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ABSTRACT: The Environmental Protection Agency's (EPA) reregistration process has had an extensive impact on the Animal Damage Control Program administered by the Animal and Plant Health Inspection Service (APHIS) of USDA. Specifically, the 1988 Amendment to the Federal Insecticide, Fungicide, and Rodenticide Act required a comprehensive reevaluation of pesticide safety; nearly 500 data submissions have been requested by EPA from APHIS to maintain its federal (Section 3) and state (Section 24(c)) low volume minor use vertebrate pesticide registrations. These registrations are used to control damage to American agricultural resources, mitigate losses to selected wildlife species, and reduce threats to public health and safety. A primary function of both APHIS's Denver Wildlife Research Center (DWRC) and Technical and Scientific Services (TSS) office is the maintenance of these registrations containing carbon, sodium nitrate, Compound 1080, sodium cyanide, DRC-1339, PA-14, zinc phosphide, and/or strychnine. APHIS has responded to EPA's data requests in a variety of ways including: requesting waivers, negotiating data requirements, proposing less costly alternatives, monitoring data contracts, and conducting the necessary studies. Since 1989, DWRC and its cooperators have submitted over 250 studies in support of these registrations. This paper will: 1) discuss the active ingredients in APHIS's vertebrate pesticides and their reregistration status; 2) evaluate the effectiveness and cost of each type of response; and 3) provide lessons for the future.

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INTRODUCTION

The Animal Damage Control (ADC) program, administered by the Animal and Plant Health Inspection Service (APHIS), an agency of the United States Department of Agriculture (USDA), provides federal leadership in managing wildlife conflicts with human activities that may result in damage to agricultural and industrial resources, pose risks to public health and safety, or impact other natural resources (Acord 1991). The ADC Program uses an Integrated Pest Management (IPM) approach that may employ the use of certain low volume minor use (LVMU) vertebrate pesticides (USDA 1994). In 1989, the ADC Program initiated an extensive reregistration data development program, through the Denver Wildlife Research Center's (DWRC) Product Development Section (PDS), to maintain these pesticides. Ramey et al. (1992) have previously reviewed data submissions through 1991 from APHIS and APHIS led consortia that have supported the reregistration of products containing strychnine, sodium cyanide, zinc phosphide, Compound 1080, sodium nitrate, carbon, DRC-1339, and PA-14. The ADC Program has had to balance the resources needed to maintain these vertebrate pesticide registrations with the development of new vertebrate damage control methods (Ramey et al. 1992).

FEDERAL REREGISTRATION OF VERTEBRATE PESTICIDES

The history of pesticide regulation in this country dates from the passage of the Federal Insecticide Act of 1910 (Ch. 191, 36 Stat. 331), which made it unlawful to sell adulterated products, thereby protecting purchasers of insecticides and fungicides from fraud (Bean 1977). The 1910 Act was essentially a labeling statute and did not require registration or establishment of safety standards for pesticides (Conner et al. 1991). In 1947, passage of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) brought rodenticides and rodent repellents under USDA administration by requiring the registration of all pesticide products in the U.S. (Jacobs 1992). Later amendments broadened FIFRA to include other mammals, birds, fishes, reptiles, amphibians, invertebrates, plants, and viruses in 1961 and transferred all pesticide registration functions from USDA to the Environmental Protection Agency (EPA) in 1970. The EPA published a notice in the Federal Register (40 CFR Part 158) in 1982 that specified and expanded data requirements based on the primary use pattern of the pesticide (i.e., terrestrial or aquatic) (Fagerstone et al. 1990). The basic data required for all pesticides have been grouped in 12 subdivisions. Required studies are intended to generate data and information necessary to address concerns pertaining to the identity, composition, toxicology, potential adverse effects, and environmental fate of each pesticide (U.S. EPA 1991a) for risk-benefit assessments (Conner et al. 1991). These study requirements are both time-consuming and costly (Poche 1992, Ramey et al. 1992), and each study must meet EPA's Good Laboratory Practice (GLP) standards (40 CFR 160).

All of APHIS's vertebrate pesticides except zinc phosphide are classified as terrestrial non-food uses and data requirements are generally required from the following six subdivisions:

1. Product Chemistry - data support the conclusions expressed in the statement of formula including starting materials, formulating process,

composition and certified limits for ingredients and impurities. A profile of the chemical's physical and chemical characteristics is also required, such as density, solubility, color, odor, and pH.

2. Hazard Evaluation: Nontarget Organisms - data are used to determine the toxicity hazard to nontarget organisms—birds, mammals, fish, terrestrial and aquatic invertebrates, and plants. These tests involve short-term acute, subacute, reproduction, simulated field, and field studies arranged in a hierarchial system which progresses from the basic laboratory tests to the applied field study. Their common purpose is to provide information for developing precautionary label statements that will minimize the potential adverse effects to nontarget organisms.
3. Hazard Evaluation: Human and Domestic Animals - data assess the hazards (toxicology) to humans and domestic animals based on the duration and route of exposure to the pesticide. Studies to determine this impact include acute studies of oral, dermal, and inhalation toxicity; subchronic studies providing information on toxicology to target organs and residue accumulation potentials; chronic feeding studies; teratogenicity and reproductive studies to assess developmental abnormalities; and mutagenicity/ genetic studies. These tests range from the basic LDtt tests to some very expensive neurotoxicity, teratogenicity and carcinogenicity tests.
4. Product Performance - data provide a mechanism to ensure that pesticide products will control the pests listed on the label and that unnecessary pesticide exposure will be minimized. Specific performance standards are used by EPA to validate efficacy data, and are required for products used to control vertebrates that may transmit diseases to humans. EPA rarely requires the submission of product performance data for non-public health use pesticides, but expects the registrant to have it available upon request.
5. Environmental Fate - data assess the eventual fate of pesticide residues in the environment based upon studies of their mobility (leaching, adsorption/desorption, and volatility); degradation (hydrolysis and photolysis); metabolism (aerobic and anaerobic); and dissipation in soil, water, and air.
6. Residue Chemistry - data are used by the EPA to estimate the exposure of the general population to pesticide residues in food and to set and enforce tolerances for pesticide residues in food or feed.

