishing baseline red blood cell or erythrocyte acetylcholinesterase (AChE) and plasma cholinesterase (PChE) levels, and performing follow-up cholinesterase testing every 60 days regardless of exposure. The only exception is immediate testing after any large unintentional exposure (e.g., a spill). All cholinesterase test results are reviewed by a Federal Occupational Health physician. Technicians whose cholinesterase levels are less than 75% of baseline are removed from working with coumaphos. These workers are retested in 30 days; if the cholinesterase levels increase to over 75% of baseline, the workers are allowed to return to work. Due to changes in laboratories, the current program does not compare cholinesterase levels to true baseline values but, instead, to a mathematically calculated baseline. Typically, two or three technicians are "flagged" each testing period due to low cholinesterase levels. However, according to the requestor, these do not always appear to be temporally related to high usage periods.

METHODS

Only those APHIS animal health technicians scheduled to spray horses, dip cattle, or mix coumaphos during our site visit were recruited for this HHE. Recruitment was also limited to employees applying coumaphos within a one-day round-trip travel distance from Laredo. Participants were asked to undergo both pre- and post-shift blood and urine testing. The Webb County APHIS field office in Laredo, Texas, was the principal site for processing and storing of biological samples, administrating of some of the questionnaires, and collecting some of the biological samples. The remainder of the questionnaire administration and biological sampling, along with environmental sampling, was conducted at various ranches in the quarantine zone within driving distance of the field office. Each technician gave informed consent prior to participation. Employees were notified of their blood and urine test results by letter.

Questionnaire

All participants were given a self-administered questionnaire prior to their shift. The questionnaire was reviewed by NIOSH researchers in the presence of the participant. The questionnaire included questions concerning the participants' coumaphos application history, the presence of symptoms related to past coumaphos exposure, and general medical history information.

Biological Samples

Blood

Pre-shift blood sampling for cholinesterase activity was performed in the morning, immediately prior to coumaphos application. Post-shift blood sampling for cholinesterase activity was performed 4-6 hours after coumaphos application.

Blood sampling and testing used the following protocol:

A. The venipuncture site was thoroughly cleansed. Using a 21-gauge needle, approximately 5 milliliters (mL) of whole blood was collected into an ethylenediamine tetraacetic acid (EDTA) tube and 5 mL into a red-top tube. Red-top tube blood was allowed to clot, then was spun down in a centrifuge to separate the serum. Both serum and whole blood (EDTA tube) were labeled and refrigerated at 1°C-4°C until cold-packed for shipment to the Pacific Toxicology Laboratory. Samples were delivered and tested within 48 hours of sampling. Pacific Toxicology Laboratory is one of a limited number of laboratories that has had its cholinesterase assay reviewed and compared with known standards at the University of California Davis reference laboratory. PChE and AChE levels were determined using the Ellman method.

B. A fingertip was thoroughly cleansed. Using a lancet, 10 microliters of blood was collected into the EQM Test-Mate® ChE Cholinesterase Test System (Model 400) (EQM Research, Inc., Cincinnati, Ohio) assay tube. The blood sample was refrigerated and taken to the APHIS field office where it was analyzed by NIOSH personnel under controlled thermal conditions (approximately 25°C). Both PChE and AChE were measured.

Urine

Pre-shift urine sampling for chlorferon was performed in the morning, before the technicians used coumaphos. Post-shift urine sampling occurred 4-6 hours after they used coumaphos. Due to the limited data available concerning chlorferon excretory kinetics, a second post-application urine collection for chlorferon was obtained the following morning prior to the next workshift.

The following protocol was used for urine collection. Participants submitted samples in urine collection containers. Urine was subjected to enzymatic (beta-glucuronidase and sulfatase) hydrolysis to determine the presence of chlorferon (Hawks Scientific, Cheshire, UK). Urine testing was performed by the NIOSH Division of Applied Research Technology laboratory. Chlorferon-glucuronide excreted in urine was converted to free chorferon via incubation with β-glucuronidase. Solid phase C18 extraction with acetonitrile was used prior to analysis by using high performance liquid chromatography (HPLC) with fluorescence detection (355 nm excitation; 460 nm emission). Recovery of chlorferon spiked urine was near 100% over a range of 0.5-500 parts per billion (ppb). The chromatographic method used a Zorbax C18-RX column with isocratic elution of 65% acetonitrile and 35% water (water buffered with 0.05 molar sodium phosphate, pH=7) at a rate of 0.8 mL/minute. A limit of detection (LOD) of 0.5 ppb and limit of quantification (LOQ) of 1.5 ppb was based on average values of instrumental baseline noise and the lowest standard that could be reliably measured. The lowest calibrator used for these analyses was 2 ppb, thus, the method LOQ was 2 ppb. Urine from 5 unexposed subjects (NIOSH personnel) was analyzed to confirm that no chlorferon was present. This urine was then pooled and used to prepare all spiked urines and calibrators.

