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METHODS OF CONTROLLING JACKRABBITS

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ABSTRACT: Since 1963, biologists of the Denver Wildlife Research Center have been investigating methods of alleviating agricultural damage by the black-tailed jackrabbit (Lepus californicus). Of the several approaches to control, most biological methods (predation, habitat manipulation, disease and parasites, and chemosterilants) appear impractical with present knowledge. Mechanical control except for fence barriers, usually has limited effectiveness. Currently, the most useful approach is still chemical control. Improved baiting techniques and several chemical control agents, including an experimental toxicant highly selective for jackrabbits, are described.

Jackrabbits (Lepus spp.) have been a problem in the plains and desert regions of the United States for over a century. Palmer (1896) reports that control measures, in the form of organized drives, were undertaken as early as the 1840's and the federal government has formulated control measures for jackrabbits periodically since the late 1800's (Palmer, 1896; Ward, 1917; Garlough et al., 1942). Some of these methods have been advocated per se or with slight alterations by state agencies (W. V. Johnson, 1964; Storer and Jameson, 1965), or modernized by federal agencies (Wetherbee, 1967).

Present-day problems are primarily those caused by the black-tailed jackrabbit (Lepus californicus) in agricultural crops and rehabilitated rangeland; the white-tailed jackrabbit (Lepus townsendii) has a more restricted range and causes only slight to moderate damage, principally to tree plantations. The black-tailed jackrabbit is closely associated with semi-desert shrub habitat and causes the most damage on developed land near, or within, these areas. Newly developed farm and improved rangelands are particularly susceptible. Although losses increase with increasing jackrabbit densities, certain local areas almost habitually experience damage regardless of the general trend in the jackrabbit population. Peak population levels usually occur about every 6 to 10 years, but fortunately these peak levels are not synchronized within the range of the black-tailed jackrabbit and may vary considerably even within a particular area's population.

About 1960, jackrabbit damage became quite acute in southern Idaho, and the public requested that the federal government work on an long-range solution to the jackrabbit problem. In late 1963, the Denver Wildlife Research Center established a field station in Twin Falls, Idaho, where the major emphasis is directed toward agricultural problems primarily associated with the black-tailed jackrabbit. Our primary goal is the alleviation of jackrabbit damage, and the population dynamics and behavior of jackrabbits are being studied as approaches to control.

This paper describes some of the problems associated with controlling jackrabbits and discusses both favorable and unfavorable methods we have studied for alleviating jackrabbit damage.

BIOLOGICAL CONTROL

Biological control is probably the most intricate approach to solving the jackrabbit problem. Many of the methods it employs appear to be quite incompatible with various public and private interests, and currently, at least, they seem to have only limited application in regulating jackrabbit populations.

Predation: It has long been recognized that natural predators do not effectively control jackrabbit populations (Palmer, 1896; Garlough et al., 1942; W. V. Johnson, 1964; French et al., 1965), and the detriment of introducing new predators into an ecosystem is pointed out by McCabe (1966) and Howard (1967).

In most instances, predators are not sufficiently abundant to maintain jackrabbit populations at tolerable levels, much less to effectively suppress upsurges. In Idaho, field rodents generally peak at the same time as jackrabbits, drawing away numerous avian and mammalian predators that would otherwise prey on jackrabbits. We have also observed that jackrabbit and rodent populations can drastically diminish where predators are almost nil. It is our opinion that predation plays a very limited role in regulating jackrabbits and that their populations will continue to flourish and dissipate regardless of the presence of predators.

Habitat Manipulation: The beneficial and detrimental aspects of habitat alteration for controlling pest vertebrates have been discussed by Howard (1967). Habitat alteration has some value of suppressing jackrabbits, but it may also produce erratic or unpredictable results.