The 1988 Amendment to FIFRA (FIFRA 88), required the EPA to reregister active ingredients (AIs) registered before November 1, 1984. FIFRA 88 strengthened and accelerated EPA's reregistration program and required a comprehensive reevaluation of pesticide safety for each registered product containing an AI (FIFRA 1988). Active ingredients are defined in 40 CFR Ch.l Sec. 158.153 to include substances (or group of structurally similar substances, if specified by the EPA) that will prevent, destroy, repel or mitigate any pest. FIFRA 88 also established a five phase reregistration process that must be accomplished by 1997. These phases are briefly described below (EPA is now in Phases 4 or 5 for most AIs):

Phase 1: required EPA to publish lists of active ingredients subject to reregistration.

Phase 2: required registrants to declare their intent to reregister the technical pesticide, to identify missing and inadequate data, and commit to provide those data.

Phase 3: required registrants to submit reformatted summaries of acceptable existing studies or generate new data, and identify any adverse effects of the pesticide.

Phase 4: required jiPA to review all Phase 2 and 3 submissions, and required registrants to meet any unfulfilled data requirements identified by EPA in a Data Call-In (DO).

Phase 5: requires EPA to review all submitted data and decide if the technical pesticide is eligible for reregistration. If so, a Reregistration Eligibility Document (RED) is issued and a DCI may be issued for any end-use product (EUP) data that are required prior to a final regulatory decision.

PRESENT STATUS OF APHIS'S VERTEBRATE PESTICIDES

The evolution of ADC's vertebrate pesticides administered by APHIS and their active ingredients have been presented elsewhere (Ward 1962, Ramey et al. 1992, USDA 1994). APHIS presently has 20 Section 3 registrations and 13 Section 24(c) registrations (S. D. Palmateer, USD A/APHIS, personal communication) which are formulated from one or more of the following active ingredients: carbon (charcoal), sodium nitrate, Compound 1080, sodium cyanide, DRC-1339, zinc phosphide, and strychnine. Although PA-14 is no longer registered by APHIS, its reregistration status will be discussed below. These vertebrate pesticides may be grouped into field rodenticides (zinc phosphide, strychnine, and gas cartridge), avicides (DRC-1339 [Starlicide] and PA-14), and predacides (the M-44 cyanide capsule, Compound 1080, and gas cartridge).

The processes of registering and reregistering APHIS's vertebrate pesticides involve the close cooperation of three APHIS entities (Figure 1). The office of Technical and Scientific Services within APHIS's Biotechnology, Biologies, and Environmental Protection (BBEP) provides regulatory support for all APHIS programs (ADC, Plant Protection and Quarantine, and Veterinary Services) using pesticides (e.g., information transfer, liaison services, and administrative support [Palmateer 1993]). DWRC is the only major federal research facility conducting research related to wildlife damage management (Reidinger 1990). Among its activities, DWRC generates data for submission to

EPA to support APHIS's vertebrate pesticide registrations and reregistration of AIs. DWRC also works with the pesticide industry through the administration of consortia (e.g., DRC-1339, strychnine, and zinc phosphide) for generating data required by EPA when it is mutually beneficial to APHIS. The Pocatello Supply Depot (PSD) formulates APHIS's vertebrate pesticides and assists ADC State Directors in providing assistance to cooperators and identifying ADC Program needs at the local level. The authority to regulate pesticides at the EPA is delegated to the Office of Pesticide Programs (OPP) for day-to-day operations (Figure 1). Most registrants have contact with OPP through either the Registration Division (RD) or Special Review and Reregistration Division (SRRD). RD coordinates new pesticide registrations and amendments to existing registrations. SRRD manages all special pesticide reviews and is responsible for supervising reregistration and DCI programs (Conner et al. 1991). Communications between these Divisions is often poor and leads to confusing or contradictory information to registrants.

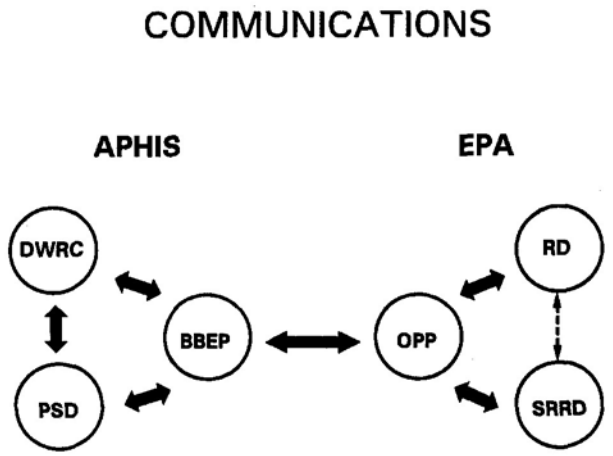

Figure 1. Schematic relationships of the interactions among APHIS's (i.e., registrant) and EPA's administrative entities (circles) involved in the process of registration or reregistration. Arrows indicate direction and magnitude of communications.

The following summary of APHIS's AIs undergoing reregistration will include their use, mode of action, clinical signs, toxicity, and current status. These AIs have all been undergoing reregistration since 1989 except zinc phosphide, a List A chemical, which started reregistration in 1982. Phase 5 RED documents have been received on the two AIs in the gas cartridge (carbon and sodium nitrate). All of APHIS's other AIs are in Phase 4 of the reregistration process, and we are awaiting RED document status and EUP data requirements; the number of studies and costs to date for each AI are presented in Figures 2 and 3, respectively. Costs represent general investigational requirements for a typical APHIS LVMU vertebrate pesticide data submission and include protocol preparation and approval; resources for personnel, supplies, and equipment; analytical, statistical and administrative support; and GLP visits, audits, and documentation. Costs for studies that have been waived, reserved, or are pending a decision by the EPA are estimated as if they had been conducted and do not reflect the administrative and scientific costs assumed by APHIS for generating these requests. Resulting cost comparisons show the importance of communicating with the EPA about data requirements and possible alternatives to meet valid data needs while trying to waive unnecessary or redundant requirements.

