University of Nebraska - Lincoln
DigitalCommons@University of Nebraska - Lincoln

Proceedings of the Thirteenth Vertebrate Pest Conference (1988)

Vertebrate Pest Conference Proceedings collection

3-1-1988

VERTEBRATE PESTICIDES AND NONTARGET WILDLIFE LOSSES IN PROPER PERSPECTIVE

James E. Miller
USDA Extension Service, Washington, DC

Follow this and additional works at: http://digitalcommons.unl.edu/vpcthirteen

Part of the Environmental Health and Protection Commons

Miller, James E., "VERTEBRATE PESTICIDES AND NONTARGET WILDLIFE LOSSES IN PROPER PERSPECTIVE" (1988). *Proceedings of the Thirteenth Vertebrate Pest Conference (1988)*. Paper 10.
http://digitalcommons.unl.edu/vpcthirteen/10

This Article is brought to you for free and open access by the Vertebrate Pest Conference Proceedings collection at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Proceedings of the Thirteenth Vertebrate Pest Conference (1988) by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

VERTEBRATE PESTICIDES AND NONTARGET WILDLIFE LOSSES IN PROPER PERSPECTIVE

JAMES E. MILLER, Program Leader-Fish and Wildlife, U.S.D.A. Extension Service, Washington, D.C.

ABSTRACT: The use of pesticides as one of the management tools to assist in the prevention and control of damage caused by vertebrate wildlife is certainly not new, nor has it become any less controversial in recent years. In fact, throughout the recent history of pesticide uses for control of vertebrate damage to the production of food and fiber, the prevention of potential epizootic diseases, and other potential threats to man's well-being and to the habitats and management of other wildlife resources, the use of pesticides as well as other management tools have generally been reviewed and monitored by professionals. Justifiably, there has been a significant amount of research conducted to monitor both direct and indirect hazards or potential hazards to nontarget vertebrate wildlife species. It is essential to assess, research and monitor these hazards to other vertebrates, as well as to evaluate the cost benefits and risk benefits of pesticide use. How can we put these concerns or potential occurrences into proper perspective? I'm not sure about many of the potential concerns because knowledge, experience and common sense use by professionals should prevent most nontarget risks. However, I do believe that by providing consideration for a review of nontarget wildlife losses to pesticides as well as other losses to vertebrates we might become more professionally cautious while concurrently improving our competence and confidence in the use of pesticides to prevent and control vertebrate wildlife damage.

Proc. Vertebr. Pest Conf. (A.C. Crabb and R.E. Marsh, Eds.),
Printed at Univ. of Calif., Davis. 13:39-44, 1988

INTRODUCTION

This paper is an attempt to provide some measure of reason about the need, concern for, and use of vertebrate pesticides and how nontarget wildlife losses might be placed into proper perspective. Initially, we need to examine the relative importance of vertebrate damage. For example, Howard (1979) stated that a conservative estimate of damage caused by vertebrates in California amounted to S100 million annually and that the use of control measures prevented an estimated additional annual loss of about $500 million. Nationwide estimates of annual losses to vertebrates are in the tens of billions of dollars just in economic losses. Damage by vertebrates cause other losses that are rarely even considered by those "whose ox is not being gored." In fact, there is very little quantitative documentation of the frustration and down-time losses suffered by landowners and managers, the damage to other wild living resources or their habitats, and the losses to individuals and their families as a result of bird strikes or related causes, or to those who have been forced out of their preferred livelihood or forced to incur significant management costs in time, labor and resources. Obviously, we all can relate to specific examples of these losses and some in recent years have been referenced in the literature. However, suffice to say that vertebrate animals whether wild, domestic, native, or exotic, in rural and urban areas do cause significant problems and present significant threats to man' s and other species' interest, and these affected interests both deserve and expect effective assistance.

