ELSEVIER

International Biodeterioration & Biodegradation 42 (1998) 85–91

INTERNATIONAL
BIODETERIORATION &
BIODEGRADATION

A new era of vertebrate pest control? An introduction

Michael W. Fall[a,*], William B. Jackson[b]

[a]National Wildlife Research Center, USDA/APHIS/WS, Fort Collins, CO 80524 USA
[b]Department of Biology, Bowling Green State University, Bowling Green, OH 43403 USA

Abstract

Vertebrate pest control has made substantial progress, worldwide, in the past century – moving from what were once uncoordinated private efforts to trap, shoot, or poison animal pests to organized IPM approaches employing a variety of pest control tactics. Some of the tools of the past are still critically important in these programs, but as new pest problems and new constraints arise, these tools are often found wanting. This paper, introducing a special issue of *International Biodeterioration & Biodegradation*, briefly examines developments in vertebrate pest control in the past 100 years and summarizes some of the current lines of research that will carry us into the future.

1. Introduction

New eras have a way of creeping up on us. How do we know when a new one starts and an old one ends? We can look to the past and see how things were and what has been accomplished. Or we can look at what is happening right now or what is planned or what we think ought to happen. But we can't predict the future. Will the 21[st] century mark a new era for vertebrate pest control? We'd like to think so. Certainly many things have changed or are rapidly changing in our discipline. The papers in this special issue of *International Biodeterioration & Biodegradation* describe some of the current work on the problems caused by vertebrate pests or deteriogens and provide some clues to future expectations. To help understand what might be expected in the next century, we will examine briefly some of the developments in vertebrate pest control in the past 100 years, look at the current status of vertebrate pest control as we end the century, and discuss how our discipline is approaching the changing and diversifying problems caused by over-abundant animal populations living in closer and closer proximity to humans.

2. A century of vertebrate pest control

In the early 1900's, much of the concern with vertebrate pests focused on rats and mice in cities and on farms in temperate areas of the world (for example, Nelson, 1917). Pest control firms operated in most major cities, but many farmers and consumers simply tolerated damage to crops and stored food. By 1933, a professional trade association, The National Pest Control Association (originally the National Association of Exterminators and Fumigators) was established in the United States and began the process of developing industry standards and fair trade practices (Snetsinger, 1983). The use of chemical control agents for vertebrates was largely unregulated at the federal level until mid-century with the passage of the Federal Insecticide, Fungicide, and Rodenticide Act of 1947, which required the federal registration of economic poisons. The common rodenticides or predacides at the turn of the century were arsenic trioxide, barium carbonate, phosphorous paste, and strychnine. Zinc phosphide and thallium sulfate came into use in the U. S. as new rodenticides in the 1920's (Snetsinger, 1983). Cage traps and early kill traps were available for rodent control; foot-hold traps for rodents and carnivores also were widely available (Emmet, 1969).

In 1900, 61 U. S. institutions in 48 states or territories had courses in agriculture (U. S. Department of Agriculture, 1901). Much of the early research on vertebrate damage in agriculture centered on identification and description of species, description of damage problems, and description of food habits of animals in agricultural environments. Most of this early work was conducted by staff of the U. S. Department of Agriculture's Division of Biological Survey, which was responsible for investigations of the economic relations of birds and mammals (U. S. Department of Agriculture, 1904). Annual sum-

* Corresponding author.

S0964-8305/98/$19.00
PII: S0964-8305(98)00058-4

maries by the U. S. Department of Agriculture included descriptions of the food habits of desirable and injurious birds in agriculture (Beal 1901a, 1901b) and damage caused by voles in agriculture, with comments on chemical and environmental control tactics (Lantz, 1906). Piper (1909) provided more detailed accounts of the impact of vole population outbreaks and the available methods of control and prevention. Also in 1909, Lantz published a detailed summary of the use of toxicants for controlling injurious mammals, focusing on the use of phosphorous, arsenic, and strychnine; his summary also included comments on methods of reducing exposure of nontarget animals to toxicants. In 1910, Lantz assessed the impact of pocket gophers in forest plantations, orchards, and nurseries, and provided instructions for trapping, poisoning, and encouraging populations of natural enemies as methods of management.