Gas Cartridge

Savarie et al. (1980) stated that a two-ingredient gas cartridge (sodium nitrate and charcoal) produces high concentrations of carbon monoxide gas when burned, and they suggested it would be an effective pyrotechnic fumigant for vertebrate pests that live in burrows or dens. Its development and testing has been reported by Savarie et al. (1980), Elias et al. (1983), and Savarie and Blom (1993). The gas cartridge is ignited, placed into the burrow or den, and all entrances and/or exits are closed to prevent the escape of gases generated by the burning cartridge. The gases are believed to be mostly simple organic and inorganic gases (U.S. EPA 1991b), with the primary toxic gas probably carbon monoxide (Savarie et al. 1980). These gases eventually: 1) disperse harmlessly into the atmosphere; 2) are entrapped in the soil where they are metabolized by soil microorganisms; or 3) enter their respective elemental cycles (USDA 1994). Carbon monoxide (CO) is highly toxic when inhaled because it has a much higher affinity for combining with hemoglobin than oxygen, and it quickly leads to tissue hypoxia (Swinyard 1975). CO is recommended by the American Veterinary Medicine Association's (1993) Panel on Euthanasia for euthanatizing animals because it quickly induces unconsciousness without pain and with minimal discernible discomfort; concentrations of 4 to 6 % result in rapid death. As one would expect based on this mode of action, no signs of secondary toxicity have been observed (Savarie et al. 1980). The gas cartridge is used only in underground burrows or dens; therefore, it should have minimal impact on nontarget animals and the environment (Dolbeeret al. 1991). Use instructions were expanded to lessen EPA's concerns about nontarget hazards (Palmateer 1993), because only burrows with signs of active use by the target species would be treated. APHIS has registrations for two gas cartridges for underground use to control burrowing rodents and coyotes (Ramey et al. 1992). The Large Gas Cartridge is a mammalian predacide, and it is undergoing the final phase of reregistration. It is effective against the coyote *(Canis latrans)* (Savarie et al. 1980), striped skunk *{Mephitis mephitis)* (Ramey 1992a), and red fox *(Vulpes vulpes)* (Ramey 1992b) in dens, but not against badgers *(Taxidea taxus)* in burrows (Ramey 1993a). The EPA approved the addition of the striped skunk and red fox to the Large Gas Cartridge (EPA Reg. No. 56228-21) in February 1993. The Gas Cartridge is widely used as a field rodenticide (USDA 1994). Efficacy of various sizes of gas cartridges with similar formulations has been reported for several rodent species (Fagerstone et al. 1981,

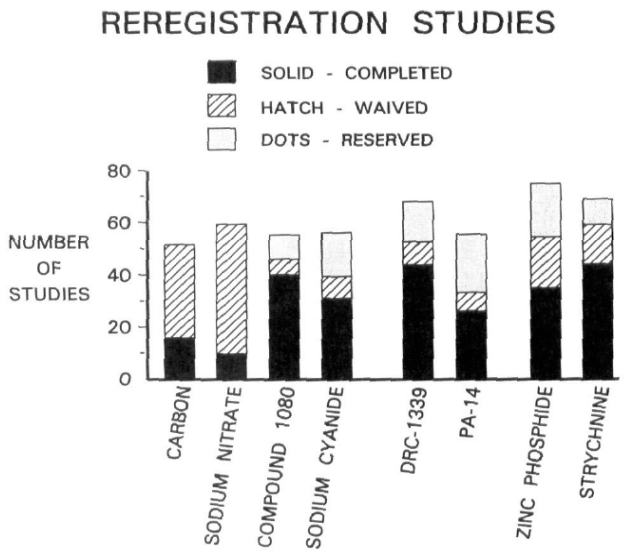

Figure 2. Bargraphs showing the number of studies requested by the EPA during reregistration for each of APHIS's active ingredients; studies completed or nearly completed (solid), waived or a waiver has been requested (hatch), or reserved pending a decision by EPA (dots).

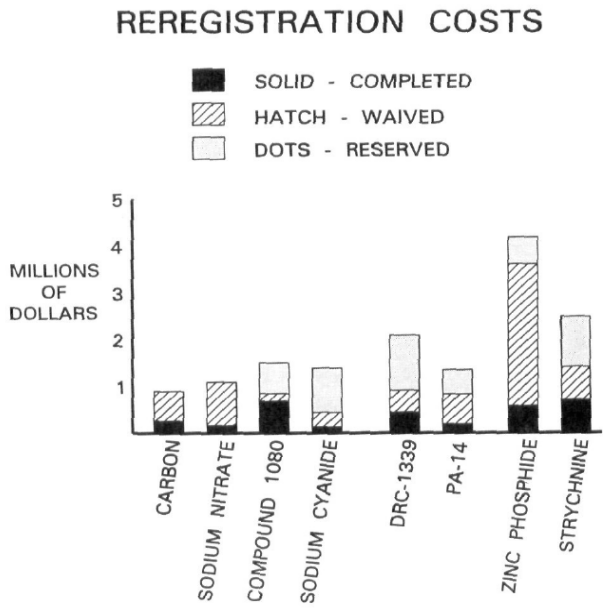

Figure 3. Bargraphs showing study costs requested by the EPA during reregistration for each of APHIS's active ingredients; studies completed or nearly completed (solid), waived or a waiver has been requested (hatch), or reserved pending a decision by EPA (dots).

