EVALUATION OF A TECHNIQUE EMPLOYING THE CHEMOSTERILANT DIETHYLSTILBESTROL FOR SUPPRESSING REPRODUCTION OF WILD FOXES IN VIRGINIA

by

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INTRODUCTION

In Virginia, rabies as a fox epizootic seriously conflicts with man's interests and welfare. According to Dr. Paul White, Director, Bureau of Epidemiology, Virginia Department of Health, enough vaccine was issued in 1968 for 283 people to have taken the 21-shot, long series rabies treatment (personal communication). During 1967, livestock losses due to rabies exceeded $30,000 in one Virginia county alone (Mr. Glen Dudderar, V.P.I. Extension Biologist, personal communication). Already in 1969 (January 4 to March 29), 189 cases of rabies have been reported in wildlife and farm species, including 138 cases in foxes (White, personal communication).

The solution of the rabies problem may be through more effective and efficient methods of vector population control. The present program of control using State trappers is helpful but not adequate. During the period of 1961 to 1966, more than 33,000 animals were trapped and killed in 43 of the 47 counties requesting the program; yet the total number of lab confirmed cases of rabies did not decrease (Marx 1966). (Improved reporting may have accounted for some of the stability in number of cases.) In addition, trapping is time consuming and expensive. In some counties, 5 man-hours per animal are needed to capture foxes (Beck 1967). The statewide average cost of trapping a fox was $38 in 1968 (White, personal communication). These figures, coupled with the seriousness of the rabies problem, suggest the need for development and application of new methods and techniques to supplement and improve the current program of controlling vector species.

However, the need for improved population control techniques is justified on a broader basis than just the rabies problem. As greater stress develops among wildlife populations, habitat, and man with time, wildlife population manipulation for a variety of purposes will become increasingly important. For example, in some situations foxes may need to be controlled because of their role as predators. Here again, very specific techniques of control may be needed because foxes, like coyotes and deer (Dasmann 1964:198-201), are somewhat resistant to conventional control methods. Ultimately, of course, the very survival of a species hinges upon keeping the population in balance with the habitat and avoiding conflicts with other land uses. Satisfactory management of a species necessitates developing and applying the most efficient and effective techniques of population control possible.

The use of chemosterilants (antifertility agents) to suppress reproduction in problem species may be one of these methods. In principle, control through suppressing reproduction offers several advantages over control through increasing mortality. The potential of this approach is suggested by the variety of investigations that have been conducted on several pest species (e.g., Davis 1961; Balser 1964b; Elder 1964; and Howard 1968). Development of an efficient and effective technique of application to wild populations is needed. Integrated with a trapping program, such a technique could conceivably permit a much greater degree of rabies control than is now possible.

Practical problems of developing and using this approach include 1) selecting a suitable antifertility agent and 2) effectively treating the target species at the appropriate period in the breeding cycle. Based on these problems and the above introduction, this project was designed and conducted as a preliminary study of fox control through suppressing reproduction. The purpose was to provide direction for further investigations of this approach. The following objectives were established:

1. To determine the feasibility of using the chemosterilant diethylstilbestrol (DES) to reduce reproduction in a wild fox population
2. To field test techniques of administering chemosterilants to wild foxes

Preliminary field investigations were begun in October, 1967, and extended through November, 1967. Extensive field work, including treating and collecting animals, was conducted from January, 1968, to June, 1968.

LITERATURE REVIEW

Two major topics were reviewed: 1) normal reproductive characteristics of the species and 2) principles and problems of the control method. The target species of this study included the gray fox (*Urocyon cinereoargenteus cinereoargenteus* Schreber) and the red fox, (*Vulpes fulva fulva* Desmarest). Although knowledge of reproduction in these species is incomplete, literature currently available provides an adequate description of general characteristics for the purposes of this study. Information concerning application of antifertility agents to predator populations is also rapidly becoming available. The principal species currently under investigation include foxes and coyotes.