Government-sponsored pest control programs for a number of agricultural pests—rodents, birds, and carnivores—were well-established by the 1920's. The Animal Damage Control Act of 1931 placed new emphasis on research programs to develop new control methods at government laboratories. Bird problems in agriculture and in cities, primarily caused by pigeons, starlings, and English or house sparrows, had begun to draw national attention. Public health had become an increasing concern, focusing primarily on plague and rabies in the early years, adding murine typhus during World War II, then greatly expanding in scope and interest following the war. In the post-war years, the U. S. Public Health Service, Center for Disease Control, had a major federal role in promoting management of commensal rodents (including integrated management concepts) and in developing and supporting training programs for both private sector and government pest control personnel and sanitarians.

By mid-century, following World War II, the urban pest control industry was well-established, active professional associations, both national and regional, were in place, and university programs focused on pest control were beginning to emerge. Sodium monofluoroacetate (Compound 1080) had emerged as a new rodenticide and predacide for agricultural use. In urban rodent control, newly developed materials and growing concerns with safety and selectivity often made alphanapthylthiourea (ANTU), fortified red squill or the new anticoagulants, such as warfarin, the rodenticides of choice. Both Compound 1080 and ANTU were developed as rodenticides during World War II in a national effort to reduce food losses and save scarce resources. Along with the insecticide, DDT, which was of critical importance in managing louse-borne murine typhus outbreaks during the war, these materials and warfarin, a post-war 'miracle' rodenticide, increased the reliance on chemical control methods and established a pattern that has continued, with some modification, to the present. Within a relatively few years of the widespread use of DDT, warfarin, and other 'new' pesticides, genetically resistant pest populations began to emerge, helping to focus private and public sector attention on the continuing need (and market) for new pesticides.

Although pest control textbooks had been available with major emphasis on invertebrates, by the 1960's, textbooks addressing vertebrate pest control were readily available. Mallis (1964, 1st edition in 1945), Truman and Butts (1962), and Kilgore and Doutt (1967) all included substantial sections on vertebrate pests. Their focus, however, remained largely on rats, mice, starlings, pigeons , and sparrows. In the United States, major research programs were developed to address the problems of blackbird damage to corn and coyote predation on livestock. By the early 1970's, the Environmental Protection Agency was in place in the U. S. to, among other things, regulate vertebrate pesticides. An array of environmental legislation (for example, The Endangered Species Act) began processes that would identify new vertebrate pest problems in situations heretofore unconsidered. Bird control was well-established in the U. S. pest control industry, with a variety of new materials emerging from research: toxicants, repellents, frightening agents, a sterilant, and recorded distress calls. Following a major crash caused by a bird-aircraft collision in 1960, support for research on bird management at airport facilities began to emerge in several countries. Multilateral and bilateral technical assistance programs sponsored by United Nations agencies and a variety of donor countries were underway to assist developing country governments increase food production by controlling damage caused by vertebrate pests. Most U. S. universities could accommodate student research on vertebrate pest problems in biology or wildlife departments, but few organized programs and virtually no courses were available for wildlife students wishing to specialize in this area.

People were talking about the future and the best use of scarce resources in managing the increasing problems and conflicts between vertebrate pests and a rapidly growing human population, particularly in urban areas. For example, Davis (1972), in the National Research Council's study, 'Pest Control Strategies for the Future,' called for an end to research on rodent control and hoped his early work on rodent population principles would serve as a model for other species problems. His solution: make the environment suitable for people and it wouldn't be suitable for pests. His work on rodent control in Baltimore, Maryland, had demonstrated that removal of food (garbage) and harborage in yards and alleys could eliminate outdoor rodent populations without rodenticide use. But this approach required a diligence by residents and consistent support by public and private sectors that proved impossible to maintain.