Environmental Sampling

During the initial site visit and subsequent telephone conversations with management, the coumaphos application activities with the highest potential for exposure were identified. On September 13-15, 2005, environmental and biological monitoring was conducted on employees applying coumaphos by horse spraying, article spraying, cattle dipping, and cattle spraying in the spray box. Due to the nature of the tick eradication program, NIOSH investigators were unable to conduct sampling for every application scenario. However, they sampled during the most routine application scenarios. Technicians were not observed applying chlorpyrifos on the days of sampling. The monitoring methodologies are described below.

Bulk Samples

Bulk samples of the coumaphos mixture in the dipping vat were collected. These samples were analyzed to identify potential interfering compounds that may be detected on the wipe samples. The concentration of the coumpahos mixture in the dipping vats was analyzed by the USDA APHIS labs after each dip event to verify that the concentration was at acceptable levels.

Skin Exposure Assessment

Polyester AlphaWipes® (4 inch x 4 inch) were used to assess the potential for skin contact to coumaphos and chlorpyrifos during tick eradication activities. All wipe samples were shipped to the NIOSH contract laboratory (DataChem, Salt Lake City, Utah) and analyzed by gas chromatography according to NIOSH Manual of Analytic Methods Method 9107.[1]

Whole Body Sampling

AlphaWipes® were loaded on pre-cut cardboard holders and pinned to the outside of the technicians' clothing and under aprons if worn. Technicians wore the patches in five locations: upper right arm, upper left arm, chest, right thigh, and left thigh. Patches were worn during coumaphos application activities, which typically did not involve an entire workshift. Twelve technicians were monitored during the evaluation. NIOSH investigators wore a new pair of nitrile gloves when handling each sample to prevent cross contamination. After sampling, each wipe was placed in a vial and stored at 4°C.

Hand Wipe Sampling

Hand wipe sampling was conducted at the end of the workshift to assess hand exposures to coumaphos. AlphaWipes® were pre-moistened with 3 mL of 99% reagent-grade isopropanol prior to conducting the hand wipe. One wipe was used for each hand. The hand and fingers were wiped thoroughly. Thirteen technicians' hands were wiped. One technician's hands were wiped twice in one day: before lunch and at the end of his work shift. NIOSH investigators wore a new pair of nitrile gloves when handling each sample to prevent cross contamination. After sampling, each wipe was placed in a vial and stored at 4°C.

Surface Sampling

AlphaWipes® were used to conduct surface sampling of respirators. Two wipe samples were collected on the surface of the interior of a technician's respirator to determine the presence of coumaphos. The wipes were pre-moistened with 3 mL of 99% reagent-grade isopropanol prior to surface sampling. After sampling, each wipe was placed in a vial and stored at 4°C.

Air Samples

Personal breathing zone air samples were collected on OSHA Versatile Sampler-2 (OVS-2) sorbent tubes using SKC® AirChek® 2000 sampling pumps. Flow rates of 1 liter per minute were used to obtain the samples. The sampling pumps were calibrated before and after each sampling event against a primary standard (BIOS® Dry-Cal) to verify flow rate. The filters were placed as close as possible to the workers' breathing zone and connected via Tygon® tubing to the sampling pump. After collection, the samples were sent to the NIOSH contract laboratory (DataChem, Salt Lake City, Utah) and analyzed by gas chromatography according to NIOSH Method 5600 with modifications using an electron capture detector.

Statistical Analysis

SAS Version 9.1.3 software (SAS Institute, Cary, North Carolina) was used for the statistical analyses. The Pearson's correlation coefficient between AChE determined by the Ellman method and AChE by the EQM Test-Mate® ChE Cholinesterase Test System (Model 400) was calculated. The Pearson's correlation coefficient between PChE determined by the Ellman method and PChE by the EQM Test-Mate® ChE Cholinesterase Test System (Model 400) was also calculated. The difference between pre- and post-cholinesterase levels, and pre- and post-urinary chlorferon was determined by the paired *t*-test. A p-value of ≤ 0.05 was considered statistically significant.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increases the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH recommended exposure limits (RELs),[2] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) threshold limit values (TLVs®),[3] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs).[4] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criteria.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 91–596, sec. 5(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended STEL or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Pesticides

A pesticide is any substance or mixture intended to prevent, destroy, repel, or mitigate arthropods (insecticide, miticide, acaricide); rodents (rodenticide); nematodes (nematocide); fungi (fungicide); or weeds (herbicide), designated to be a pest. Each type of pesticide has numerous modes of action, chemical classes, target organs, formulations, and physicochemical properties. Pesticide toxicity is equally diverse, and even within a similar chemical class, individual compounds ranging from extremely toxic to practically nontoxic can be found.[5] As such, generalizations about the toxicity of pesticides cannot be made without considerable qualification and explanation.