The black-tailed jackrabbit is quite closely associated with sagebrush (*Artemesia* spp.) over much of its range (Greig-Smith, 1957; Adams and Adams, 1959). Conversion of vast areas of sagebrush to farmland has resulted in an almost total disappearance of jackrabbits; yet, certain jackrabbit populations have adapted to these purely agricultural lands and have become divorced from their sagebrush habitat (Lechleitner, 1959a). Similar adaptation has occurred in some jackrabbits in Idaho, but they have not been abundant enough to cause noticeable damage. It is possible that jackrabbits might totally adapt to homogeneous agricultural areas and follow cycles similar to those they now follow in a desert complex.

Clean farming practices advocated by Allen (1942) and vegetative barriers used by Lewis (1946) may have some value in alleviating jackrabbit damage when population densities are at or below tolerable levels, but appear to have little value when populations are flourishing. In Idaho, vegetative barriers up to 1/4 mile wide and clean cultivated areas have failed to keep jackrabbits from damaging grain or forage crops. Supplemental winter foods--placing out hay or leaving a volunteer stand of grain in a stubble field--have also failed to keep them from damaging winter grain planting or haystacks.

Land barriers between the sagebrush habitat and farmland have yielded erratic results in restraining jackrabbits, and appear to be an uneconomical utilization of the land. Besides, it seems impracticable to clear a strip of land wide enough to keep jackrabbits out. Telemetry studies have indicated that nightly excursions of 1 mile or more may be common for jackrabbits, and we have recovered poisoned jackrabbits more than 2 miles from baiting sites. We have observed masses of jackrabbits living in agricultural areas 7 or more miles from their sagebrush habitat during abnormal winter conditions. In addition, our movement studies indicate that extensive migration of 10 or more miles may be normal occurrences.

Habitat alteration exclusively for jackrabbit control may not only have little or no effect on alleviating damage, but may conflict with other land use projects. For example, several state game agencies and federal agencies such as the Bureau of Land Management are attempting to preserve the sagebrush edge or large areas of sagebrush within farmland complexes to provide protective and nesting cover for valuable game birds such as pheasants (*Phasianus colchicus*), Hungarian partridge (*Perdix perdix*), and sage grouse (*Centrocercus urophasianus*). In some areas, sage grouse have been virtually eliminated from rehabilitated rangeland.

Promoting grazing or keeping rangeland in good pasture is another controversial method of suppressing jackrabbits. For example, Brown (1947) and Storer and Jameson (1965) report that over-grazed areas support greater densities of jackrabbits than areas moderately grazed or those kept in good pasture; but Taylor et al. (1935) report that jackrabbits prefer moderately grazed areas, and Norris (1950) reports that they prefer nongrazed land. Vorhies and Taylor (1933) state that rangeland in good condition is not conducive to jackrabbits, whereas Bronson and Tiemier (1958) state that it is. In Idaho, at least, we have found that crop damage generally increases when range conditions are poor because of grazing or drought, and that jackrabbits tend to redisperse into the sagebrush habitat when range conditions once again become favorable.

In general, alteration of the habitat, either purposely for controlling jackrabbits or as a result of land use, is controversial both in the conflicts it creates and in its overall value for suppressing jackrabbits.

Disease and Parasites: Currently, we cannot foresee the feasibility of introducing diseases for controlling jackrabbits. The dangers of introducing a new disease into an ecosystem are discussed by H. M. Johnson (1964), and the impracticability of introducing a disease already prevailing in a wildlife population is reported by Howard (1967). Several diseases are already enzootic in the black-tailed jackrabbit (E & E Research Group, 1966; Lechleitner 1959b), but we do not know if they are ever the primary cause for heavy mortality. Although mass die-offs of jackrabbits have been linked to a particular disease such as tularemia (Francis, 1921), other die-offs have not been traceable to any particular disease or parasite (Philip et al., 1955; French et al., 1965). We suspect that factors such as malnutrition, hypoglycemia, or anticholinergic processes are also important in causing mass mortality, and that it may be more feasible to devote attention to the use of antimetabolites described by Balser (1964) than to use a disease for suppressing jackrabbits.

Chemosterilants: The various problems associated with using antifertility agents on wild animals, particularly species that have several litters per season, are reported by Balser (1964) and Howard (1967). With jackrabbits, there are two other qualifications. The antifertility agent should not affect cottontail rabbits (*Sylvilagus* spp.) which are valuable game species in several western states, and it should not be stored appreciably in the tissues, because jackrabbit carcasses are used by the mink food industry.