Matshcke and Fagerstone 1984, Dolbeer et al. 1991). A new formulation for rodents is being developed by DWRC that contains only two Als-sodium nitrate and charcoal (Palmateer 1993). It is very similar, but smaller than the Large Gas Cartridge. EPA originally requested 110 studies costing more than $2 million for reregistration of the two AI Gas Cartridge and Large Gas Cartridge. After extensive negotiations with the EPA, 24 studies have been or are being completed ($290,000) by APHIS, and 86 have been waived. Waivers resulted from information submitted by APHIS to the EPA about the simple elemental cycling of the two AIs in the environment and references to the extensive published databases for each AI. Use instructions have been refined to allay concerns about nontarget hazards.

Compound 1080

Compound 1080 (sodium fluoroacetate) has a long history as a potent single dose acute toxicant (Pattison 1959). Tissue enzymes metabolize it into fluorocitrate (Peter 1952), which disrupts the Krebs cycle and inhibits cellular energy production (Savarie 1991). Death results from respiratory paralysis in carnivores, from cardiac fibrillation in herbivores, and from both causes in omnivores (Crabtree 1962). Perhaps the outstanding characteristic of the toxicology of Compound 1080 is the extreme variation in the susceptibility between species or even within a species, and the divergence in the symptoms exhibited among species (Chenoweth 1949). Even though Compound 1080 has been perhaps the most successful lethal pesticide ever employed for predator and rodent control, it is a nonspecific toxicant and can cause primary and secondary poisoning (Ward and Spencer 1947). Because adequate data were not submitted by technical registrants to support the technical product, EPA canceled all rodenticide uses in 1990 (Fagerstone et. al. 1994). Currently, its use is very limited in the U.S. It is only registered to control coyote predation on livestock by means of the Livestock Protection Collar (LPC). The EUP formulation consists of an aqueous solution of Compound 1080 (1.04%) contained within the LPC that fits around the neck of a sheep. The toxicant is dispensed once the coyote attacks the neck of the sheep and punctures the collar (Connolly 1990). This use has little potential for causing nontarget mortality. Connolly (1980) found that avian scavengers such as vultures and ravens generally avoided consuming the wool or hair contaminated with Compound 1080 after the LPC was punctured and preferred instead to feed on uncontaminated tissues. The LPC may be used by the ADC program directly or through technical assistance to its cooperators (USDA 1994). Two collars are available,

a small one for use on lambs and kid goats and a larger one approved by EPA on July 19, 1993, for use with sheep and goats over 50 lbs. In the 1992 DCI addressing only the technical product used in the LPC, EPA requested 55 studies at a cost of nearly $1.5 million; of these, 40 studies have been completed ($700,000), 4 have been waived ($120,000), and 11 have been reserved ($645,000). APHIS is unaware of additional EUP requirements.

Sodium Cyanide

APHIS uses sodium cyanide as a predacide in the M-44. The M-44 has been described by Connolly (1978) as one of the most important techniques for controlling livestock losses by coyotes. The capsules are placed in rangeland along game trails, ridges, and seldom used ranch roads. The toxicant is delivered in a capsule the size of a 44 caliber cartridge from a spring-activated ejector directly into the mouth of the target species (Connolly and Simmons 1984). Its mode of action involves the production of hydrocyanic acid when the capsule comes into contact with moisture in the mouth; death is rapid, usually within one to three minutes (USDA 1994). The cause of death is an inhibition of the tissue's oxidative enzymes and cellular respiration (Weimeyer et al. 1986) resulting in rapid death by asphyxiation. Therefore, it has been classified a general protoplasmic poison (Crabtree 1962). Sodium cyanide is highly toxic to most animal species, and domestic animals such as cattle, sheep, and rabbits have LD_{JO} values below that of the coyote (4.0 mg/kg, Sterner 1979). Secondary toxicity to predators is unlikely to occur because rapid death limits the assimilation of the toxic compound into the prey's tissues leaving no residues for the predator to consume. Its persistence in the environment is also not a concern, as it rapidly degrades, releasing hydrogen cyanide gas and eventually either breaking down into carbon dioxide and ammonia or is degraded by microorganisms (USFWS 1975). Sodium cyanide is currently in Phase 4 of reregistration. APHIS has supplied 29 (51%) of the 56 studies requested by the EPA at a cost of more than $100,000. Of the remaining studies originally requested by the EPA totalling nearly $1.3 million, 12 studies have been waived ($300,000) and 14 have been reserved ($966,000). APHIS is presently unaware of additional EUP requirements.

DRC-1339

DRC-1339 is a slow-acting avicide that is highly toxic to pest birds such as starlings, blackbirds, and pigeons (primary toxicity) and low to moderately toxic to most predatory birds and almost all mammals (DeCino et al. 1966). It is commercially available as a ready-to-use pellet as Starlicide Complete, a registration of Purina Mills (Schafer 1984). Starlicide Complete may be used by personnel who are State-certified in pesticide application (USDA 1994). DRC-1339 is also available as a concentrate (98% Al) that may be formulated with grain, bread, french fry, egg, or meat baits; it may be formulated and applied only by ADC personnel trained in bird damage control or persons under their direct supervision. Upon ingestion, DRC-1339 is readily absorbed into the circulatory system (Felsenstein et al. 1974) and is quickly metabolized (3 to 24 hrs) in the liver, with the target species dying as soon as three hours after consuming the bait (Decino et al. 1966). The mode of action of DRC-1339 involves the build-up of uric acid in the kidneys and blood vessels which cause necrosis and circulatory impairment, resulting in death from uremic poisoning and congestion of major organs (Felsenstein et al. 1974). Because DRC-1339 is rapidly metabolized and excreted in birds and other species, it is apparently not accumulated in plant or animal tissues (Schafer 1991) and has demonstrated very little potential for secondary toxicity (Schafer 1984).