Almost simultaneously, the concepts of systems ecology applied to pest control brought us new words—

'integrated pest management' or 'IPM,' and an evolving new concept in pest control. This approach defined people as part of 'pest problems,' placed a focus on economics, and emphasized the need for a variety of control tactics that a 'manager' could draw upon for managing pest problems (Jackson 1996; Kogan 1998). Improved cultural practices and the fostering of natural population controls to minimize pesticide use—a keystone of the IPM concept—closely paralleled Davis's (1972) analysis of how to approach rodent problems. But IPM approaches have emphasized a need for increased research, testing methods and programs in field situations, and planning and feedback with user input to continuously improve programs (Rabb and- Guthrie 1970; Kogan 1998).

3. Where are we now?

The progress that has been made and the changes that have occurred in vertebrate pest control in the past century (indeed, in the past 25 years or in the past 10 years!) have been truly amazing. For most of the world, the major species of urban and agricultural vertebrate pests have been identified and studied in the environments where they cause problems. For many important pests, considerable biological, behavioral, and ecological information is already available. Many countries have personnel in universities or within government organizations related to agriculture or public health who are trained in vertebrate ecology and are responsible for research, pest control operations, or both. The number of universities offering course work in the management of animal damage has increased substantially and continues to increase, with courses under titles such as, 'wildlife damage management,' 'human/wildlife conflicts,' or 'economic biology,' (Schmidt, et al. 1992). The literature of vertebrate pest control has also increased, with numerous books—both popular and technical—available and a rapidly growing array of research publications in an increasing number of new and traditional technical journals. Literature databases, discussion groups, electronic mail, and electronic publications, all accessible through the Internet, are creating an explosion of information resources for researchers and managers worldwide, (Fall and Jackson, 1997).

The array of vertebrate animals considered as pests or 'problems' has undergone almost an order of magnitude increase in only the past couple of decades. And, agriculture and public health are no longer the only areas of concern. As human populations continue to increase and sprawl into agricultural, rangeland, or forest habitats, many of the species of animals heretofore considered inherently desirable, increasingly are found in the news—attacking people or pets, damaging property, causing vehicle or aircraft collisions, fouling public areas, spreading newly discovered diseases, or creating nuisance. In the U.S., white-tailed deer, beaver, and Canada geese—all species that occurred in limited numbers a century ago—are increasingly requiring management efforts in urban and suburban areas. In the relatively recent past, these species and others were the subjects of careful husbandry, reintroductions to former and new habitats, and intensive efforts by wildlife managers to encourage population growth. Now, these and a variety of other wildlife species and feral animals have created new problems associated with overabundance. In addition, we are, in many cases, still confronted by the infrastructure of the past—building practices that encourage pests (Fall and Schneider, 1968), city sewers that provide pathways for invasion and hidden infestation (Colvin et al., 1990) and landscape modifications that put domestic animals and valued wildlife species in the midst of predator populations. In many cases, we, like Davis (1972), 'know' what to do. But, if our legal frameworks, social institutions, and public mores cannot implement and sustain our solutions, we must look further and avoid past mistakes in approaching new problems.

The concept of 'threatened or endangered species,' codified as The Endangered Species Act by the U. S. in 1973, and utilized similarly by many other countries, has had a major effect in broadening the numbers of animals considered as pests or damaging species and has greatly increased the range of environments where pest control activities take place. Originally, much effort was devoted to identifying declining populations, tracking through the bureaucratic process of 'listing' species, fostering critical species in captivity for reintroduction, and developing recovery plans. As the actual work of endangered species recovery began, it became clear that, just as in agriculture, producing desirable animals and plants in small, unprotected areas opens the way for pest problems (Temple, 1990; Garrot et al., 1993). And the problems have been substantial—either competition for food and habitat or direct predation. Introduced or alien species—rats, goats, foxes, or snakes, and many others—have been particular problems on islands and other restricted habitats. Often the tools and materials developed for managing agricultural or urban vertebrate pests have proven inadequate due to regulatory constraints that presumably reflect public attitudes.