Characteristics of Fox Reproduction

Gray Fox

Apparently wild populations of this species consist largely of animals 1 year old or less. Approximately 60 percent of yearly populations were subadults in southern Georgia and Florida (Wood 1958 and Lord 1961a). In southern Illinois 52 percent of the breeding population were yearlings (Layne 1958). Richards and Hines (cited by Layne 1958) reported a figure of 69 percent subadults for Wisconsin populations. A significant aspect of population age structure is the number of animals which breed the first year of life. In this regard, Wood (1958) reported that 92.3 percent of the yearling females bred their first year in southern Georgia and Florida. However, Sheldon (1949) cited circumstantial evidence that some animals may not breed until the second year, and Layne (1958) suggested that a few animals may reach sexual maturity too late to breed the first year.

Yearly sex ratios did not differ significantly from the expected 100:100 ratio in Illinois (Layne 1958), Alabama (Sullivan 1956), or Georgia and Florida (Wood 1958 and Lord 1961a). However, a preponderance of males was observed in New York (Layne and McKeon 1956 and Linhart 1959). Some seasonal variation in sex ratios was noted in several studies.

Gray foxes are monestrous (Asdell 1964:441). Most investigators assumed them to be monogamous for 1 year. However, length of gestation was controversial. Many investigators assumed a period identical to that of red foxes, 51 to 53 days; but Grinnel et al. (cited by Asdell 1964:441) listed 63 days. Length of breeding season was similar for all regions, but breeding occurred about 1 month earlier in southern states. In New York, breeding took place from late January to the end of May (Layne and McKeon 1956). In Georgia and Florida, Wood (1958) reported a season occurring from late December to late March. Peaks of breeding ranged from early March in New York (Sheldon 1949) to late January or early February in Georgia and Florida (Wood 1958). In southern Illinois, which is on a latitude comparable to that of southern Virginia, the breeding season was from late January to the end of February, with the peak in mid-February (Layne 1958).

Mean litter size based on counts of placental scars and embryos varied from 4.71 to 3.33 on different areas in Florida (Lord 1961). Values from all other states and locations were within this range. Conception rates were high for all regions: 96.2 percent in New York (Layne and McKeon 1956), 98.0 percent in Illinois (Layne 1958), 93.5 percent in Alabama (Sullivan 1956), and 93.6 percent in Georgia and Florida (Wood 1958). Table I presents a summary of gray fox reproductive data.

Red Fox

Evidence indicates that red fox populations are also largely comprised of subadults. In Michigan, 63.9 percent of the animals captured during the spring were juveniles (Schofield 1958). Collection of animals during the winter in Wisconsin revealed that 66±10 percent were subadults (Ables 1968). Apparently, percentage of yearlings which breed is also high. In New York, 84 percent of ranch raised animals bred the first year (Pearson and Bassett 1946). Swink (1952:98) noted two instances in which wild yearlings produced litters on the V.P.I. college farm.

The sex ratio from fall and winter counts was 100:100 for adults in Wisconsin (Ables 1968). However, as in gray foxes, a preponderance of males was noted in New York (Layne and McKeon 1956 and Linhart 1959).

Red foxes, like gray foxes, are monestrous (Asdell 1964:436). They are known to be polygamous in captivity, but are generally considered monogamous for one season in the wild (Swink 1952:96). Various authors have listed length of gestation as 51 to 53 days;

Table I. A summary of gray fox reproductive characteristics taken from the literature

Area	Source	Adult sex ratio (M:F)	Breeding# period	Breeding# peak	Mean* litter size	Conception rate (percent)	Percent yearlings	No. breeding yearlings
N. Y.	Sheldon 1949	--	2-4/3-2	3-1	3.66	96.7	--	(Some may not breed)
N. Y.	Layne & McKeon 1956	142.4:100	1-3/5-4	3	4.4	96.2	--	--
S. Ill.	Layne 1958	108:100	1-4/2-4	2-2	3.77	98.0	52.0	(Some may mature late)
Ala.	Sullivan 1956	98:100	--	2	3.84	93.5	--	--
S. Ga. & Fla.	Wood 1958	117:100	9-4/3-4	1-4/2-1	4.56 $\pm$1.09	93.6	61.0	92.3 (percent)