Organophosphate Pesticides

Cholinesterases are enzymes that control the amount of nerve impulse transmitters at nerve endings. OP and carbamate pesticides cause illness by binding to and inactivating cholinesterase, thereby causing an accumulation of these transmitters at nerve endings. This results in increased and continued stimulation at those sites and can lead to symptoms such as increased sweating; blurred vision; increased tears, saliva, nasal and lung secretions; chest pain; trouble breathing; wheezing; nausea, vomiting, abdominal cramps, and diarrhea; muscle weakness and twitches; memory problems; and decreased concentration.

In addition to these symptoms of acute OP poisoning, some OPs can cause a delayed neuropathy, which manifests several weeks after the acute exposure.[6] The neuropathy is characterized by abnormal sensations in the extremities, such as coldness, numbness and tingling, which are followed by weakness. In the absence of acute poisoning, chronic exposure to low levels of OPs may also lead to adverse health effects on the central and peripheral nervous system.[7]

Most OPs are highly lipid soluble and are easily absorbed through the skin, mucous membranes, gastrointestinal tract, and respiratory tract. Skin exposures to pesticides are often considered to be a more important portion of total exposure than inhalation.[8,9,10] Pesticide applications generally entail considerable contact during mixing, spraying, and handling of treated animals and items. In general, hand exposure represents a major fraction of total dermal exposure.[11] Exposure standards, guidelines, or recommendations by NIOSH or regulatory agencies have not been established for pesticides on skin or work clothes.

External exposure measures using conventional air, bulk, and wipe sampling do not indicate the amount of agent absorbed into the body. Internal exposure to OPs has commonly been measured in the blood by documenting cholinesterase levels. There is great variation among methods for measuring cholinesterase, as well as among laboratories that use the same method.[12] This makes it very important to consistently use one laboratory and one method for determining cholinesterase levels. California, one of only two states with mandatory cholinesterase monitoring programs, approves the use of the Ellman method, and the World Health Organization considers this the reference method.[13] In addition, because of the wide range of normal values in the population, comparison of subsequent values with a baseline value is important because the percent decrease from baseline is more important than the actual value in determining whether overexposure to pesticides has occurred. This baseline should be determined prior to beginning work with pesticides or after 30 days without pesticide use, and should be the average of two or more tests taken at least 3 days but not more than 14 days apart.

AChE reflects cholinesterase activity in tissues (e.g., the nervous system, the target organ system of most concern). PChE is a more sensitive measure of cholinesterase activity than AChE, but PChE returns to baseline earlier than AChE. Therefore, PChE values may not reflect the severity of toxicity unless blood specimens are drawn immediately after poisoning. The rate and duration of cholinesterase depression varies somewhat with the type of OP being used. In general, depression of PChE activity can occur within 2-3 hours of exposure. Depression of AChE activity may take longer to occur. Cholinesterase levels can be affected by a variety of conditions, medications, and some beverages, which can make interpretation difficult.

Several agencies have guidelines for monitoring cholinesterase levels among workers exposed to OPs. Three guidelines, the ACGIH biologic exposure index, the German Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area's Biologic Tolerance Value, and the World Health Organization's Health Based Biological Limit all specify an AChE value of 70% of the individual's baseline.[14] In addition, California and Washington require that individuals with an AChE value of 70% or a PChE of 60% or lower of the baseline be removed immediately from exposure. They also specify that a drop to 80% requires an investigation of work practices.[15]

Urinary metabolites have been used as biomarkers for some OP pesticides. The most commonly used urinary metabolites for OPs are the dialkylphosphates (DAPs). These DAPs, however, are non-specific, being elevated with exposure to many different OP pesticides. However, it is not possible to estimate the absorbed dose for most OPs, which limit the usefulness of DAPs in biologic monitoring. [13] A small number of OPs have been found to have specific urinary metabolites that are useful as exposure biomarkers.

Coumaphos

Coumaphos (CAS number 56-72-4 [Co-Ral®]) is an OP insecticide. It is used to control larvae of fecal-breeding pests in livestock and swine bedding by direct application to cattle, horses, sheep, and swine.[16] It is not registered for use on crops or in homes. Acute excessive exposure to coumaphos results in the health effects noted above. While coumaphos does cause delayed neuropathy in hens, it does not appear to do so in humans.[17] The ACGIH TLV-TWA for coumaphos is 0.05 milligrams per cubic meter (mg/m^3) inhalable fraction and vapor. The TLV was based on animal studies because there was no quantitative information on human exposures. No other occupational exposure criteria exist for coumaphos.

The serum half-life of coumaphos after oral or intravenous administration is 2-3 hours in rats, with 80% excreted in the urine in 24 hours. The primary urinary metabolite is 3-chloro-4-methyl coumarin (chlorferon), reported in animal studies to be specific for coumaphos exposure. No data are available concerning serum half-life of coumaphos after dermal or inhalational exposure. A skin notation was also assigned in the TLV because two studies in dermally exposed animals resulted in symptoms of OP poisoning.[18] A skin notation indicates a potential significant contribution via the cutaneous route.