Why then is there so much controversy and emotion about the control of these vertebrates? Basically I believe it is partially because both the public and our profession cares about these wildlife species, partially because people are more familiar with some of these species, and many of the vertebrates are capable of blinking, whimpering, or making noise unlike many of the fish, insects, and invertebrates. In addition, there are many people who find it offensive to kill or know that others are killing vertebrate wildlife species for any reason. Part of this is because, by and large, we have been taught not to kill vertebrates that have any anthropomorphic capabilities, and because the great majority of the present human population in the United States (over 98% according to recent census figures) do not live on farms, thus do not have much opportunity to experience significant losses. Therefore, they do not perceive that it is necessary to control vertebrate damage. If, however, we examine closer the actions of many of these people, we find that most, as quoted by Berryman (1983), are "closet controllers" who use pesticides for controlling mice or rats, roaches and ants in or around the house, or fleas on the family pets. Some of them might even resort to traps or pesticides to control moles in the lawn, chipmunks in the flowerbeds, rabbits in the garden, or unwanted birds and squirrels around their bird feeders. Some of these people might even dump their unwanted goldfish down the toilet, take their unwanted pets or their offspring for a ride and dump them or even have them euthanized.

In obtaining information and references to prepare this paper, I became aware of the need for a much more extensive review than was possible during this effort. Hopefully this brief review and attempt to provide some perspective may encourage further, more comprehensive studies on this subject in the future. I am indebted to a number of professional colleagues who provided references, encouragement and helpful suggestions about how such perspective could be presented. Particularly helpful were Terry Salmon, Rex

Marsh, Guy Connolly, Paul Hegdal, Ed Schaffer, Russ Reidinger, Thurman Booth and Scott Craven.

DISCUSSION

There is among the vast majority, if not all, professionally trained wildlife biologists a sincere concern for the judicious use of prevention and control measures for vertebrate species whether these measures include the use of pesticides, mechanical, or other nonpesticidal means. Certainly I believe it is appropriate to state that professional wildlife biologists have been in the past, and continue to be, more concerned about the use of vertebrate pesticides and their potential impact on non-target species and the environment than any other group of professionals or non-professionals. In fact, the great majority of us have been formally trained at the great universities of this nation not to control vertebrates, but to manage the habitats and the populations to enhance and increase these wild living resources with little or no concern that some of them may at some point require direct or indirect control. This is, of course, not entirely true in that, for most game species, we are taught that regulated hunting or trapping harvests serve as means of cropping off surpluses and sustaining annual yields. However, even with the many successes in wildlife restoration over the past 50 years, we are constantly being faced with diminishing habitats, more people, and increasing conflicts between people and their interests and vertebrate wildlife.

Most federal and state wildlife agencies with related agricultural and natural resources interests have long-standing policies regarding vertebrate animal damage control as do many professional organizations. In all of these policies or position papers. a common interest of safety to humans and to nontarget species is evident.

Obviously, there is always the remote possibility of accidental loss to a nontarget individual when vertebrate pesticides or other control measures are used. However, with trained and experienced professionals doing the work or through training others how to safely and effectively use vertebrate pesticides, these losses of nontarget animals have with few exceptions been minimal. Even more important is the fact that such programs, even though professionally monitored and researched by wildlife biologists and others, have not been proven to have a major, significant, short- nor long-term adverse impact on nontarget wildlife species or the environment. Clearly, the research, evaluation and monitoring of the use of vertebrate pesticides by competent wildlife professionals has and will continue to be necessary. These efforts in concert with the concern, caution, common sense, and competency of those professionals implementing the programs are the primary reasons why no such long-term, adverse impacts have occurred.

Admittedly some vertebrate pesticides have significantly greater potential for nontarget hazard than do others. However, much of the perceived risk to nontarget wildlife is based on anecdotal, rather than documented evidence. In fact, review of the literature reveals that most nontarget potential risk information has been generated in the lab, without any evidence of field evaluation or field documentation.