Three of four Section 3 registrations that were submitted to the EPA by APHIS to consolidate many Special Local Need (SLN) 24(c) registrations have been recently approved by the EPA: pigeon control was approved in July 1992, egg and meat baits for depredating ravens and crows in May 1993, and feedlot use in June 1993. The fourth SNL label consolidation for the control of blackbirds and starlings at staging areas is still under EPA review (Palmateer 1993). EPA originally requested 68 studies at a cost of $2.1 million for APHIS and Purina Mills, a cooperator, to reregister DRC-1339. These registrants have submitted 44 studies for more than $500,000, 9 studies have been waived (about $400,000), and 15 studies are reserved ($1.2 million). EUP requirements are not known.

Compound PA-14

PA-14 (Tergitol) is a compound that acts as a surfactant (a nonionic surface-active agent) that lowers the surface tension of water (Union Carbide 1989). Orally, it is only slightly toxic to birds and mammals (Schafer 1984). For pesticide purposes this product is classified as a Restricted Use Pesticide and is referred to not as a toxicant, but as a stressing agent causing death by hypothermia. It acts by breaking down the natural oils in avian feathers and removing their natural waterproofing which decreases the insulating properties of feathers. PA-14 was used to control damage by blackbirds and starlings (USFWS 1976), typically in upland roosts away from water (USDA 1994). It was sprayed on target birds in roost situations as a 99.5% Al when temperatures were near freezing and/or prior to rainfall, both conditions promote hypothermia. The primary non-target hazard is to avian species in the roost at the time of the application (Heisterberg et al. 1987). No instances of secondary poisoning have been reported in the literature, and none are expected (USFWS 1976). APHIS recently transferred this registration to Nita Industries (Palmateer 1993) and no longer maintains a registration for this Al. Prior to the transfer, APHIS had completed 26 studies (at a cost of $130,000) out of the 55 studies ($1.3 million) requested by the EPA. APHIS had also requested that 24 studies for $750,000 be waived, but no responses had been received from the EPA when the transfer was effective. Five studies for $470,000 were reserved.

Zinc phosphide

Zinc phosphide is a nonspecific acute rodenticide (Gratz 1973), and its history has been reviewed by Marsh (1988). Its use often requires prebaiting because of its offensive taste and odor (USDA 1994). Its mode of

action is attributed to the release of phosphine gas following hydrolysis by stomach acids in the gastrointestinal (GI) tract of poisoned animals (Henderson and Boggess 1979). Death in rodents typically occurs in < 120 h and results from cessation of respiration induced by phosphine (Andreev et al. 1959). Besides rodents, it can cause primary toxicity to rabbits and birds (Savarie 1991, Hegdal and Gatz 1977a). Of the avian species tested, waterfowl and gallinaceous birds appear to be the most sensitive (Janda and Bosseova 1970, Matschke and Higgins 1978, Littrell 1990, Ramey 1993b). Secondary poisoning with zinc phosphide is unlikely, because it is not accumulated in muscle tissue, and it decomposes rapidly in the GI tract of poisoned animals (Savarie 1991). Johnson and Fagerstone (1993) recently reviewed its potential non-target hazards and found a low risk of secondary toxicity in reported studies which they attributed to the following factors: mammalian predators are less susceptible to zinc phosphide than other species, strong emetic action reduces secondary risks, and some animals refuse to eat the GI tract of poisoned animals. Also, Hayne (1950) has reported that zinc phosphide breaks down when exposed to wet conditions, and this can lead to reduced toxicity.

Currently, APHIS is leading the Zinc Phosphide Consortium (ZPC) for reregistration of the technical product. The ZPC was formed in May 1991, following receipt of the Phase 4 DCI, and it is coordinated by the PDS at DWRC (Fagerstone 1993a). It is composed of APHIS, state agencies, and private companies that joined together to generate funds to support data requirements of the DCI. Although the EPA has requested that 75 studies for $4.2 million be submitted by technical registrants for the reregistration of zinc phosphide since 1982, the ZPC has had success in requesting and receiving data waivers (e.g., 26% of the studies have been waived for more than $3 million in savings). Besides the studies the ZPC has funded for $750,000, it has also committed to develop residue data for already registered crop uses (Palmateer 1993). Some studies have been reserved pending the outcome of the review and evaluation of other data submissions. The Phase 5 EUP requirements are unknown.

Strychnine

Strychnine is probably the most widely used pesticide throughout the world (Buck 1991). Presently, it is used in the United States only as a rodenticide (Savarie 1991), although it has been used as a predacide (Ramey et al. 1992) and avicide (Schafer 1991). It is derived from plants of the *Strychnos* genus in Southeast Asia. It is usually mixed with cereal grains or pellets to form baits. All aboveground uses of strychnine were temporarily canceled by the EPA in 1988. Currently, its use by ADC is restricted to underground placement of grain baits in burrows to control pocket gophers (Evans 1990, USDA 1994). Strychnine is highly toxic to birds and mammals. It is metabolized in the liver where pathologic changes occur (USDA 1994). Its action is directly upon the Central Nervous System (CNS), causing interference with postsynaptic inhibition in the spinal cord and medulla (Buck 1991). The principal symptoms of strychnine poisoning are convulsive seizures, commonly appearing minutes after ingestion, and death occurs from a tetanic arrest of respiration (anoxia) during a major convulsion. While the animal lives, strychnine is excreted and detoxified within the first 24 hours after administration (U.S. EPA 1980). However, if the animal dies, strychnine resists decomposition for long periods in the GI tract (Hegdal and Gatz 1977b) and may be available to non-target predators and scavengers (Copeman 1957, U.S. EPA 1980). Secondary toxicity is more likely for carrion-eating mammals than raptors, because the latter generally eviscerate the carcass before ingestion. In the field, secondary toxicity may not be great, because some coyotes have been observed to reject the toxic GI tract (Marsh et al. 1987).