In 1996, the U.S. Environmental Protection Agency (EPA), in its Coumaphos Reregistration Eligibility Decision (RED) document, reported that cattle dipping did not pose a significant pesticide exposure threat. Likewise, the report stated that while high pressure wand spraying may pose an exposure threat, low pressure spraying did not. This EPA report was not based on chemical-specific exposure data (which was unavailable), but instead relied on generic dosimetry data in the pesticide handlers' exposure database (PHED) to estimate coumaphos exposure. In 2000, the RED was amended, and coumaphos was approved for additional uses provided certain risk mitigation measures are in place. EPA restricts use of the 42% flowable form of coumaphos (which the technicians use) to USDA staff enrolled in a cholinesterase medical monitoring program. For hand-held spray applications, individuals are limited to spraying 100 head per day.[16]

Chlorpyrifos

Chlorpyrifos (CAS number 2921-88-2 [Dursban 7]) is also an OP insecticide. It is used to control fire ants, ornamental plant insects, stored product insects, and turf- and wood-destroying insects.[17] Because its half-life in soil is 30 days, it is considered a moderately persistent insecticide.[18] The NIOSH REL and ACGIH TLV for chlorpyrifos in air are 200 mg/m^3 (8-hour TWA), and the TLV has a skin notation.[2,3]

RESULTS

Of the 59 AHPIS animal health technicians, 15 met the criteria for our evaluation. All 15 agreed to participate, although two did not provide post-shift blood or urine samples (but did provide fingerstick samples) due to time constraints. The population was 100% male. The mean age of participants was 41 (range: 21-63), and the mean tenure as an animal health technician with APHIS was 13 years (range: 1 month to 35 years). Participants reported mixing coumaphos 8.5 days per month and spraying or dipping livestock 11 days per month, on average. Three reported being removed from coumaphos use (one time each) in the past year due to low cholinesterase levels. Four reported use of chlorpyrifos in the last 3 months.

Technicians were asked about symptoms consistent with OP poisoning experienced within 6 hours of coumaphos use in the past 3 months. Two each reported headache, weakness, and tearing eyes, and one each reported cough and nervousness.

Only one technician reported eating, drinking, or smoking while using coumaphos. Technicians were asked about their use of PPE when handling coumaphos in a variety of settings. Reported PPE use varied by task and type of PPE (see Table 1).

Biological Monitoring

Blood

Ellman Method

None of the 13 technicians who provided blood both pre- and post-shift had PChE or AChE levels outside the laboratory's range of normal. There was not a statistically significant change in PChE (p=0.89) or AChE (p=0.40) from pre-shift to post-shift. The mean pre-shift PChE was 3.12 international units per milliliter (IU/mL) (range: 2.50-4.00), and the mean post-shift PChE was 3.13 IU/mL (range: 2.50-3.70). The mean pre-shift AChE was 10.89 IU/mL (range: 9.60-12.00), and the mean post-shift AChE was 10.61 IU/mL (range: 9.40-11.80).

Test-Mate®

Fifteen technicians had both a pre- and post-shift fingerstick for cholinesterase analysis by the Test-Mate®. None had PChE or AChE levels outside the range of normal. There was not a statistically significant change in either PChE (p=0.69) or AChE (p=0.92) levels from pre-shift to post-shift. The mean pre-shift PChE was 2.21 IU/mL (range: 1.81-3.02), and the mean post-shift PChE was 2.20 IU/mL (range: 1.62-3.04). The mean pre-shift AChE was 4.06 IU/mL (range: 2.99-5.08), and the mean post-shift AChE was 4.05 IU/mL (range: 3.19-5.05).

Relationship Between Methods

There was significant positive correlation between PChE levels measured with the Test-Mate® and with the Ellman method (r=0.91, p<0.01, n=28). There was also significant positive correlation between AChE levels measured by the two different methods (r=0.63, p<0.01, n=28).

Urine

Fifteen technicians submitted urine for chlorferon analysis prior to coumaphos application. The mean urinary chlorferon was 77.31 parts per billion (ppb), with a range of non-detectable-404.88 ppb (See Table 2). Two of these 15 technicians had levels below the limit of detection. All 15 reported coumaphos use within the past 7 days. Chlorferon was detected in the urine of all 13 animal health technicians who submitted urine 4-6 hours after using coumaphos (mean: 203.04 ppb; range: 4.17 ppb - 429.72 ppb). Urinary chlorferon levels were significantly higher 4-6 hours after use (p<0.01), and declined significantly from the post-shift levels by the next day (p=0.01). The mean urinary chlorferon concentration on the next day was 92.97 ppb, with a range of 0.25-192.16 ppb.

Environmental Sampling

Samples were collected during a variety of coumaphos application activities including use of a mobile spray box, hand spraying of horses, and dipping and scratching of cattle in fixed vats. Samples were collected only during activities involving application of coumaphos and cattle scratching. Therefore, most samples were not collected over a full workshift. Technicians spent considerable time processing paperwork in the office, coordinating and staging the dipping with ranchers, and traveling to remote locations to conduct coumaphos application.