Currently, the use of temporary antifertility agents such as diethylstilbestrol appear to have very limited application for jackrabbit control. Black-tailed jackrabbits that abort their young conceive again very soon and an abortificant would probably not keep these females from contributing to the population. Our studies have shown that black-tailed jackrabbits born in the latter part of a breeding season constitute the major portion of the succeeding year's breeding population, but the contribution of these individuals cannot be eliminated by applying an abortificant late in the breeding season because breeding is usually not synchronized.

Pilot tests with mestranol show that it causes black-tailed jackrabbits to abort during all stages of pregnancy. This eliminates the chance of sterilizing their offspring as reported in voles by Howard and Marsh (1969). Estrone, reported to cause degeneration of ova in rabbits (*Oryctolagus cuniculus*) (Chang and Yanagimachi, 1965), appears to be effective only when administered after mating. The lack of breeding synchrony and the fact that jackrabbits very rarely exhibit pseudopregnancy also limit the use of this chemosterilant.

One of the big problems with using a temporary antifertility agent is getting the chemical to the jackrabbits during the breeding season. When populations are at tolerable levels, individuals are widely scattered during this period. Baiting tests showed that jackrabbits--at least in Idaho--did not readily take scattered bait and were not concentrated sufficiently to make other baiting applications favorable without exposing cottontail rabbits. On the other hand, permanent or seasonal sterilizing agents may have value. Black-tailed jackrabbit populations often show definite winter concentration areas regardless of population levels. Such concentrations would lend themselves to application of a sterilizing agent before, or during the early part of, the breeding season with minimum exposure to cottontails.

Thalidomide, which causes breeding failures, abortions, malformation, and paralysis in the domestic rabbit, is carried in appreciable amounts and for a considerable time in the rabbits' sperm (Lutwak-Mann et al., 1967). Although this chemical may have potential as a seasonal reproductive inhibitor, it is doubtful if the public would accept its use because of its previous involvement in human malformations. Currently, chemical vasectomizing agents are being tested on black-tailed jackrabbits; a favorable candidate might have the potential of keeping future jackrabbit populations in check.

MECHANICAL CONTROL

Several mechanical methods have been advocated for suppressing jackrabbits; these primarily include fence barriers, drives, shooting, trapping and snaring, and coursing. Of these, only fence barriers appear feasible for alleviating damage by the black-tailed jackrabbit. The other methods are limited by current attitudes of the public and the landowners, or have limited value in controlling damage.

Fence Barriers: Fences constructed of 1- or 1-1/2-inch mesh poultry netting, 36 inches high with at least 6 inches buried in the ground, have given nearly 100% control of jackrabbits in Idaho. In addition, wrapping the base of haystacks with 3 ft. high poultry netting provided excellent protection. Regular poultry netting made of 20-gauge wire can provide protection for 5-7 years or more when fences are properly maintained; "stucco netting" made from 17-gauge wire with a 1-1/2-inch mesh may be effective even longer. Although the initial cost of fences appears quite high--about $900 per mile of fence made of regular poultry netting--they are economically feasible for protecting high-value crops and provide year-round protection on farm areas with a history of recurrent damage. Poultry netting with a mesh greater than 1-1/2 inches, and graduated woven-wire fencing--about 1 inch at the bottom to about 4-1/2 inches at the top--do not adequately exclude jackrabbits.

McAtee (1939) found that electrical fences are effective on jackrabbits and other wildlife species. We have found that fences directly wired with a 110-volt source killed jackrabbits when the ground was damp but, on dry ground, even this high voltage was not effective. Because of its limitations and obvious hazards, we do not advocate electrical fences for suppressing jackrabbits.