Data Call-Ins in 1986 and 1987 required technical registrants to submit data on toxicology, environmental fate, and efficacy that were too costly for each technical registrant to individually fund; therefore, the Strychnine Consortium (SC) was formed in 1988 (Fagerstone 1993b). The SC generates funds to produce data required by EPA for the Strychnine Settlement Agreement (SSA) and for the reregistration of the strychnine AI (Ramey et al. 1992). APHIS coordinates SC activities through the PDS at DWRC; the SC has over 20 members consisting of APHIS, state agencies, and private companies. In 1993, the SC received the Phase 4 DCI, which increased reregistration requirements to 69 studies for nearly $2.5 million. Of these studies, APHIS has submitted or is in various phases of completing 34 studies for the SC at a cost of $725,000. In addition, 15 studies have either been waived or the waiver requests are awaiting decisions by EPA. Ten studies have been reserved by the EPA pending the review of other data submissions. Ten studies have been completed or are under contract from the SC with data submissions expected by 1995. Phase 5 EUP requirements are unknown, although APHIS has already submitted all efficacy studies required by the SSA for below-ground use. For above-ground uses of strychnine, the SC is working with the U.S. Fish and Wildlife Service and the EPA to meet the labeling requirements of the Endangered Species Act. Completion of this three-party effort may allow EPA to ask for a lifting of the injunction against the above-ground use of strychnine.

THE FUTURE OF APHIS's VERTEBRATE PESTICIDES AND THE LESSONS LEARNED

FIFRA, as amended, requires the EPA to weigh the benefits derived from the use of a pesticide against any risks that it may pose to public health and the environment (Conner et al. 1991). This decision-making process by the EPA Administrator uses risk assessment and risk management techniques that involve: 1) the hazard posed by the pesticide; 2) the potential exposure to the pesticide; and 3) the probable degree of risk (i.e., toxicity and exposure interaction). In addition, FIFRA Sec. 3(c)(2)(A) requires the EPA to consider minor uses when establishing standards for data requirements. However, historically the EPA has considered reducing reregistration data requirements for registrants of minor or low volume use pesticides only if all uses of the ingredient are low volume. Although all of APHIS's vertebrate pesticides are low volume and minor use, the

data requirements of the EPA have not been generally reduced by accepting LVMU waivers from APHIS or APHIS coordinated consortia. The total quantities of AIs used by APHIS each year are very small. During the fiscal years 1988 through 1991, the maximum annual ADC Program uses nationally were: zinc phosphide (177 kg), strychnine (429 kg), sodium nitrate (643 kg), DRC-1339 (68 kg), PA-14 (2707 1), sodium cyanide (100 kg), and Compound 1080 (0.02 kg) (USDA 1994). These quantities of AIs used nationally in APHIS's vertebrate pesticides seem to have very costly data requirements relative to more widely used pesticides, fungicides, and insecticides. For example, reregistration costs for Compound 1080, based upon the 0.4 lb of AI used in the LPC in the U.S. for 1988 to 1992 (Connolly 1993), would have been approximately $250,000 per oz used if it were not for the development of excellent communications and scientific relationships between APHIS and EPA that allowed for a lessening of data requirements and a lowering of associated data costs by nearly 50%.

APHIS or APHIS coordinated consortia have completed or have committed to complete 258 of 488 studies (53%) requested by the EPA for nearly $15 million, but these requests have been decreased by nearly 50% ($7.4 million) by negotiating, proposing less costly alternatives, requesting LVMU and technical waivers, and familiarizing the SRRD staff with LVMU vertebrate pesticides. These actions did not attempt to avoid valid data requirements to answer significant scientific inquiries, but attempted to use the most cost-effective means to answer scientific questions and to waive unnecessary or redundant requirements. Without these activities by DWRC and TSS, most of these pesticides would have been lost due to a lack of funding rather than because of decisions based upon risk-benefit analyses.

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LITERATURE CITED

ACORD, B. R. 1991. Animal Damage Control: Are we prepared for the next century? Proc. Great Plains Wildl. Damage Conf. 10:18-22.

AMERICAN VETERINARY MEDICAL ASSOCIATION. 1993. Report of the AVMA Panel on Euthanasia. J. Am. Vet. Med. Assoc. 202(2): 229-249.

ANDREEV, S. B., A. V. VOEVODIN, V. A. MOLCHANOUR, and A. V. KHOTYANOVICH. 1959. Some results on the use of tracer techniques in the study of plant protection. Proc. U. N. Inter. Conf. Peaceful Uses of Energy, Geneva, Switzerland, 27:85-92.

BEAN, M. J. 1977. The evolution of National Wildlife Law, Pages 262-287 *in* Animal Damage Control-Predators and Pesticides. U.S. Govt. Printing Office, Washington, D.C.

BUCK, W. B. 1991. Toxicity of pesticides in livestock. Pages 571-587 *in* D. Pimental, ed. CRC Handbook of Pest Management in Agriculture, Vol. II. CRC Press, Inc., Boca Raton, FL. CHENOWETH, M. B. 1949. Monofluoroacetic acid and related compounds. J. Pharm. Exp. Therapeutics. 97(4):383-424. CONNER, J. D., L. S. EBNER, S. W. LANDFAIR, C. A. O'CONNOR, K. E. WEINSTEIN, and A. P. JOVANOVICH. 1991. Pesticide Regulation Handbook. Executive Enterprises Publ. Co., Inc., New York, NY. 540 pp. CONNOLLY, G. E. 1978. Predators and predator Control. Pages 369-394 *in* J. L. Schmidt and D. L. Gilbert, eds. Big Game of North America Ecology and Management. Stackpole Books, Harrisburg, PA. CONNOLLY, G. E. 1980. Use of Compound 1080 in livestock neck collars to kill depredating coyotes: a report on field and lab research. U.S. Dept. Interior, Fish Wildl. Serv., Unpubl. Rep. 125 pp.

CONNOLLY, G. E. 1990. The livestock protection collar. Pages 89-93 *in* G. A. Guisti, R. M. Timm, and R. H. Schmidt, eds. Predator management in north coastal California. Un. Calif. Hopland Field Station Publ. 101. CONNOLLY, G. E. 1993. Livestock Protection Collars in the United States, 1988 - 1993. Proc. Great Plains Wildl. Damage Control Workshop. 11:25-33.