Review and Perspective

The literature as well as the media in recent years have provided a wide diversity of information both factual as well as sensationalized about nontarget losses occurring to wildlife and domestic animals from the use of both pesticidal and nonpesticidal prevention and control programs. In most cases, because it is less attention getting, wildlife and domestic vertebrate losses to other causes are much less sensational and in most cases one must search the literature to gain a perspective of such losses, be they to disease, pollution, habitat destruction, physical barriers, obstructions, or other causes. The following examples of losses to nontarget wildlife and domestic animals from pesticide use as well as losses to these animals from other causes will hopefully provide some perspective for our consideration.

The Quarterly Die-off Reports for July 1986 through September 1987 obtained from the National Wildlife Health Center in Madison, Wisconsin, summarized 183 reports of vertebrate wildlife losses reported from across the nation. In a review of these losses, which amounted to 138,065 animals with birds making up the preponderance of species, the causes of mortality were in rank of numbers of losses: avian botulism, avian cholera and lead poisoning, botulism type c, airsacculitis-pericarditis, emaciation, drowning, net and garbage entrapment and trauma, salmonella, pasturellosis, organophosphate and carbamate toxin suspect, and other suspect poisonings, although no vertebrate pesticide was identified. Most of the species examined were waterfowl, gulls, shorebirds, gamebirds or songbirds with a few mammals, including foxes, elk and squirrels, also being examined for cause of death.

Data from reports such as these are valuable and must be continually monitored, however, we should also look to other sources. To gain some perspective of documented losses to nontarget wildlife from pesticides, let's review an investigation of goose mortality in California from the use of zinc phosphide as a rodenticide (Keith and O'Neil 1964). In late October 1963 a total of 455 dead geese made up of white-fronted, cackling, snows, and Canadas was recovered at the Tule Lake National Wildlife Refuge. These birds died in a 2-day period between October 23-25, and pathological examinations were conducted on six of the dead birds.

Although one of the birds died of fowl cholera, the other five each were found to have small amounts of zinc phosphide bait in the gizzards. As a result of this finding, baits were collected from the field treated over three months before with a broad-scale aerial application to control meadow mice. These collected baits normally would not have been expected to retain toxicity in field applications over such a long period of time. However, burning of this treated barley field, not normally allowed, had created a situation which made lethal quantities of the bait available to the geese, and further study revealed a significant surplus of bait remaining in the field. Further investigations of feeding trials with bait collected

from the field indicated that about one-third of the original zinc phosphide still remained on the field baits after three months' exposure to field conditions. These collected baits were then fed to 23 snow geese in captivity. All of these geese eating 300-400 kernels of this bait died and most eating 200 or more kernels died. This information suggests that geese found dead in the field could have been poisoned by the zinc phosphide bait. Recommendations from this investigation suggested that: burned fields should not be treated with toxic baits, thus increasing significantly the exposure to waterfowl in the area; baiting should be done earlier in the year; the rate of application and the location of bait placement could have been improved; and other toxicants less toxic to geese should have been used in this case.

Such evidence clearly makes a case for research and monitoring to prevent such nontarget hazards to wildlife. However, again put into perspective with geese taken by hunting, disease, e.g., botulism, cholera, etc., and those lost to collisions, such exceptional case losses as these have minimal impacts on the goose populations in the region. Admittedly this information reports important data to be used to prevent such occurrences in the future and is beneficial to management decision making.

Other references that are useful in gaining a proper perspective include data on wildlife killed in collisions with towers-either TV towers, energy towers or other aerial structures-and with automobiles or other man-made objects. For example, Crawford (1978) reported avian kills at a TV tower near Tallahassee, Florida, examined daily between August and November for three years 1973-1975, to consist of 3864 individuals of 109 species. Another study during the fall months of the same years 1973-1975 at a coal- fired power plant near Central Illinois by Anderson (1978) indicated that some 200-400 waterfowl were killed annually by collision with power lines crossing a slag pit and lake near the plant. There are numerous other studies of bird mortality with power plant structures, TV and related towers, power lines, etc. However, wildlife collisions with automobiles on highways have also been examined and help us put losses of wildlife into perspective.