Drives: Organized drives for coralling and clubbing jackrabbits appear to be outmoded in today's society. In the past, such drives were community affairs, and hundreds of thousands of jackrabbits were eliminated annually according to Palmer (1896); today, they are only occasional "happenings." This change is due primarily to the current attitude of landowners and the general public. W. V. Johnson (1964) reports that California farmers and sportsmen's clubs refrain from organized drives or hunts because of possible property damage or liability from injury. Idaho farmers generally do not favor organized rabbit drives for the same reason, and in addition state that too much effort is involved. The public's attitude was reflected recently in an editorial by Boyd (1969), commenting on the finale of an organized jackrabbit drive as the "craziest cruelest brawl I ever saw." Although potentially quite selective for controlling jackrabbits and a favorable means of suppressing a population, organized drives appear to be a thing of the past.

Other Mechanical Control: Shooting, trapping, snaring, and coursing are reported to repress jackrabbits (Garlough et al., 1942), but only shooting reduces the population enough to alleviate damage. Even improved trapping and snaring methods yield only minor reductions, and coursing with dogs has mainly aesthetic value, and then only for the few interested individuals.

Currently, shooting is mainly done by individuals or small groups; the organized hunt, like the organized drive, is a thing of the past. Early morning and late evening shooting is reported to be effective for alleviating jackrabbit damage in California (W. V. Johnson 1964), and is presumably effective in many southern states. In northern states, and other areas where it is legal, shooting jackrabbits is more effective at night with a vehicle-mounted spotlight. In Idaho, morning and evening shooting is not too effective, when jackrabbits are active in daylight hours, constant harassment usually changes their activity to nocturnal ventures into croplands. Even night shooting has its limitations; constant or even periodic harassment makes jackrabbits "noise- and light-shy." Where the organized hunts in the past accounted for 5,000 or more jackrabbits in a day (Palmer, 1896), today's shooters are fortunate if the daily kill exceeds 100. On high damage areas in Idaho, heavy shooting by groups of individuals hired by local farmers accounts for less than a 5% reduction in any particular area's jackrabbit population and does not noticeably reduce crop damage.

Although shooting has its primary value in appeasing the landowner, there is some economic value derived. Jackrabbits consume about 1 to 1-1/2 pounds of green forage daily (Vorhies and Taylor, 1933), and the elimination of every 100 jackrabbits means enough daily forage saved for 12-18 ewes or 2-3 cows. Garlough et al. (1942) also reported that shooting effectively controls damage on tree plantations or orchards, but we have no current evaluation of this.

CHEMICAL CONTROL

Biological control is in its infancy, and mechanical control, except for fence barriers, has limited application. Currently, chemical control is probably the most effective means of alleviating jackrabbit damage. In our research to determine the utility of new and old chemicals, we are interested not only in good control, but in avoiding or limiting the primary and secondary hazards to wild and domestic species such as cottontail rabbits, pheasants, coyotes, dogs, and commercial minks.

McCabe (1966) lists five chemicals used most to kill pest animals--anticoagulants, zinc phosphide, sodium fluoroacetate (1080), strychnine, and thallium sulfate. Of these, we feel that three are unsuitable for controlling jackrabbits. Although anticoagulants have been used successfully to suppress jackrabbits (Anonymous, 1966) and were discussed by Merrill (1967) for jackrabbit control, we obtained unfavorable results with them in our cage testing and have avoided them because of their secondary hazards to minks and dogs (Evans and Ward, 1967). W. V. Johnson (1964) also reports that the anticoagulants produce erratic results and are not economically feasible in jackrabbit control. Sodium fluoroacetate is effective on black-tailed jackrabbits (LD_{50} = 5.55 mg/kg), but has high secondary hazards (Rudd and Genelly, 1956) and has restrictive regulations governing its use (Ward et al., 1967). We have not tested thallium sulfate on jackrabbits because of its reported high secondary poisoning potential and high tolerability in rabbits (Rudd and Genelly, 1956).

McCabe's two remaining compounds, strychnine and zinc phosphide, appear to have specific utility for jackrabbit control. In addition, several new compounds have shown promise. In the discussion that follows, these compounds are named only by their DRC (Denver Research Center) number, because they are still classified as experimental.