Regulation of the means by which problem wildlife species can be managed has greatly increased with a maze of federal, state, local, and international restrictions on techniques, materials, and timing for management actions. In the U.S., for example, rodenticides that home owners could buy in a grocery store and use in their kitchens to remove rats are not available for use in removing rats from agricultural fields or from unoccupied islands where they prey on endangered species without development of substantial data on chemical residues, on primary and secondary hazards, and on ecological effects for regulatory agencies. Development and marketing of new materials for vertebrate pest problems holds little incentive for the private sector to develop new chemical tools, with the exception of rodenticides for commensal rodent control in and around structures. Virtually all chemical control agents for birds and mammals, fall into a category of 'minor use' such that the costs of obtaining environmental and health effects data to meet regulatory requirements outweigh the potential profit for maintenance of older materials and development or extension of new uses. Many of the formerly available chemical control materials have disappeared from the marketplace, forced out by the costs associated with increasingly restrictive regulations (Fagerstone, et al., 1990).

Regulatory impacts have also extended into other areas. Trapping, one of the most selective tools for removing problem animals, is increasingly restricted at state or local levels. Under the leadership of small, but vocal and well-financed organizations emphasizing the cruelty of animal control efforts, more and more legislation is introduced and sometimes enacted to restrict or ban the use of capture techniques for problem animals. Shooting, also a mainstay of agricultural animal control efforts, is virtually unavailable as a technique in populated areas except on a limited basis to enforcement personnel. Keeping deer from the garden, raccoons from the attic, skunks from under the porch, or rodents and birds from the ornamental fruit trees is no longer the routine task it was a century ago.

In response to these changes, new industries have arisen. 'Environmental consulting,' unheard of a couple of decades ago, now rivals 'pest control' for phone directory listings in many areas. Experts can lead farmers, towns, cities, or corporations through regulatory constraints, obtain essential compliance data, and develop plans for comprehensive animal control actions or engineer 'pest free' environments. They fulfill an essential function that will surely grow in importance as the diversity of problems requiring action exceeds the capacity of the traditional wildlife management and pest control institutions. The nuisance wildlife control industry has also emerged and is growing rapidly to deal with the growing suburban wildlife problems outside the scope of work of traditional pest control companies. Nuisance wildlife control operators, highly constrained by the same regulations that effect private landowners, rely on knowledge of animal behavior and skill in capture techniques or use of new materials to assist in managing the problems created by people sharing their homes, yards, and greenbelts with wildlife. As occurred 75 years ago with the pest control industry, trade associations are emerging to address industry standards, and regulatory agencies, mostly state wildlife or conservation departments, are examining ways to test, license, or regulate the activities of this new industry (Schmidt, 1998).

The loss or restricted use of traditional management tools and materials, the host of new regulations and data requirements, and the rapid growth of new problems and applications have not failed to stimulate new research on methods, materials, and tactics for managing pest problems. We'll examine the status of a few of the more prominent lines of investigation.

The literature on animal repellents has grown more in the past decade than ever before, particularly for birds, rodents, and ungulates. Although few materials are registered for use, the number can be expected to grow, based on the number and variety of materials being researched (Mason, 1997.). Chemical repellency approaches include examination of materials with strong tastes or strong odors, materials that cause sensory irritation, materials that cause illness or unpleasant post-ingestinal effects, and tacky materials or textured materials that repel by contact. Natural extracts from a variety of plants are being examined, based on behavioral studies, that indicate avoidance of particular species by grazing or browsing animals (Nolte et al., 1995). Predator urines have been found to have repellent effects for a variety of herbivore species (Lindgren et al., 1997). These later approaches place a premium on evolved species responses to natural occurring materials, potentially producing stronger avoidance, reducing learning periods, and gaining natural reinforcement. Frightening tactics for repelling animals continue to be examined despite the well-known difficulty that animals readily adapt to 'scarecrows.' Combinations of stimuli and random delivery patterns may extend the period of effect to practical ranges for some species (Linhart et al., 1984). Multisensory repellent arrays (Beauchamp, 1997) coupled with electronically based delivery systems activated by animals entering protected areas are already being examined as means of making repellent tactics more effective.