CONNOLLY, G. E., and G. D. SIMMONS. 1984. Performance of sodium cyanide ejectors. Proc. Vertebr. Pest Conf. 11:114-121. COPEMAN, VAN R. DR. 1957. Poisoning by strychnine. J. Forensic Med. 4:180-185.

CRABTREE, D. G. 1962. Review of current vertebrate pesticides. Bureau of Sport Fisheries and Wildl., Wildl. Res. Ctr. pp. 327-362. DECINO, T. J., D. J. CUNNINGHAM, and E. W. SCHAFER. 1966. Toxicity of DRC-1339 to starlings. J. Wildl. Manage. 30:249-253.

DOLBEER, R. A., E. BERNHARDT, T. W. SEAMANS, and P. P. WORONECKI. 1991. Efficacy of two gas cartridge formulations in killing woodchucks in burrows. Wild. Soc. Bull. 19:200-204. ELIAS, D. J., P. J. SAVARIE, D. J. HAYES, and M. W. FALL. 1983. A simulated burrow system for laboratory evaluation of vertebrate control fumigants. Pages 226-230 *in* D. E. Kaukeinen, ed., Vertebr. Pest Control and Manage. Materials: Fourth Symp., Ann Arbor, MI. EVANS, J. 1990. Efficacy data for registration of strychnine grain baits to control pocket gophers *(Thomomys* spp.). Proc. Vertebr. Pest Conf. 14:82-86. FAGERSTONE, K. A. 1993a. Status of the zinc phosphide consortium, Abstract. Field Rodent Manage. Sym., Reno, NV. p. 22. FAGERSTONE, K. A. 1993b. Status of the strychnine consortium, Abstract. Field Rodent Manage. Sym., Reno, NV. p. 21. FAGERSTONE, K. A., R. W. BULLARD, and C. A. RAMEY. 1990. Politics and economics of maintaining pesticide registrations. Proc. Vertebr. Pest Conf. 14:8-11.

FAGERSTONE, K. A., G. H. MATSCHKE, and D. J. ELIAS. 1981. Radiotelemetry to evaluate effectiveness of a new fumigant cartridge for controlling ground squirrels. Proc. 3rd Int. Conf. on Wildl. Biotelemetry. Laramie, WY. pp. 20-25.

FAGERSTONE, K. A., P. J. SAVARIE, D. J. ELIAS, and E. W. SCHAFER, JR. 1994. Recent regulatory requirements for pesticide registration and the status of Compound 1080 studies conducted to meet EPA requirements. *In* Proc. Royal Society New Zealand. In Press.

FELSENSTEIN, W. C, R. P. SMITH, and R. E. GOSSELIN. 1974. Toxicological studies on the avicide 3-Chloro-p-Toluidine. Toxicol. Appl. Pharmacol. 28:110-125.

FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT (FIFRA). 1988. The Federal Insecticide, Fungicide, and Rodenticide Act of 1947 as Amended. EPA 540/09-89-012, Fed. Reg. Vol. 53, No. 86, 73 pp.

GRATZ, N. G. 1973. A critical review of currently used single-dose rodenticides. Bull. World Health Org. 48:469-477.

HAYNE, D. W. 1951. Zinc phosphide: its toxicity to pheasants and effect of weathering upon its toxicity to mice. Mich. Agr. Exp. Sta. Quart. Bull. 33(4):412-425.

HEISTERBERG, J. F., A. R. STICKLEY, K. M. GARNER, and P. D. FOSTER. 1987. Controlling blackbirds and starlings at winter roosts using PA-14. East. Wildl. Damage Conf. 3:177-183.

HEGDAL, P. L., and T. A. GATZ. 1977a. Hazards to pheasants and cottontail rabbits associated with zinc phosphide baiting for microtine rodents in orchards. U.S. Fish and Wildlife Service, Unpubl. Rep. 60 pp.

HEGDAL, P. L., and T. A. GATZ. 1977b. Hazards to seed eating birds and other wildlife associated with surface strychnine baiting for Richardson's ground squirrels. Unpubl. Rep. U.S. Fish and Wildl. Ser. 42 pp.

HENDERSON, F. R., and E. K. BOGGESS. 1979. 2% zinc phosphide for prairie dog control. Kansas State Univ. Coop. Exten. Serv. AF-29. 4pp.

JACOBS, W. W. 1992. Vertebrate pesticides no longer registered and factors contributing to loss of registration. Proc. Vertebr. Pest Conf. 15:142-148.

JANDA, J., and M. BOSSEOVA. 1970. The toxic effect of zinc phosphide baits on partridges and pheasants. J. Wild. Manage. 34:220-223.

JOHNSON, G. D., and K. A. FAGERSTONE. 1993. Primary and secondary hazards of zinc phosphide to nontarget wildlife - A review of the literature. USDA/APHIS/DWRC Res. Rep. No. 11-55. In Press.

LITTRELL, E. E. 1990. Effects of field vertebrate pest control on nontarget wildlife (with emphasis on bird and rodent control). Proc. Vertebr. Pest Conf. 14:59-61.

MARSH, R. E. 1988. Relevant characteristics of zinc phosphide as a rodenticide. Pages 70-74 *in* U.S. For. Serv. Gen. Tech. Rep. RM-154.

MARSH, R. E., R. H. SCHMIDT, and W. E. HOWARD. 1987. Secondary hazards to coyotes of ground squirrels poisoned with 1080 or strychnine. Wildl. Soc. Bull. 15(3):380-385.

MATSCHKE, G. H., and K. A. FAGERSTONE. 1984. Efficacy of two-ingredient fumigant on Richardson's ground squirrel. Proc. Vertebr. Pest Conf. 11:17-19.

MATSCHKE, G. H., and W. H. HIGGINS. 1978. Adult mallard duck LD50 and 95% confidence limits. U.S. Fish Wildl. Serv. Denver Wildl. Res. Center Unpubl. Report. 14pp.