Whole Body Wipe Results

The results of the whole body wipe sampling for coumaphos are shown in Table 3. Of the 60 patch samples collected, 26 (43%) were either non-detectable or between the analytical LOD and LOQ. Analytical LODs ranged from 0.7 micrograms per sample (µg/sample) to 3µg/sample and LOQs ranged from 2 µg/sample to 10 µg/sample. Detection limits varied by analysis set. No chlorpyrifos was detected in any of the samples.

Hand Wipe Results

The results of the hand wipe sampling for coumaphos and chlorpyrifos are shown in Table 4. Thirteen technicians' hands were wiped, and a total of 28 wipe samples were collected. One technician's hands were wiped before lunch and again at the end of the shift because his work activities took place across lunch time. NIOSH investigators conducted hand wipe sampling after three technicians washed their hands with soap and water at the end of the application process. Coumaphos results ranged from < LOQ to 1400 µg/sample for the employees who did not wash their hands prior to sampling. Coumaphos results for employees who washed their hands prior to hand wipe sampling ranged from 4.8 µg/sample to 54 µg/sample. Chlorpyrifos was detected in three samples from two employees and ranged from below the LOQ to 3.2 µg/sample. Neither employee reported working with chlorpyrifos on the day of sampling.

Surface Wipe Results

The inside of two respirators were sampled for coumaphos; one measured below the LOD and the other measured 11 µg/sample.

Air Sampling Results

A total of nine PBZ air samples were collected. All samples except one measured below the LOD. The minimum detectable concentration (MDC) for coumaphos was 0.004 mg/m^3 assuming a sample volume of 119 L. One sample, collected on a technician who sprayed horses for the majority of the day, measured 0.003 mg/m^3 and was between the LOD and LOQ.

Workplace Observations

PPE use varied by technician, job task, and perceived risk of exposures. Hindrances to wearing PPE included thermal comfort and time constraints. No standard guidance for what type of PPE should be worn during specific tasks was available. We observed two employees wearing respirators, aprons, and gloves while operating and opening the chute to the mobile spray box. The remaining employees working the cattle into the chute and scratching cattle while they were in the chute wore no PPE. Through conversations with employees, most felt the risk of exposure was greatest when operating the spray box; therefore, wearing PPE during these tasks was standard practice. Some technicians chose to wear respirators and aprons during horse spraying; others wore no PPE while spraying horses. Employees wore no PPE when dipping cattle in fixed vats or when scratching cattle. Employees did not wear gloves when diluting the coumaphos mixture or when collecting bulk samples of the mixture. NIOSH investigators observed technicians having direct skin contact with coumaphos on their hands. Employees reported being uncomfortable wearing PPE on hot days. Typical work clothing wore year round by technicians included denim jeans, long sleeve shirts, boots, and cowboy hats.

Technicians stored all PPE in plastic containers or in a tool box in the bed of their trucks becasue the job required them to travel to many different places in a single day. NIOSH investigators observed respirators stored with other dirty PPE, such as gloves and aprons, rather than in their own container or bag. At the time of the site visit, the tick eradication program had not implemented a full respiratory program in accordance with the OSHA respiratory protection standard. Employees were not fit tested to wear their respirators, and NIOSH investigators observed employees wearing respirators incorrectly. Some employees wearing respirators had facial hair, which interferes with the sealing surface of the respirator to the face. Respirators were visibly dirty, and some respirator parts were warped by the heat. No filter/cartridge change out schedule was in place. Filters and cartridges appeared to be extremely dirty and needed to be replaced. Most employees had replacement filters, particularly with the newly issued 3M full facepiece respirators.

Technicians may be exposed to heat stress conditions when working in the outdoor environment. The outdoor work can require them to work in the sun for several hours at a time in temperatures exceeding 100°F. No formal heat stress program was in place. Management reported employees receive limited training about working in hot environments. Employees wear pants and long sleeve shirts even in the summer to protect their skin against exposure to the sun and animals. Employees were conscious of the heat and were observed taking frequent water breaks.

Noise levels appeared to be very high while the portable spray box was in operation. Hearing protection devices are not provided by the tick eradication program.

DISCUSSION AND CONCLUSIONS

USDA APHIS animal health technicians were exposed to and absorbed coumaphos during their routine activities, as evidenced by urinary chlorferon levels. Urinary chlorferon levels rose significantly after coumaphos use. Results from PBZ air, handwipe, and patch sampling confirmed that employees were primarily exposed to coumaphos via the skin.

An inhalational health hazard to coumaphos did not exist at the time of the NIOSH visit. Air sampling represented task-specific sampling between 30 minutes and 120 minutes with no other exposures for the rest of the workshift. However, exposures could increase if certain work tasks where coumaphos may have been aerosolized, such as spray box application of pesticides, occurred over a longer period of time. One PBZ sample detected trace amounts of coumaphos and represented a worst case scenario. This employee sprayed horses and dipped cattle for the entire day. Results of our evaluation suggest that respiratory protection may not be necessary and may increase exposures due to the presence of residual pesticides inside the respirator. One wipe sample taken on the inside of the respirator that was reportedly used infrequently found residual pesticide contamination.