Barriers to keep animals from areas or from individual plants or structures continue to be a subject of active investigation. As more information is gained on the behavior of individual animals and as new materials are investigated, barriers are becoming more practical and less costly for a variety of situations. Electric fencing, which deters animal movements by delivering a mild shock, is being adapted or made more effective for new situations by configurations that account for the behavior of particular species (for example, Acorn and Dorrance, 1994; Mott and Flynt, 1995; McKillop and Poole, 1994). Electroshock techniques, applied in water, are also being developed as means of changing the activity patterns of aquatic birds and mammals around protected areas (Kolz and Johnson, 1997). Netting (Martin and Hagar, 1990) and wire configurations (Belant and Ickes, 1996) are being adapted to new, unconventional uses and the increasing use of mechanization (Fuller-Perrine and Tobin, 1993) in barrier application may provide means of reducing labor costs. Barriers to protect individual plants, particularly in forest industry applications, are generating new interest (Engeman et al., 1997). A number of commercial products are now marketed and evaluations are underway to improve efficiency and reduce high labor costs.

Drugs, vaccines, humane capture devices, introductions of parasites and diseases, and habitat modification are all current lines of investigation for applications in wildlife damage management, based on new biological and ecological information and on advances in genetics and engineering. Hyngstrom et al. (1994), in an extensive review of biological control approaches (redefined for vertebrate pests as 'biological management'), expected significant advances in the near-term future based on current work underway on a variety of applications. As with many other areas of applied work, they suggested that, in many cases, applying what we already know to vertebrate pest systems could result in rapid progress. New developments in approaches to contraception or reproductive inhibition in vertebrates are an example. Such investigations first became prominent in the 1960's, following successes in invertebrate control and advances in human birth control research (Davis, 1961; Balser, 1964; Knipling and McGuire, 1972). By the early 1980's, much of the initial interest in the approach had waned, because of difficulties related to critical timing in animal reproductive cycles (which were often unknown or geographically variable for common pest species), temporary effects of available materials in suppressing reproduction (requiring repeated applications), delivery systems that failed to reach substantial proportions of animal populations, broad spectrum effects of available materials, and anticipated problems with producing the regulatory data needed for commercial development. By the mid- 1980's Kirkpatrick and Turner (1985) called for re-examination of this 'neglected' technology, based on new developments in immunology and human fertility control. Rapid advances in molecular biology and development of more effective delivery systems have provided promising options that may overcome many of the problems encountered in the early investigations. A variety of work is now underway examining development and application of contraception approaches across a number of wildlife species (Kreeger, 1997).

As we approach the end of the century, the prospects for new technology, new applications and approaches, and a continuing record of scientific responsiveness to public demands for 'action' provide ample reason for optimism about how effectively wildlife or vertebrate pest problems can be managed. Nonetheless, the continuing emergence of new problems and the increasing social, ecological, and economic constraints that dictate how and where technology can be applied suggest that this optimism be colored with caution.