For example, Ebert (1972) estimated that vehicle-deer collisions alone result in 126,000 deer lost annually and damage to vehicles at $34 million. The Humane Society estimated nearly 1.5 million animals killed daily on America's highways (Gregory 1975). In addition, Case (1978) reported for Interstate 80 through Nebraska, examinations of road kills for years 1969-1975 which revealed 24,244 animals of 9 principal wildlife species were killed as a result of collisions with vehicles. Other studies indicate that by 1980, deer-vehicle accidents in the United States amounted to over 200,000 annually.

In a study conducted by Wilkins and Schmidly (1980) along stretches of three highways in southeastern Texas, a total of 286 carcasses were observed within 1768 km of highway examined during 1975-76. These kills included 187 mammals, 49 birds and 50 reptiles and amphibians. Another study reported by Sargeant (1981) of ducks killed in some parts of the Prairie Pothole Regions of Eastern North Dakota and North-central South Dakota during nesting months of April-July from 1969-78 and 1970-72, respectively, provided estimates of an average of no more than 4500 adult ducks killed annually on roads in the Prairie Pothole Regions.

When these figures of wildlife loss are estimated via scientific studies and compiled with other sources of nonpesticide-caused mortality to wildlife, the reported few cases of nontarget kills caused by pesticides obviously are somewhat insignificant, especially when hunting and trapping harvests of game species are included. In a Special Scientific Report by the Fish and Wildlife Service (Banks 1979), estimates of human-related mortality of birds in the U.S. are summarized as follows for the early 1970s:

~ Human activity caused death to approximately 196 million birds annually or about 1.9% of the total U.S. population of wild birds.

-- Hunting was the greatest cause of direct mortality, accounting for about 61% of all wild bird deaths caused by humans.

- Control or prevention of bird depredations took about 1% of the total.

~ Research and propagation accounted for about 0.5% of the total.

-- Collision with man-made objects accounted for 32% of human related deaths.

-- Pollution and poisoning from all sources caused the death of about 2% of the total human-related mortality.

The results were summed up with the following statements: "A relatively few species account for most of this mortality, but these species continue to maintain large, harvestable populations, suggesting that the numbers of most bird species are essentially unaffected by the human activities causing major mortality to avian species." "Other activities of man that do not necessarily result in the death of birds, but rather reduce reproductive po ten tial are more likely to have long-term effects on avian populations."

In a study of 76 bald eagles that died during the period 1960-65, provided by 41 different cooperators from across the U.S. to the Patuxent Wildlife Research Center for necropsy (Coon, Locke, Cromartie and Reichel 1970), the results indicated that only one was suspected of being killed by pesticide poisoning—dieldrin. As might be suspected, the major cause of death was trauma, with gunshot injuries being the primary cause of trauma. Other causes included impact, electrocution, diseases, undetermined, trapped, and intestinal obstructions.

Obviously, there are many other studies that indicate mortality to wildlife species from a wide variety of causes, ranging from predation at bird feeders to collisions with vehicles, towers, etc., to animals caught in plastic garbage to nontarget losses caused by the use of pesticides or other prevention or control measures. The important considerations are: (1) by evaluation, research and monitoring of these causes can we change our behavior or our methodologies to keep these losses well below the level at which any of these populations are severely impacted, (2) does the benefit of

using pesticides or other prevention or control measures clearly outweigh the risks as we review, research and monitor these efforts, (3) as a result of these studies can we determine methods of reducing risks to nontarget animals, (4) can we provide the continuing education of professionals and other users to increase adoption of these new and emerging technologies to improve selectivity, reduce the risks, increase efficacy, and maintain cost-effectiveness, and (5) can all of these efforts be combined to develop and deliver educational programs to the public, to decisionmakers, to regulatory agencies and to the Congress that will allow the continuation of professional wildlife management, including the vital area of wildlife damage prevention and control, to ensure wise stewardship for the future?