Coded dates, symbols: M-W/M-W = month and week that breeding begins to month and week that breeding ends

* Based on counts of placental scars and/or embryos

however, Swink (1952:106), among others, felt that 52 days was usually correct. Breeding occurs about 1 month earlier in red foxes than gray foxes. Animals bred from the second week in January to the third week in April in New York (Layne and McKeon 1956). The peak (83.8 percent) occurred from the third week in January to the third week in February. In Virginia, ranch raised animals bred from December 24 to March 15, with the peak from the last week in January through the third week in February (Swink 1952:96). However, Swink suggested that wild foxes bred earlier than captive animals.

Mean litter size ranged from 4.6 in New York (Layne and McKeon 1956) to 6.8 in Indiana (Hoffman and Kirkpatrick 1954). The value for 1 year in Virginia was 5.3 (Swink 1952:108). Conception rates were not widely reported, but values from New York were 95.3 percent (Sheldon 1949) and 88.5 percent (Layne and McKeon 1956). Table II presents a summary of red fox reproductive data.

Use of Antifertility Agents for Population Control

Principles and Outlook

Davis (1961) was one of the first researchers to point out that reduction of birth rate in wild pest populations is a promising approach to population control. Based on the concept that objectives of a management program must be defined in terms of desired population level, he ratified the importance of increasing mortality rate as a control measure; however, he explained that results are often offset by compensation through increased survival and productivity of remaining animals. On the other hand, he postulated that if gametocides

Table II. A summary of red fox reproductive characteristics taken from the literature

Area	Source	Adult sex ratio (M:F)	Breeding# period	Breeding# peak	Mean* litter size	Conception rate (percent)	Percent yearlings	No. breeding yearlings
N. Y.	Sheldon 1949	--	1-2/2-2 (76 percent)	1-4	5.37	95.3	--	--
N. Y.	Layne & McKeon 1956	125.4:100	1-2/4-3	1-3/2-3	4.6	88.5	--	--
N. Y.	Pearson@ & Bassett 1946	--	--	2-2	--	94.0 (adults)	--	84.0
S. Wisc.	Ables 1968	100:100	--	1-3	--	--	66±10	--
Va.	Swink 1952	--	9-3/3-3@	1-4/2-4@	5.3	--	--	(2 cases)

Coded dates, symbols: M-W/M-W = month and week that breeding begins to month and week that breeding ends

* Based on counts of placental scars and/or embryos

@ Refers to ranch-raised animals

(a type of antifertility agent) can be applied appropriately at the inception of the reproductive process, compensatory factors of population dynamics will have little effect and control will be achieved. In addition, he added that this approach may be less expensive than increasing mortality since it can alleviate the problem of reducing populations below the level from which reproduction can rebound. However, he also noted that this approach will not be a panecea, only an additional tool for the management of populations.

Balser (1964a; 1964b) and Linhart (1964) were also early proponents of this approach to animal control. Based on reviews of work with domestic animals, Balser felt that regulation of populations through suppressing reproduction is a basic and promising approach which warrants investigation. He explained that reproduction is the only force that can overcome all mortality factors operating against a species; suppressing reproduction will cause the population to decrease as surely as increasing one or more mortality factors. Balser also defined the problem of applying antifertility agents to predator populations. He divided the problem into two phases: 1) selecting a suitable antifertility agent for the particular target species and 2) developing effective application methods which will provide a high degree of selectivity and safety. Requirements of a suitable agent were listed as 1) effective in a single oral dose; 2) safe by a wide margin between effective and lethal dosage; 3) stable, inexpensive, and effective in small field doses; 4) relatively tasteless, odorless, or capable of being masked; and 5) effective for a temporary period of one breeding season or 1 year. These rather rigid qualifications narrowed the list of suitable agents to just a few, with DES being the most promising.