4. So, what about the future?

Scientists and managers seem to have a penchant for considering the future. We hope this relates to our 'cautious optimism,' not to our reluctance to confront the present. The 'future' literature is growing in many fields as the century mark approaches, and vertebrate pest control and wildlife damage management are not exceptions. Some recent papers addressing this issue include Hawthorne (1993), Acord et al. (1994), Edwards and Tiega (1995), Kessler and Eastland (1995), Witmer et al. (1995), and Koch (1998). What will the next century bring? New vertebrate pest problems and vector-borne diseases? Yes! Greater concern for protecting wildlife resources? Yes! More regulations? Yes! Higher costs? Yes! New organizations and institutions? Yes! More public oversight of research and management actions? Yes! And, new materials, technology, and management strategies for problem resolution beyond what we can presently conceive. Can (or will) we be able to use these new technological resources to counter the short-comings of past generations and the challenges of the future? We must—the public will demand that we do. Yet, we see no end to the conflicts among the inner city resident wanting the pigeon to represent 'nature,' the suburbanite who wants to 'preserve nature,' and the agriculturist who attempts trapping the sun's energy to produce food and fiber. IPM has given us the framework to adapt to these conflicts and unanticipated changes, to seek and use input and feedback from concerned publics, and to use multiple tactics to achieve defined goals. The rigorous application of this approach should continue to serve us well as we enter the 21st century.

Acknowledgments

We are grateful to Abbey A. Bishop and Jean A. Alleman for assistance with technical literature and preparation of the manuscript and to the authors who have contributed to this special issue of *International Biodeterioration & Biodegradation*.

References

Acord, B. R., Ramey, C. A., Werge, R. W., 1994. Charting a future: process and promise. In: Halverson, W. S., Crabb, A. C., (Eds.). Sixteenth Vertebrate Pest Conference, University of California, Davis, CA, pp. 5–8.

Acorn, R. C., Dorrance, M. J., 1994. An evaluation of anti-coyote electric fences. In: Halverson, W. S., Crabb, A. C., (Eds.), Sixteenth Vertebrate Pest Conference, University of California, Davis, CA, pp. 45–50.

Balser, D. S., 1964. Management of predator populations with anti-fertility agents. Journal of Wildlife Management, 28 (2): 352–358.

Beal, F. E. I., 1901a. The food of nestling birds. Yearbook of the United

States Department of Agriculture, 1900. Government Printing Office, Washington DC, pp. 411–436.

Beal, F. E. I., 1901b. How birds affect the orchard. Yearbook of the United States Department of Agriculture, 1900. Government Printing Office, Washington DC, pp. 291–304.

Beauchamp, G. K., 1997. Chemical signals and repellency: problems and prognosis. In: Mason, J. R., (Ed.). Repellents in wildlife management proceedings of a symposium, National Wildlife Research Center, Fort Collins, CO, pp. 1–10.

Belant, J. L., Ickes, S. K., 1996. Overhead wires reduce roof-nesting by ring-billed gull and herring gulls. In: Timm, R. M., Crabb, A. C., (Eds.). Seventeenth Vertebrate Pest Conference, University of California, Davis, CA, pp. 108–112.

Colvin, B. A., Ashton, A. D., McCartney, W. C., Jackson, W. B., 1990. Planning rodent control for Boston's artery/tunnel project. In: Davis, L. R., Marsh, R. E., (Eds.). Fourteenth Vertebrate Pest Conference, University of California, Davis, CA, pp. 65–69.

Davis, D. E., 1972. Rodent control strategy. Pest control strategies for the future. National Academy of Sciences, Washington, DC, pp. 157–171.

Davis, D. E., 1961. Principles of population control with gametocides. Transactions of the North American Wildlife Conference, 26: 160–166.

Edwards, S. R., Tiega, A., 1995. A vision for the future. In: Bissonette, J. A., Krauseman, P. R., (Eds.). Integrating People and Wildlife for a Sustainable Future, Proc. First International Wildlife Management Congress, The Wildlife Society, Bethesda, MD, pp. 579–594.

Emmet, B., 1969. Montgomery Ward & Co. catalogue and buyers' guide, No. 57, 1895. Unabridged facsimile edition. Dover Publications Inc., New York, NY.

Engeman, R. E., Anthony, R. M., Krupa, H. W., Evans, J., 1997. The effects of Vexar seedling protectors on the growth and development of lodgepole pine roots. Crop Protection, 16(1): 57–61.