Fifty-eight percent of the whole-body patch sampling detected measurable levels of coumaphos. Patches sampled exposures outside of the clothing. However, coumaphos could contact the skin if enough were present on clothing to soak through. In addition, contaminated clothing could contaminate the technicians' vehicle and possibly their homes. Ninety-six percent of hand-wipe sampling detected coumaphos, indicating the majority of exposures occur from hand contact with the pesticide. This was verified through observation. Employees were observed having direct skin contact with coumaphos during several work tasks. For example, employees stirred the coumaphos mixture in fixed vats for approximately 20 minutes with a pressurized paddle. When removing the paddle from the vat, employees' hands contacted residual coumaphos. Employees collected a bulk sample of the coumaphos mixture before and after cattle dipping. Sample bottles were attached to a pole and dipped in the vat. Employees were exposed to the coumaphos mixture when capping the bottles.

To accommodate spraying horses on private property, technicians had tanks in the truck bed. They charged the water-filled tank with coumaphos and collected a bulk sample for concentration verification. NIOSH investigators observed the coumaphos mixture splashing out from the top of the tank due to a worn seal on the hose. The employees touched the hose with their bare hands. Opportunities for hand exposures also occured when employees collected bulk samples from the tank. During horse spraying, employees had the potential for exposure to the overspray and direct skin contact when handling the horse. It was not always feasible to spray upwind from the horse. Employees were issued a 5 gallon can to fill with water for hand washing after working in the field. Although technicians' hands were visibly soiled with fecal material, urine, and dirt after working with the cattle, they waited until lunch to wash their hands. Technicians expressed concerns that emergency showers were not in place at the fixed vats in case of an accidental spill or gross exposure, such as falling into the vats.

Most employees did not wear adequate PPE, particularly gloves. Barriers to wearing PPE included heat stress, comfort, time constraints, and the perception that it was not needed. PPE and work practices are the main methods of reducing exposure to these employees. The EPA has established minimum PPE requirements for use when using emulsifiable concentrate and flowable concentrate.[19] Mixers, loaders, and others exposed to the concentrate, and all handlers participating in dip-vat applications must wear long-sleeve shirt and long pants, chemical-resistant gloves, chemical-resistant footwear and socks, chemical-resistant apron, and face shield or goggles. All other handlers must wear long-sleeve shirt and long pants, chemical-resistant gloves, and chemical-resistant footwear and socks.

PChE and AChE levels did not change significantly from pre-shift to post-shift, which is not surprising because pre-shift levels did not represent an exposure-free baseline. All participants had used coumaphos in the prior week, and some in the prior 48 hours. We did not have baseline results available for comparison. There was good correlation between the Ellman method and the Test-Mate® Field ChE Cholinesterase Test System (Model 400). The United States Army found the Test-mate ChE to be reliable and useful for measuring AChE in the field in detection of OP nerve agent poisoning.[20] Other researchers have noted it can provide useful information on pesticide exposures when measurements are made in a temperature-controlled system.[21] These researchers found a stronger correlation between the Ellman method and the Test-Mate (r=0.99) for AChE than NIOSH did (r=0.63). The other researchers did not evaluate PChE. California requirements state that for a method other than the Ellman to be used, the correlation coefficient squared (r^2) must be at least 0.9, and that field test kit methods are not satisfactory. However, the Test-Mate® Field ChE Cholinesterase Test System's convenience may make it an option for APHIS if they decide to continue their cholinesterase monitoring program because it may increase compliance with and timeliness of testing. It would be useful in the event of an acute overexposure. Urinary chlorferon levels were a more sensitive marker of exposure, showing significant increases after application or mixing of coumaphos. However, chlorferon has limited commercial availability, and its use would require further validation prior to replacing cholinesterase monitoring.

RECOMMENDATIONS

Our evaluation documented that USDA APHIS animal health technicians are exposed to and absorb coumaphos during their routine work activities, primarily through their skin. In addition, we noted potential health hazards from heat stress and noise. The following recommendations are based upon these conclusions.

1. Mixers, loaders, and others who may come into contact with the coumaphos concentrate, and all handlers participating in dip-vat applications should wear long-sleeve shirts and long pants, chemical-resistant gloves, chemical-resistant footwear and socks, and chemical-resistant apron. Technicians should always wear gloves when collecting vat samples, stirring the vat, and charging the tanks in their truckbeds. All other handlers must wear long-sleeve shirts and long pants, chemical-resistant gloves, and chemical-resistant footwear and socks. NIOSH was not able to observe all uses of coumaphos and therefore cannot provide specific recommendations by task. USDA should determine the appropriate PPE for all the tasks performed by the animal health technicians that involve the use of coumaphos. At a minimum, employees should follow the EPA requirements for PPE during coumaphos use. Most approaches for selecting appropriate PPE incorporate the following process:[22]

   - Determination of the hazards most likely to occur
   - Assessment of the adverse effects of unprotected exposure
   - Identifying other control options that can be used instead of protective clothing
   - Determining the performance characteristics needed for protection
   - Evaluating the need for decontamination

- Assessing any constraints that may hinder the use of PPE (ergonomics, safety, vision, dexterity)

Once it is determined that PPE is required for a task, its use should be mandatory. Written procedures should be in place to ensure consistent selection and use of PPE. Affected users must be informed of the need for PPE; consequences of not wearing the appropriate PPE; and how to properly inspect, wear, maintain, and store the PPE. Users must also be informed of all limitations associated with the use of PPE and must be aware that the equipment does not eliminate the hazard. Finally, periodic inspections and evaluations of the PPE program should be conducted to ensure that procedures are consistently followed, to identify any process changes that may have occurred, and to verify that the selected PPE is still appropriate for the given task.