More recently Howard (1967; 1968) reiterated what many scientists have postulated: that a given number of sterile individuals in a population exerts a much greater biological control pressure on the population than removal of the same number of fertile individuals. (Sterile animals do not contribute to the next generation, but they do compete for space, food, and social order. Of course, sterile individuals must still behave as fertile individuals socially to make these principles valid.) Howard added that chemosterilants probably will be most valuable as part of integrated control of problem species, particularly in maintaining populations of vertebrates at low level after they have been brought there by other means.

Applied Research

Much of the pioneer work in wildlife management has stemmed from discoveries in domestic animal research. The use of antifertility agents to control populations is no exception. Greenwald (1952) found that estrogen caused death of embryos in rabbits in different ways at different stages of pregnancy, depending on the stage of development of the reproductive tract and of the embryo. Estradiol benzoate was administered post coitum. Jackson (1953) reported that development of pregnancy was prevented in all 12 cases under study of mismated female dogs given one intramuscular injection of sepositol DES. Hill and Pierson (1958) found that sepositol DES could also be used as an abortifacient in feedlot heifers. In domestic mink, DES caused nearly total reproductive failure when given every third day during the period between conception and whelping (Travis and Schaible 1962). Such results supplied the impetus for investigations of chemosterilants in wildlife research.

In studies at the Denver Wildlife Research Center, Balser (1964a) initiated tests of DES on coyote reproduction. In preliminary trials on penned coyotes (Canis latrans), pregnancy was terminated in six animals fed a single 100-mg oral dose dissolved in tallow. A subsequent field trial using drop baits was conducted on a 20-township area in New Mexico with a reference area 25 miles distant. Baits were placed wherever coyote sign was found, immediately after the estimated peak of breeding. Animals were trapped 3 weeks later. On the treated area, only four females out of 20 in breeding condition had viable embryos. On the reference area, 13 out of 13 females in breeding condition either had viable embryos or had litters. In the majority of reproductive failures recorded for the treated area, females which ovulated simply failed to implant.

As a parallel to Balser's coyote work, Linhart and Enders (1964) measured effects of DES on reproduction in captive red foxes. All females force-fed a single 50-mg oral dose of DES from nine days before mating to 10 days after mating failed to produce kits. Corpora lutea were found in the ovaries of all experimental females. Apparently in cases of reproductive failure, either the ova were not fertilized, the fertilized ova failed to survive, tubal transport was blocked, or the young embryos failed to implant. Testicular biopsies showed that males were not affected by DES.

Linhart (1964) also tested the acceptance by wild foxes of certain baits for administering antifertility agents. In a comparison of eight different baits, no one type was preferred. Foxes, dogs, and crows, in that order, most frequently consumed baits. Bait acceptance by foxes progressively improved throughout the winter.

Linhart, Brusman, and Balser (1968) continued the coyote work on a larger scale. In total, 14 field trials were conducted on 12 study areas in the Southwest during a 5-year period (1963-67). Baits were modified and improved throughout the period. The 1/3-oz tallow baits used in 1967 each contained 100-mg of DES and one 75-mg coated tablet of demethylchlortetracycline (hereafter referred to as DMCT). The latter compound, a physiological marker, permitted subsequent identification of individual coyotes which consumed one or more baits. All of the sexually mature females showing evidence of the marker were barren. However, data were not sufficient to determine effects of the hormone on reproduction. One difficulty was the variability of normal reproductive success between areas and years. Other major problems were getting the hormone into a large segment of the population and preventing molestation of drop baits by non-target species. However, multiple bait applications were superior to single applications; and DMCT was an effective oral marker. Also, Brusman et al. (1968) developed a highly efficient technique for producing antifertility tallow baits. Treatment of coyotes is still under investigation in Texas.