Management Implications

Obviously, the challenges that face wildlife managers in the future are both diverse and extensive. To attempt to meet these challenges alone would probably be foolish and certainly more costly than the profession could sustain. We must encourage increased support from within our profession, as well as outside, from those that have traditionally provided some support for our programs, and many who have either not felt they were impacted or some who have openly opposed us on how we manage wildlife. Clearly we are aware of some of our needs within the profession, e.g., strengthening our wildlife curriculums at the universities by providing comprehensive courses in the prevention and control of wildlife damage. Such courses obviously must be taught by knowledgeable and objective instructors. We must also provide strong continuing education programs for wildlife professionals such as this and other conferences, and we need to obtain more interest and acknowledgment by The Wildlife Society for the competency and need for scientific articles in its publications, as well as recognition of the need for a standing committee within its committee structure.

Another area that we need to continue to work on within our profession is to remove the black hat/gopher choker image that some seem to want to perpetuate. We must constantly work to improve our professionalism in this area of work. In my opinion, that image of non-professionals being employed in the prevention and control of wildlife damage should be a thing of the past. We must look to the future and learn from the past, not continue to perpetuate false impressions. There have been a number of quality papers addressing some of these issues and concerns published within the past several years that we need to encourage our colleagues to become aware of, e.g., Howard, Timm, Marsh, Miller, Connolly, Berryman, O'Gara, Petoskey and others in a wide variety of publications and proceedings. In regard to our need to encourage traditional supporters, I have been a participant in a number of major wildlife damage conferences, workshops and other programs during the last 20 years and rarely do we see major, or at many of these, even minor participation by State Fish and Wildlife Agency personnel, or from universities' wildlife professors whose primary responsibility is teaching students, unless they themselves are directly involved in related research.

Although I am certainly not in favor of reducing conferences such as this one in favor of more broad-based wildlife conferences, I do believe we need to make a major effort to get more strong research and management papers on the prevention and control of wildlife damage into other major wildlife and natural resources programs, e.g., regional and national association meetings and related conservation meetings. We also need to work at encouraging more agency and university wildlife professionals who are not directly involved in this area of wildlife management to become more aware of this work. In addition, I believe we must be diligent in keeping state and federal agency administrations, local and national organizations, e.g., Farm Bureau, the International Association of Fish and Wildlife Agencies, the Wildlife Management Institute, and other professional societies, e.g., Society for Range Management, Society of American Foresters, and others aware of the importance of this work. Although, we may have tried in the past and failed, I believe we must continue to keep our State and Congressional legislators aware of the comprehensive nature of this work, and the efforts being made to assess, evaluate and monitor potential hazards to nontarget animals.

SUMMARY

Some recent data have been provided to improve our capabilities as wildlife managers, our understanding about nontarget losses, and to encourage us to continue searching for new and better research. Technology and management tools provide an excellent way to summarize this examination of the literature and attempt to improve perspective. Some of these studies conducted by personnel at the Denver Wildlife Research Center, e.g., Hegdal et al. 1986 on "Hazards to wildlife associated with 1080 baiting for California ground squirrels," indicated both primary and secondary hazards to a variety of nontarget species when 1080 baits were broadcast over a large area via aerial application. Several management recommendations were provided within the study to reduce significantly such nontarget hazards. Another study (Schafer 1984), "Potential primary and secondary hazards of avicides," which reviewed six chemicals or groups of chemicals registered as avicides, has provided new information and technologies to aid wildlife managers. These findings help managers select the most efficacious pesticides and use them in the safest and most effective ways to control problem vertebrate wildlife species, yet prevent potential losses to nontarget wildlife. Obviously, studies such as these must be continued, along with applied management and behavior studies, to provide the broad base of expertise needed to avoid additional losses of nontarget species.