Fagerstone, K. A., Bullard, R. W., Ramey, C. A., 1990. Politics and economics of maintaining pesticide registrations. In: Davis, L. R., Marsh, R. E., (Eds.). Fourteenth Vertebrate Pest Conference, University of California, Davis, CA, pp. 8–11.

Fall, M. W., Schneider, D. E., 1968. Pest birds and modern architecture. Proceedings of the Fourth Bird Control Seminar, Bowling Green State University, Bowling Green, OH, pp.129–135.

Fall, M. W., Jackson, W. B., 1997. Technical publication of wildlife damage research. In: Lee, C. D., Hyngstrom, S. E., (Eds.). Thirteenth Great Plains Wildlife Damage Control Workshop Proceedings, Cooperative Extension Service, Kansas State University, Manhattan, KS, pp. 173–178.

Fuller-Perrine, L. D., Tobin, M. E., 1993. A method for applying and removing bird-exclusion netting in commercial vineyards. Wildlife Society Bulletin, 21:47–51.

Garrot, R. A., White, P. J., Vanderbilt-White, C. A., 1993. Overabundance: an issue for conservation biologists? Conservation Biology, 7(4): 946–949.

Hawthorne, D. W. ,1993. Prospects for the future in animal damage control. In: Henderson, F.R., Pierce II, R. A., (Eds.). Eleventh Great Plains Wildlife Damage Workshop, Great Plains Agricultural Council, Kansas State University, Manhattan, pp. 111–116.

Hyngstrom, S. E., Vercauteren, K. C., Schmaderer, T. R., 1994. Biological management (control) of vertebrate pests—advances in the last quarter century. In: Halverson, W. S., Crabb, A. C., (Eds.). Sixteenth Vertebrate Pest Conference, University of California, Davis, CA, pp. 293–300.

Jackson, W. B., 1996. Introduction—setting the stage. International Biodeterioration & Biodegradation, 36(1&2): 1–6.

Kessler, W. B., Eastland, W. G., 1995. Strategies to sustain human and wildlife communities. In: Bissonette, J. A., Krauseman, P. R., (Eds.). Integrating People and Wildlife for a Sustainable Future, Proc. First International Wildlife Management Congress, The Wildlife Society, Bethesda, MD, pp. 1–3.

Kilgore, W. W, Doutt, R. L., 1967. Pest control—biological, physical, and selected chemical methods. Academic Press, NY.

Kirkpatrick, J. F., Turner, Jr., J. W., 1985. Chemical fertility control and wildlife management. BioScience, 35 (8): 485–491.

Knipling, E. F., McGuire, J. U., 1972. Potential role of sterilization for suppressing rat populations: a theoretical appraisal. Technical Bulletin 1455. US Department of Agriculture, Agricultural Research Service, Washington DC.

Koch, E., 1998. Our forests, our wildlife, our wealth. Ford Foundation Report, Winter, 1998, pp. 12–15.

Kogan, M., 1998. Integrated pest management: historical perspectives and contemporary developments. Annual Review of Entomology, 43: 243–270.

Kolz, A. L., Johnson, R. E., 1997. In-water electroshock techniques to repel aquatic mammals and birds. In: Mason, J. R., (Ed.). Repellents in wildlife management: proceeding of a symposium, National Wildlife Research Center, Fort collins, CO, pp. 203–215.

Kreeger, T. J., (Ed.), 1997. Contraception in wildlife management. Technical Bulletin No. 1853. US Department of Agriculture, Animal and Plant Health Inspection Service, Washington, DC.

Krieger, J. H., 1952. Rodenticides, arsenic to warfarin. Agricultural Chemistry, 7(4):46–48,135,137,139,141,143.

Lantz, D. E., 1906. Meadow mice in relation to agriculture and horticulture. Yearbook of the United States Department of Agriculture, 1905. Government Printing Office, Washington DC, pp. 363–376.

Lantz, D. E., 1909. Use of poisons for destroying noxious mammals. Yearbook of the United States Department of Agriculture, 1908. Government Printing Office, Washington DC, pp. 421–432.