Bait Carrier and Placement: Fresh, unpeeled carrots, cut into pieces about 2 inches long, are well accepted by black-tailed jackrabbits in Idaho during all seasons and regardless of range conditions. The 2-inch size facilitates handling and reduces the hazards to game birds. A coating of corn oil (0.5% by weight of total bait) acts as a sticker for toxicants and preserves carrots for at least 5 days during summer months; latex-treated and untreated carrots become pulpy and unacceptable within 48 hours.

Prebaiting is necessary for good bait acceptance. Control averages less than 50% in non-prebaited areas, but better than 90% in areas prebaited for 1, 2, or 3 consecutive nights. Generally, we recommend using nontoxic oil-coated carrots for 2 nights and toxic carrots the third night.

We have found that the best methods of bait placement in agricultural areas are the Australian furrow-baiting method (a shallow, U-shaped furrow on either vegetated or non-vegetated land) and a line baiting method (placing bait in a line only on nonvegetated areas such as trails, road systems, or disked areas). In both methods, the prebait and bait are placed along a line parallel to the area of damage to intercept jackrabbits. Tests with untreated and tranquilizer-treated carrots indicate that both methods are also favorable on nonagricultural areas; BUT, we recommend the corral-type bait station described by Wetherbee (1967) if poisoning campaigns are conducted where livestock are present. For prebaiting, 80-90 pounds of cut carrots are needed for each mile; one piece of carrot is placed in the furrow or road-trail every 5-6 ft. For baiting, only about 60 pounds of cut carrots per mile are needed; one piece of poison bait is placed every 10 ft. along the same line used in prebaiting. It is best to put out the poison bait in the late afternoon and leave it exposed for 3-5 days.

Strychnine: Strychnine alkaloid has been used for decades for controlling jackrabbits, and although it is not selective for jackrabbits and presents secondary hazards to canines, it is still useful for controlling jackrabbits in certain locations such as at airports. Pearson (1967) points out the bird hazards when using toxicants at airports. Strychnine, a "showy" toxicant that kills rapidly and leaves many dead jackrabbits along the bait line, can reduce the hazards of congregating carrion-eating birds because most of the carcasses can be recovered rapidly.

A 0.3% strychnine-carrot bait is well accepted by caged jackrabbits--they eat from 2-1/2 to 7-1/2 times their LD_{50} (4.41 mg/kg)--and this material has proved to be quite effective (90% or better) in reducing jackrabbit populations with prebaiting and either the furrow or line baiting method. In secondary poisoning tests, cage- and field-poisoned jackrabbits were lethal to coyotes, but only when the stomach contents were eaten. One great-horned owl became prostrate but recovered in 3 days after consuming the stomach contents of a field-killed jackrabbit, but golden eagles have shown no signs of strychnine poisoning after consuming numerous field-killed jackrabbits in multiple feeding experiments. We are currently attempting to overcome the secondary hazard of strychnine to canines by adding emetics.

Zinc Phosphide: We tested zinc phosphide as a possible substitute for strychnine, primarily because of its lower secondary hazard potential. Golden eagles, owls, and coyotes receiving multiple feedings of cage- and field-poisoned jackrabbits showed no visible symptoms of intoxication. Other tests with zinc phosphide indicate that any potential secondary poisoning is associated with the consumption of the stomach contents and not the tissues or organs of poisoned animals, and that animals capable of regurgitating will do so after consuming the stomach of a zinc phosphide-poisoned animal as large as a jackrabbit.

A 0.75% zinc phosphide-carrot bait is well accepted by caged jackrabbits--they eat about 17 to 23 times their LD_{50} (8.25 mg.kg). This concentration proved to be the best one for controlling jackrabbits in the field. A 0.5% formulation was no longer lethal after about 48 hours of exposure, and a 1.0% bait was avoided until after 24-36 hours. The 0.75% formulation is as effective as strychnine, giving 90% control or better. As with strychnine, prebaiting and a 3- to 5-day bait exposure are necessary for effective control. Both the furrow and line baiting methods produce equal results.