In the evaluation and reviews of some of the primary vertebrate pesticides, e.g., zinc phosphide, 1080, strychnine and the anticoagulants, most researchers clearly recognize and admit that these pesticides can pose both primary and secondary hazards to nontarget wildlife species. However, with proper use most of the primary hazards can be avoided.

Although with most of these pesticides, secondary hazards are much lower than the primary hazards, there are still some precautions that can reduce these hazards. However additional field studies on reduced concentrations and determinations of interactions and effects are needed.

As Kaukeinen (1982) stated and I will paraphrase here, the list of potentially deleterious factors for wildlife (target and nontarget) is long, but certainly direct human disturbances, vehicle kills, and habitat loss are highly important components affecting wildlife, and must be given consideration in the overall context of cause and effect and risk-benefit assessments of pesticides use. Other deleterious factors include disease, infertility, prey population cycles and declines, intra- and interspecific aggression, chemicals and pollutants and other agents. All these factors interact with any pesticides effects on wildlife. He further noted, "It is suggested that there is, in many cases, a point at which some wildlife loss must be acceptable, considering the alternatives in terms of economic damage or danger to public health.... However, there should be government and public recognition of the potentially greater non-chemical adverse effects on wildlife."

Such studies that provide additional information or both primary and secondary hazards to nontarget species must be continued to ensure that we improve not only our knowledge of potential impacts, but also our perspective about cost benefits and risk benefits. In addition, we need improved scientific data collection about other impacts on wildlife and domestic animals including man. Some examples would include data such as those provided by the National Wildlife Health Center via their quarterly Die-off Reports, The National Center for Health Statistics Reports, and information on animal losses from other sources. One that was recently brought to my attention was an American Humane Animal Shelter Reporting Study (Nassar and Fluke 1987), which pointed out that somewhere between 8.3 and 13.8 million dogs and 9.3 and 15.4 million cats were euthanized in 1986. When this is put into perspective with those few killed as nontargets from use of pesticides it clearly changes the perspective promoted by some groups that nontarget pets are being decimated by pesticide use, trapping, or through wildlife damage control efforts. In fact, according to a paper by Os weiler (1969), "Incidence and diagnostic consideration of small animal toxicoses," a U.S. survey revealed only 843 possible cases of small animal toxicoses due to vertebrate pesticides out of a total of 3452 reported clinical diagnostic examinations in 1968.

In the closing statements of this paper, the author stated (after pointing out that strychnine was often implicated in malicious poisonings which were included in the totals), that: "The greatest number of pesticide accidents, however, were due to organophosphates, often when used for oral or dermal ectoparasite control."

We also need to keep in mind the impact of some pest wildlife species on preferred wildlife or game species. A study to determine the impacts of coyote on deer productivity (Stout 1982) showed increases in fawn/doe ratios of 262%, 92% and 167% the first summer following coyote reductions on three deer ranges in Oklahoma.

As wildlife professionals, we have a continuing and massive challenge facing us.

We know from past experience that in the absence of professional operational, technical, financial, and educational assistance programs on the prevention and control of wildlife damage, both human and domestic animal health and well-being will be adversely impacted. We also know that wildlife, wildlife habitat, and the quality of the environment will be adversely impacted without reasonable and efficacious control of problem vertebrate wildlife. We must work together and continue to be aware of the ecological, social, and economic aspects of wildlife management with an integral part being the prevention and control of wildlife damage. We must also work harder to ensure that we have carefully planned and conducted our efforts to minimize potential nontarget wildlife losses.

And last but of no less importance, we need to educate the public about the positive benefits of wildlife management including the prevention and control of wildlife damage. The public includes those organizations and agencies that generally perceive this part of management as environmentally bad, the black hat image. Admittedly, this is no small order; however, it cannot be ignored. As mentioned earlier, with less than 2% of the total U.S. population living on farms, we must educate the public that to maintain viable and comprehensive natural resources programs, there must be continuing support for a vital element of wildlife damage prevention and control. It is positive, it contributes strongly to economic well-being, safety, environmental stability, the sustainability of agriculture and wildlife, and to other wild and domestic living resources for use and enjoyment by future generations.