2. Perform a more comprehensive evaluation of the risk of inhalation exposure to coumaphos. PBZ samples should be collected for tasks that generate aerosols, such as those involving hand spraying of coumaphos for long periods of time. Our evaluation suggests that it may be possible to discontinue use of respirators. If management chooses to continue to provide respirators to employees, then a comprehensive respiratory protection program should be established in accordance with the OSHA respiratory protection standard.[23] The program should include regular worker training; maintenance, inspection, cleaning, and evaluation of the respirator; use of the respirator in accordance with the manufacturer's instructions; fit testing; medical evaluation; and annual fit testing. Workers issued respirators should also be clean shaven to ensure a good face-to-respirator seal. A comprehensive inspection of all respirators issued to technicians should be completed. Damaged facepieces, exhalation/inhalation valves, and cartridges/filters should be replaced. Institute a frequent inspection and cleaning program to ensure all respirators are clean and in good condition. Special emphasis should be placed on proper storage of respiratory protection in hard containers to avoid distortion and contact with contaminated PPE. When possible, respirators should be stored in the air-conditioned county offices on days when they are not worn. Technicians should avoid storing respirators in their vehicles during hot months as the heat may damage the respirator causing it to provide inadequate protection to the wearer. A filter/cartridge change-out schedule should be developed, and employees should be reminded to change out their filters and cartridges. Detailed information on respirator programs is available at: [http://www.osha.gov/SLTC/etools/respiratory].

3. Encourage employees to follow good hand hygiene practices. Employees should wash their hands with soap and water after applying pesticides even if they were wearing gloves. Hands should be washed for a minimum of 15 seconds or until visible dirt is removed from hands. Hands should be washed prior to eating, drinking or smoking. Chemical-resistant gloves should be cleaned each day.

4. Contact USDA resources to determine the feasibility of validating urinary chlorferon as a biomarker of coumaphos exposure. While there is no known absolute value of urinary chlorferon at which health effects occur, documentation of an increase after coumaphos use indicates that PPE and work practices are not adequate and should be re-evaluated.

5. In the meantime, improve the existing cholinesterase monitoring program. Due to changes in laboratories, the current program does not compare cholinesterase levels to true baseline values but, instead, to a calculated baseline. It is preferable to use only one laboratory to perform cholinesterase testing. Over time, slowly establish true baseline cholinesterase measurements on all employees. This can be accomplished by testing all new employees and by doing serial

testing of all employees who are flagged and removed from work until a relative steady-state level of cholinesterase is reached, then using that level as a baseline. While this does not meet the standard definition of a establishing a baseline, it should be an adequate substitute.

6. Consider field test kit testing for cholinesterase. The convenience and cost-savings make this a viable option. The field test kit testing would also allow for more rapid assessment of levels in the event of an acute high exposure to coumaphos. A field test kit cholinesterase baseline would be necessary if you choose to use the field test kit, as would training your personnel to use it appropriately.

7. Develop a continuing education program to ensure that all employees potentially exposed to hot environments and physically demanding job activities stay current on heat stress and heat-stress prevention information. Include at least the following components for a good heat stress training program:

- Knowledge of the hazards of heat stress
- Recognition of predisposing factors, danger signs, and symptoms
- Awareness of signs and symptoms of heat-related illness and first-aid procedures for treatment
- Employee responsibilities in avoiding heat stress
- Dangers in using drugs, including therapeutic ones, and alcohol in hot and physically demanding work environments
- Purpose and coverage of environmental and medical surveillance programs and the advantages of worker participation in them

Encourage personnel to drink water or any cool liquid (except alcohol and caffeinated beverages) to stay hydrated. Encourage them to drink small amounts frequently (e.g., one cup every 20 minutes). Investigate opportunities to schedule outdoor work in the mornings to avoid high temperatures.

8. Ensure employees are trained on emergency procedures in the event of an accidental high exposure to pesticides, such as falling into a vat. Ensure these accidents are reported to management so that they can be investigated in order to prevent them in the future.

9. Conduct an assessment of noise levels during mobile spray box use to determine if hearing protection is needed. Noise levels seemed high on the days of the evaluation.

10. Require employees to report their locations to the county office throughout their work day to ensure the locations of the technicians are known in case of emergencies. Establish good lines of communication with local law enforcement and U.S. Customs to pre-identify dangerous areas technicians should avoid.