In New York, investigation of fox control with antifertility agents continued under Parks (1968). An initial field test of DES during the winter of 1961-62 was inconclusive; a pellet form of the hormone was used which passed through foxes without being digested. In a search for better methods, several reproductive inhibitors were screened: DES, mestranol, clomiphene and 6 chloro-Δ^6-17-acetoxyprogesterone. When fed in a meat base to ranch-raised red foxes, DES showed the greatest potential in terms of cost and effectiveness. A single 50-mg dose administered to females was nearly 100 percent effective in preventing pregnancy during the first 10 days after mating. DES had little or no effect on spermatogenesis. In field trials with various baits, red foxes showed a distinct preference (2.4:1) for honey-tallow baits over plain tallow baits. No preference was shown by gray foxes. The most promising physiological marker tested was tetracycline hydrochloride (achromycin). (DMCT was not tested.) In field tests using achromycin and DES, achromycin was very satisfactory. Approximately 68 percent of all foxes captured were marked. However, the effectiveness of DES was not determined due to alterations of the population by mange. Additional trials are being conducted.

Storm and Sanderson (1969) recently tested the effects of various doses of medroxyprogesterone acetate (provera) on productivity of captive red foxes. Pup production by the treated animals was significantly lower than production by controls during the first post-treatment whelping season. All females mated after treatment; apparently, provera did not affect developing follicles, ovulation, or estrus. Animals were not sacrificed to determine actual effects of the hormone.

DESCRIPTION OF THE STUDY AREAS

The Havens Wildlife Management Area, owned by the Virginia Commission of Game and Inland Fisheries, was selected as the nucleus of the area to be treated. The approximately 6,000-acre tract is located on Fort Lewis Mountain in Roanoke County, 3 miles northwest of Salem, Virginia. Adjacent private lands owned by Valleydale Packers Incorporated and the Times-World Corporation, both of Roanoke, Virginia, were included as part of the total area to be treated (approximately 13,000 acres). The location was selected on the basis of land area, accessibility, habitat, and control advantages.

The Havens area was originally designated a game sanctuary (Engle and Gillam undated). A 5,738.3-acre tract purchased in 1930, along with 325 acres added in 1932, was named the Havens Refuge in honor of W.S. and E.M.P. Havens of the Alleghany Mountain Corporation, from whom the larger tract was acquired. The status of sanctuary was retained until 1953 when public hunting was permitted. Prior to purchase by the Game Commission in 1930, the area was heavily cut for tannin bark. And in 1953, an uncontrolled fire burned 2,572 acres. The terrain is typically rolling and mountainous with an elevation range of 1,400 to 3,200 feet. The principal cover-types on the heavily wooded area are mixed hardwoods and pine. Small farms and rural homes dot the periphery, and a network of access roads and fire lanes provide thorough access. The area is lightly managed for the major game species, including squirrel, grouse, and turkey. The conditions represent typical gray fox habitat in southwest Virginia. A map of the Havens area is shown in Fig. 1.

The Broad Run Management Area on the Jefferson National Forest, Craig County, Virginia, was selected as the principal reference area. The approximately 11,400-acre tract is very similar to the Havens area in history, topography, and cover-type. It is located approximately 10 air miles northwest of Salem, Virginia. In addition, the city dump of Salem, Virginia, was included as a second reference area. The area is very similar to the Havens area, but it is only a few hundred acres in size. It is located on Fort Lewis Mountain in Roanoke County, Virginia, approximately 8 air miles southwest of Salem and 4 air miles southeast of the Havens area.