PALMATEER, S. D. 1993. APHIS rodenticides, Abstract. Field Rodent Manage. Sym., Reno, NV. p. 39.

PATTISON, F. L. 1959. Toxic aliphatic fluorine compounds. Elsevier Publ. Co., New York, NY. 227 pp.

PETER, R. A. 1952. Lethal synthesis (Croonian lecture). Proc. R. Soc. London, Ser. B, 139-143.

POCHE, R. M. 1992. How GLP provisions influence costs of rodenticide field evaluations. Proc. Vertebr. Pest Conf. 15:245-248.

RAMEY, C. A. 1992a. Product Performance with the coyote gas cartridge (EPA Reg. Nos. 56228-21 and NE920001) in a field efficacy study with the striped skunk *(Mephitis mephitis)*. Unpub. Rep., Denver Wildl. Res. Ctr., USDA-APHIS-ADC, Denver, CO. 195 pp.

RAMEY, C. A. 1992b. Product Performance with the coyote gas cartridge (EPA Reg. Nos. 56228-21, ND880001, NE920001, SD920001) in a field efficacy study with the red fox *(Vulpes vulpes)*. Unpub. Rep., Denver Wildl. Res. Ctr., USDA-APHIS-ADC, Denver, CO. 150 pp.

RAMEY, C. A. 1993a. Evaluating the gas cartridge for coyotes in controlling badgers. Proc. East. Wildl. Damage Control Conf. 6: In Press.

RAMEY, C. A. 1993b. Non-target hazards to gallinaceous birds in simulated field studies using zinc phosphide to control voles, Abstract. Field Rodent Manage. Sym., Reno, NV. p. 42.

RAMEY, C. A., E. W. SCHAFER, JR., K. A. FAGERSTONE, and S. D. PALMATEER. 1992. Back to the future for APHIS's vertebrate pesticides. Proc, Vertebr. Pest Conf. 15:17-21.

REIDINGER, R. F. 1990. Keynote address - Thoughts on the future of vertebrate pest management. Proc. Vertebr. Pest Conf. 14:2-4.

SAVARIE, P. J. 1991. The nature, modes of action, and toxicity of rodenticides. Pages 589-598 *in* D. Pimental, ed. CRC Handbook of Pest Management in Agriculture, vol. II, CRC Press, Boca Raton, FL.

SAVARIE, P. J., and F. S. BLOM. 1993. Fuse and cartridge burn times of gas cartridges that contain 2 active ingredients (sodium nitrate and charcoal) plus 2 inactive ingredients (borax [sodium tetraborate decahydrate], and fuller's earth [a variety of kaolin, a clay]. Unpub. Rep., Denver Wildl. Res. Ctr., USDA-APHIS-WS, Denver, CO. 157 pp.

SAVARIE, P. J., J. R. TIGNER, D. J. ELLIS, and D. J. HAYES. 1980. Development of a simple two-

ingredient pyrotechnic fumigant. Proc. Vertebr. Pest Conf. 9:215-221.

SCHAFER, E. W., JR. 1984. Potential primary and secondary hazards of avicides. Proc. Vertebr. Pest Conf. 11:217-222.

SCHAFER, E. W., Jr. 1991. Bird control chemicals-nature, modes of action, and Toxicity. Pages 599-610 *in* D. Pimental, ed. CRC Handbook of Pest Management in Agriculture, vol. II, CRC Press, Boca Raton, FL.

STERNER, R. T. 1979. Effects of sodium cyanide and diphacinone in coyotes *(Canis latrans):* applications as predacides in livestock toxic collars. Bull. Environ. Contam. Toxicol. 23:211-217.

SWINYARD, E. A. 1975. Noxious gases and vapors: carbon monoxide, hydrocyanic acid, benzene, gasoline, kerosene, carbon tetrachloride, and miscellaneous organic solvents. Pages 900-904 *in* L. S. Goodman and A. Gilnian, eds. The Pharmacological Basis of Therapeutics. Macmillan, New York, NY.

UNION CARBIDE. 1989. Tergitol Nonionic surfactant 15-S-9. Product Information. 14 pp.

U.S. DEPARTMENT OF AGRICULTURE. 1994. Animal Damage Control Program FinalEnvironmental Impact Statement. APHIS, Washington, DC. Vol. 1-3, 1102 pp.

U.S. ENVIRONMENTAL PROTECTION AGENCY. 1980. Strychnine position document No. 4, EPA Office of Pesticide and Toxic Substances, Sept. 30, 1983. U.S. ENVIRONMENTAL PROTECTION AGENCY.

1991a. Code of federal regulations: protection of the environment. 40 (Parts 150 to 189). U.S. Government Printing Office: Washington, DC. 674 pp. U.S. ENVIRONMENTAL PROTECTION AGENCY.

1991b. Reregistration eligibility document (RED) - inorganic nitrate/nitrite (sodium and potassium nitrates), Office of Pesticide Programs, Washington, DC. 108 pp. U.S. FISH AND WILDLIFE SERVICE. 1975. Hazards to the environment: sodium cyanide. Unpubl. Rep. July 7, 1975, under 6704-75: CDL: 222125-E.

U.S. FISH AND WILDLIFE SERVICE. 1976. The use of compound PA-14 avian stressing agent for control of blackbirds and starlings at winter roosts. Final Environmental Statement, July 1976. WARD, J. C. 1962. Federal Law and Vertebrate Pest Control., Proc. Vertebr. Pest Conf. 1:363-371.

WARD, J. C, and D. A. Spencer. 1947. Notes on the Pharmacology of sodium fluoracetate Compound 1080. J. Am. Pharm. Assoc. 36(2):59-62.

WEIMEYER, S. N., E. F. HILL, J. W. CARPENTER, and A. J. KRYNITSKY. 1986. Acute oral toxicity of sodium cyanide in birds. J. Wildl. Dis. 22:538-546.