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TABLES

Table 1
PPE Use during Coumaphos Application, by Task
USDA APHIS Tick Eradication Program
HETA 2002-0203-3050
Laredo, Texas
September 13-15, 2005

	Mixing			Spraying			Dipping		
n=15	Always	Sometimes	Never	Always	Sometimes	Never	Always	Sometimes	Never
Gloves	12	0	3	10	4	1	6	5	4
Respirator	5	3	7	10	4	1	4	7	4
Goggles	3	1	11	5	3	7	2	1	12
Outerwear or Apron	1	2	11	3	6	6	0	5	10
Special Boots or Shoe Coverings	1	1	12	2	5	8	0	5	10

Table 2
Urinary Chlorferon Levels, in parts per billion
USDA APHIS Tick Eradication Program
HETA 2002-0203-3050
Laredo, Texas
September 13-15, 2005

Used coumaphos in 7 days prior to sampling	Used coumaphos in the 48 hours prior to sampling	Pre-exposure	4-6 hours after use of coumaphos	Morning after using coumaphos
yes	no	7.53	291.62	192.16
yes	no	ND	62.07	27.21
yes	no	ND	4.17	ND
yes	no	7.12	52.61	11.76
yes	no	56.03	32.07	163.99
yes	no	41.04	68.51	28.02
yes	yes	127.98	429.72	67.87
yes	yes	69.53	341.95	162.82
yes	yes	101.68	339.31	165.41
yes	yes	202.00	378.69	129.63
yes	yes	404.88	403.77	114.89
yes	yes	45.51	78.96	55.28
yes	yes	36.39	155.99	89.37
yes	yes	45.06	No sample	No sample
yes	no	14.37	No sample	No sample

Table 3
Coumaphos Patch Sampling Results
USDA APHIS Tick Eradication Program
HETA 2002-0203-3050
Laredo, Texas
September 13-15, 2005

Work activity	Amount of coumaphos by patch location (µg/sample)				
	Right Arm	Left Arm	Right Leg	Left Leg	Chest
Sprayed a horse and tractor for 35 minutes	(2)	18	110	22	20
Sprayed 1 horse	14	19	100	70	30
Sprayed 2 horses and dipped cattle for 10 minutes	50	33	14	6.5	ND
Pushed cattle into chute during cattle spray box application	ND	3.5	4.1	ND	10
Scratching cattle in chute during cattle spray box application	13	ND	(1)	ND	(1)
Pushed cattle into spray box	ND	ND	19	(6)	ND
Opened spray box gate and transferred OP mixture from spray box to truck	ND	(6)	23	43	ND
Operated spray box; charged the water in box with coumaphos; primed transfer pump	230	(8)	11	(4)	ND
Sprayed 27 horses and dipped 5 cattle	56	(7)	220	1200	38
Sprayed 24 horses and 1 backhoe, dipped 6 cattle	75	48	ND	ND	ND
Scratched cattle and dipped 8 cattle	27	29	(2)	10	(1)
Scratched cattle and sprayed 1 horse	20	27	(4)	11	ND

µg/sample = micrograms per sample

ND = Non-detectable = results were below the analytical limit of detection (LOD)

( ) Indicates results between the analytical LOD and limit of quantification (LOQ).

Table 4
Coumaphos and Chlorpyrifos Hand Wipe Sampling Results
USDA APHIS Tick Eradication Program
HETA 2002-0203-3050
Laredo, Texas
September 13-15, 2005

Work Activity	Coumaphos (µg/sample)		Chlorpyrifos (µg/sample)		Washed hands prior to sampling?
	Right Hand	Left Hand	Right Hand	Left Hand	
Sprayed a horse and tractor for 35 minutes	(7)	12	ND	ND	No
Sprayed 1 horse	110	200	ND	ND	No
Sprayed 2 horses and dipped cattle for 10 minutes	150	130	(0.2)	ND	No
Pushed cattle into chute during cattle spray box application	38	54	ND	ND	Yes
Scratching cattle in chute during cattle spray box application	73	130	ND	ND	No
Pushed cattle into spray box	4.8	18	ND	ND	Yes
Opened spray box gate and transferred OP mixture from spray box to truck	480	510	ND	ND	No
Operated spray box; charged the water in box with coumaphos; primed transfer pump	32	9.7	ND	ND	Yes
Sprayed 27 horses and dipped 5 cattle	610 (am) 1400 (pm)	410 (am) 470 (pm)	ND	ND	No
Sprayed 24 horses and 1 backhoe, dipped 6 cattle	74	170	ND	ND	No
Scratched cattle and dipped 8 cattle	130	82	ND	ND	No
Scratched cattle and sprayed 1 horse	83	37	ND	ND	No
Sprayed his own horses	87	62	3.2	2.7	No

µg/sample = micrograms per sample

( ) = Indicates concentrations reported between the analytical limit of detection (LOD) and the limit of quantification (LOQ).

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