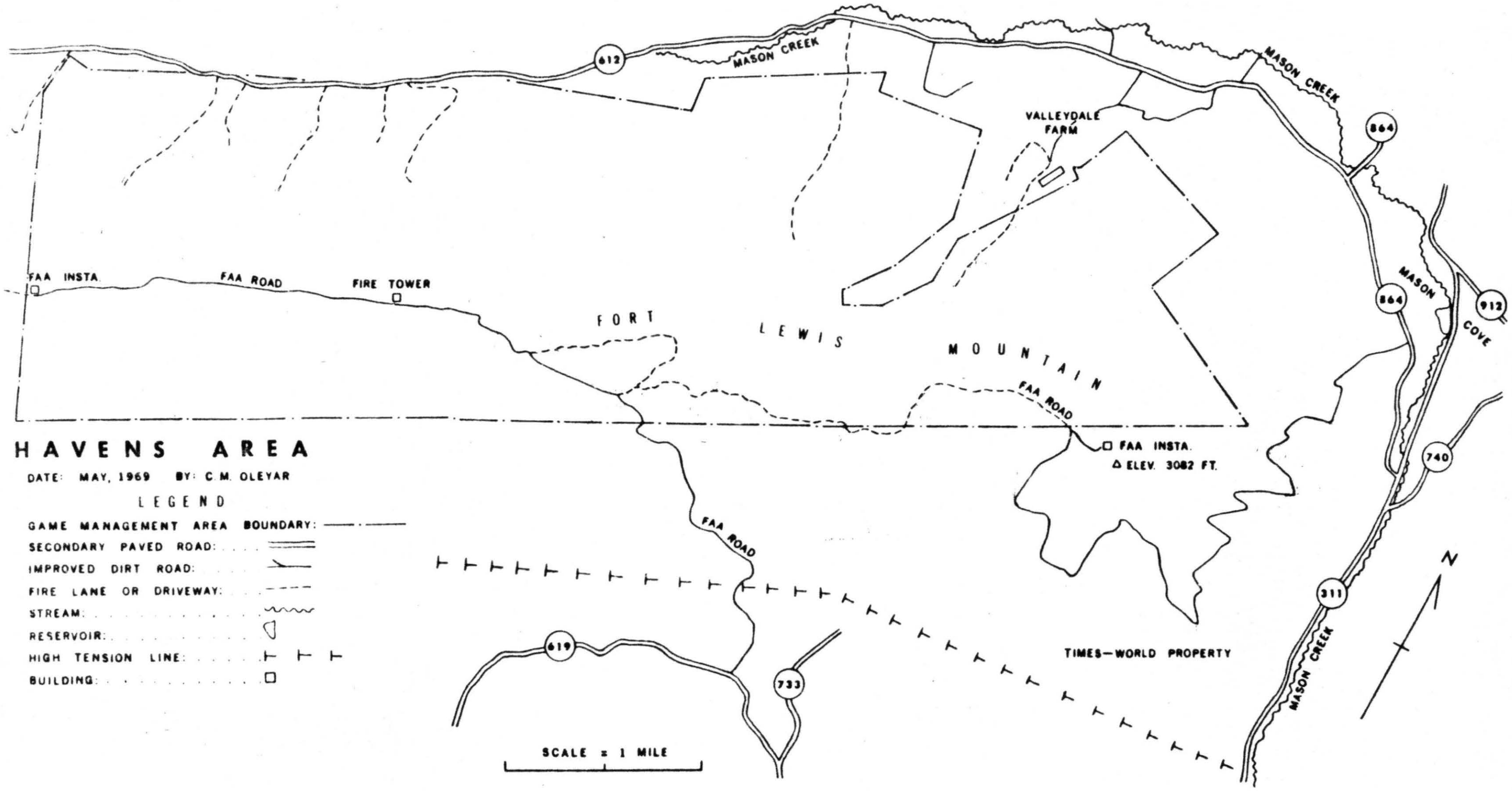

Fig. 1. A map of the Havens area on Fort Lewis Mountain, Roanoke County, Virginia, 1969

TECHNIQUES AND PROCEDURES

The study had two phases: 1) treating the population and 2) collecting and processing specimens. Most of the techniques and procedures were suggested in the literature, but some modifications were adopted. A control area was not used because time precluded distribution of baits on more than one area; however, reference, or untreated, areas were employed. Centers of fox activity and relative population densities were noted on all areas during preliminary surveys. Pre-conditioning baits were distributed on the Havens area prior to application of treated baits. After treatment application on the Havens area during the breeding season, animals were collected from all areas and processed. A calendar of all field activities is presented in Table III.