LITERATURE CITED

ANDERSON, W.L. 1978. Waterfowl collisions with power lines at a coal-fired power plant. Wildl. Soc. Bull. 6(2): 77-83. BANKS, R.C. 1979. Human related mortality to birds in the United States. U.S. Fish & Wildl. Serv. Spec. Scient. Rept. No. 215. Washington, D.C. 15 pp. BERRYMAN, J.H. 1983. Wildlife damage control: a current perspective. In: Proc. 1st East. Wildl. Dam. Cont. Conf. Sept. 27-30,1983. Cornell Coop. Ext. Serv. Ithaca, New York. pp. 3-5. CASE, R.M. 1978. Interstate highway road-killed animals: a data source for biologists. Wildl. Soc. Bull. 6(1):8-13. COON, N.C., L.N. LOCKE, E. CROMARTIE, and W.L. REICHEL. 1970. Causes of bald eagle mortality 1960-1965. J. Wildl. Dis. 6:72-76. CRAWFORD, R.L. 1964. Bird casualties at a Leon County, Florida TV tower. Tall Timbers Res. Stn., Bull. No. 18, Nov. 1964. Tallahassee, Florida. 27 pp. EBERT.P.W. 1972. Vehicles, roads and wildlife. Oregon St. Game Comm. Bull. 27(4):3-6.
GREGORY, M. 1975. Good earth almanac. Lincoln Journal-Star. Oct. 5, p. 4F.

HEGDAL, P.L., K.A. FAGERSTONE, T.A. GATZ, J.F. GLAHN, and G.A. MATSCHKE. 1986. Hazards to wildlife associated with 1080 baiting for California ground squirrels. Wildl. Soc. Bull. 14(1):11-21.

HOWARD, W.E. 1979. Political and sociological aspects of wildlife damage control. In: Proc. 4th Gr. Plains Wildl. Dam. Cont. Wksp., Manhattan, Kansas, Dec. 4-6,1979. Gr. Plains Agric. Counc. and Kansas St. Univ. pp. 147-165.

KAUKEINEN, D.E. 1982. Potential nontarget effects from the use of vertebrate toxicants. In: Proc. Conf. Organis. Pract. Vert. Pest Cont. Aug. 30-Sept. 2, 1982, Hampshire, England, pp. 619-629.

KEITH, J.O. and E.J. O'NEIL. 1964. Investigations of a goose mortality resulting from the use of zinc phosphide as a rodenticide. U.S. Fish & Wildl. Serv. 7 pp.

NASS AR, R. and J. FLUKE. 1987. American humane animal shelter reporting study: 1986. Sept. 1987 Rep. 2 pp.

NATIONAL WILDLIFE HEALTH CENTER. 1987. Quarterly die-off report. Wildl. Dis. Newsletter, Oct. 1987.2 pp.

OSWEILER, G.D. 1969. Incidence and diagnostic considerations of major small animal toxicoses. J. Am. Vet. Med. Assn. 155(12):2011-2015.

SARGEANT, A.B. 1981. Road casualties of prairie nesting ducks. Wildl. Soc. Bull. l(l):65-69.

SCHAFER, E.W. 1984. Potential primary and secondary hazards of avicides. Proc. 1lth Vert. Pest Conf., Davis, California, pp. 217-221.

STOUT, G.G. 1982. Effects of coyote reduction on white-tailed deer productivity on Fort Sill, Oklahoma. Wildl. Soc. Bull. l0(4):329-332.

WILKINS, K.T. and D.J. SCHMIDLY. 1980. Highway mortality of vertebrates in southeastern Texas. Texas J. Sci. 23(4):343-350.