No nontarget animals have been recovered from any of our field tests with zinc phosphide-carrot bait, but it is doubtful if the toxicant is exclusively selective for jackrabbits when used in this manner. Although zinc phosphide is effective on agricultural lands, jackrabbits react to it more slowly than to strychnine, and carcasses are well scattered--up to 2-1/2 miles from bait sites. These widely distributed carcasses are potential attractants for large numbers of carrion-eating birds, which may present a hazard to aircraft if the bait is used around airports.

DRC-1144: This experimental organophosphate insecticide has shown excellent control of black-tailed jackrabbits and minimal hazards to nontarget species. When used as a foliar spray, the chemical produces 100% jackrabbit mortality but has no discernible effects on cottontail rabbits that feed on the same foliage. Ducks and pheasants have fed exclusively for 3 days on treated foliage without symptoms of organophosphate poisoning, and two pheasants showed only minor cholinesterase depression after consuming 550 grams of wheat grain and over 7,000 grams of wheat foliage treated with DRC-1144. Multiple feedings of jackrabbits poisoned with DRC-1144 have produced no symptoms of poisoning in eagles, owls, hawks, coyotes, and dogs. A 2-pound-per-acre spray application is effective on jackrabbits for 12 to 15 days, and residues are well below the tolerance limits already established for this chemical.

DRC-1144 presents a new concept for controlling jackrabbits, since it can be applied to natural foods and crops by ground or air spraying equipment without the necessity of prebaiting. Enclosure studies indicate that a narrow spray strip on natural vegetation yields about 90% reduction in the population, and a field test on alfalfa showed that a 12-foot-wide sprayed strip along the edge of the damaged area almost completely stopped further damage. Although this chemical has shown remarkable effectiveness and selectivity in extensive enclosure tests, it is necessary to field test it exhaustively for at least 1 more year before it can be used operationally.

Soporifics: Two experimental soporifics--DRC-1320 and DRC-1327--have shown promise for controlling jackrabbits. A 0.2% (by weight) DRC-1320-carrot bait successfully tranquilizes jackrabbits and cottontail rabbits for field capture and may increase kill success when used in conjunction with shooting. DRC-1327 is a fright-producing chemical that results in distress behavior and cries from affected jackrabbits. So far, it has been tested only as a 0.01% carrot bait on caged and penned jackrabbits, but it is water soluble and may be applicable as a foliar spray. Behavior and acceptance studies are currently being conducted to determine if DRC-1327 will deter jackrabbits from particular crops through distress association.

Repellents: Several jackrabbit repellents are reported by W. V. Johnson (1964), but only those reported by Merrill (1967) and Welch (1967) have been tested at our station. In extensive enclosure and field tests, TMTD (tetramethyl thiuram disulphide) has protected fruit trees, ornamentals, cover plants, and experimental plantings of tomatoes, grain, and forage crops not used for food. TNBA (trinitrobenzene-anilene) and ZAC (zinc dimethyldithiocarbamate cyclohexylamine) have protected trees and shrubs in extensive enclosure testing and should prove favorable in field applications. None of these repellents prevent damage to haystacks, which are better protected from jackrabbits by using 1-inch mesh poultry netting.

CONCLUSIONS

In brief, most means of biological control appear to have limited application at this time in suppressing jackrabbit populations. Methods that may work on one population may have little or no value for another. Little-known factors that may be governing natality, mortality, and other population parameters need a more thorough understanding before biological control can be effectively utilized to control jackrabbits. Of the mechanical methods, only fence barriers appear to be useful, and then only with high-value or concentrated crops such as haystacks or on areas that experience recurrent damage regardless of population trends.

Chemical control is currently the most feasible means of alleviating jackrabbit damage. Strychnine and zinc phosphide on carrot baits are both very useful for reducing jackrabbit populations with either the furrow or line baiting method. However, these materials must be used with extreme care, as both present hazards to other animals. The experimental spray, DRC-1144, appears to be a very selective method of alleviating jackrabbit damage with very little danger to other animals, but further work is needed before it can be registered and used operationally. Several commercially available repellents, especially TMTD, provide excellent protection for trees and ornamentals.

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