Lantz, D. E., 1910. Pocket gophers as enemies of trees. Yearbook of the United States Department of Agriculture, 1905. Government Printing Office, Washington DC, pp. 209–218.

Lindgren, P. M. F., Sullivan, T. P., Crump, D. R., 1997. Review of synthetic predator odor semiochemicals as repellents for wildlife management in the Pacific Northwest. In: Mason, J. R., (Ed.). Repellents in wildlife management: proceedings of a symposium, National Wildlife Research Center, Fort Collins, CO, pp. 217–230.

Linhart, S. B., Sterner, R. T., Dasch, G. J., Theade, J. W., 1984. Efficacy of light and sound stimuli for reducing coyote predation upon pastured sheep. Protection Ecology, 6:75–84.

Mallis, A., 1964. Handbook of pest control, Fourth edition. MacNair-Dorland Co., New York.

Martin, L. R., Hagar, S., 1990. Bird control on pond containment sites. In: Davis, L. R., Marsh, R. E., (Eds.). Fourteenth Vertebrate Pest Conference, University of California, Davis, CA, pp. 307–310.

Mason, J. R., (Ed.), 1997. Repellents in wildlife management: proceedings of a symposium. National Wildlife Research Center, Fort Collins, CO.

McKillop, G., Poole, D., 1994. Developing an electrified fence to exclude rabbits from crops. In: Halverson, W. S., Crabb, A. C., (Eds.), Sixteenth Vertebrate Pest Conference, University of California, Davis, CA, pp. 283–286.

Mott, D. F., Flynt, R. D., 1995. Evaluation of an electric fence system for excluding wading birds at catfish ponds. The Progressive Fish Culturist, 57:88–90.

Nelson, E. W., 1917. The rat pest. National Geographic, 31 (1): 1–23.

Nolte, D. L., Kelly, K. L., Kimball, B. A., Johnston, J. J., 1995. Herbivore avoidance of digitalis extracts is not mediated by cardiac glycosides. Journal of Chemical Ecology, 21(10)):1447–1455.

Piper, S.E., 1909. Mouse plagues and their control. Yearbook of the United States Department of Agriculture, 1908. Government Printing Office, Washington DC, pp. 301–310.

Rabb, R. L., Guthrie, F. E.,(Eds), 1970. Concepts of pest management. North Carolina State University, Raleigh, NC.

Schmidt, R. H., Conover, M. R., Dueser, R. D., Knowlton, F. F., Messmer, T. A., 1992. Training tomorrow's specialists in wildlife damage management. In: Curtis, P. D., Fargiane, M. J., Caslick,

J. E., (Eds.). Proceedings of the Fifth Eastern Wildlife Damage Conference, Cooperative Extension Service, Cornell University, Ithaca, NY, pp. 216–217.

Schmidt, R. H., 1998. One view of the WCT seminar. The Probe, Issue 186:1, 6.

Snetsinger, R., 1983. The ratcatcher's child. Franzak and Foster Co., Cleveland, OH.

Temple, S. A., 1990. The nasty necessity: eradicating exotics. Conservation Biology, 4(2): 113–115.

Truman, L. C, Butts, W. L., 1962. Scientific guide to pest control operations. Pest Control Magazine Inc., Cleveland, OH.

US Department of Agriculture, 1904. Yearbook of the United States Department of Agriculture, 1903. Government Printing Office, Washington DC.

US Department of Agriculture, 1901. Yearbook of the United States Department of Agriculture, 1900. Government Printing Office, Washington DC.

Witmer, G. W., Fall, M. W., Fiedler, L. A., 1995. Rodent control, research, and technology transfer. In: Bissonette, J. A., Krauseman, P. R., (Eds.). Integrating people and wildlife for a sustainable future, Proc. 1st International Wildlife Management Congress, The Wildlife Society, Bethesda, MD, pp. 693–697.