Treating the Population

This phase consisted of three principal steps: 1) selecting materials, 2) pre-conditioning animals to bait acceptance, and 3) applying treated baits.

Selecting Materials

The synthetic estrogen DES was selected as the treatment hormone. The objective was to disrupt pregnancy (Balser 1964b:355). A 50-g sample of DES was obtained *gratis* from Greenfield Laboratories, Eli Lilly and Company, Greenfield, Indiana.

DMCT was chosen as an oral marker to enable identification of animals which consumed treated baits. (See Linhart and Kennelly 1967:317.) DMCT induces a characteristic golden-yellow fluorescence

Table III. Calendar of field activities on three study areas* during an evaluation of a technique employing the chemosterilant diethylstilbestrol for suppressing reproduction of wild foxes in Virginia, October, 1967 to June, 1968

Dates	Area	Activity
October-November, 1967	Havens Broad Run Salem dump	preliminary surveys (5) to note fox activity centers and population densities
November 26-28, 1967	Havens	initial pre-baiting
December 12-22, 1967	Havens	2nd and 3rd pre-baitings
January 23-27, 1968	Havens	final pre-baiting
January 30-March 28, 1968	Havens	7 treatment applications (approximately 10-day intervals)
April 21-June 3, 1968	Havens	trapping operations
May 1-21, 1968	Broad Run	trapping operations (State trapper)
June 1-3, 1968	Salem dump	trapping operations
October, 1968	Havens	surveys (2) to note fox activity

* Havens area (treated), Roanoke Co.; Broad Run area (reference), Craig Co.; Salem dump area (reference), Roanoke Co.

in bones and teeth under long-wave ultraviolet light. A powdered form of the chemical was available from Lederle Laboratories, American Cyanimid Company, Pearl River, New York. A 30-g sample was obtained *gratis*.

The basic bait material selected was ground beef suet supplied *gratis* by the A & P Food Store, Blacksburg, Virginia. This material was chosen as an alternative to tallow because of the limited success attained with tallow baits in New York (Linhart 1964a:73). Body and kidney fat were selected for moistness, collectively ground to hamburger texture, and refrigerated until made into baits. Baits were manufactured according to a technique described by Mr. John R. Beck, State Supervisor, Division of Wildlife Services, Bureau of Sport Fisheries and Wildlife (personal communication). Bait molds were fashioned by drilling a grid of 3/4-inch holes through a section of 2-x8-inch planking. Baits were formed by packing suet in the holes by hand. Completed baits were extruded and then refrigerated to prevent spoilage and melting.

Pre-conditioning Animals to Bait Acceptance

Reasons for pre-conditioning were two-fold: 1) to induce foxes to take baits regularly without aversion and 2) to determine the most acceptable type of suet bait. Initially, baits coated with cane sugar, baits coated with sardine oil, and baits without additives were compared in field trials. Later, baits coated with both sugar and oil were tried. Centers of fox activity, including the Federal Aviation Agency access road, the Valleydale farm road, and selected fire lanes were chosen as distribution sites. Bait stations (sites at which sets were constructed) were located at spots along each road where fox tracks and droppings were evident. Each station consisted of one to three sets placed either on the road or along its edge. At stations consisting of more than one set, sets were spaced at 10 to 30-ft intervals. Sets were designed to facilitate identification of visiting species by tracks. At places with suitable tracking conditions, baits were simply placed on bare soil or sand. However, in the majority of cases "dirt-hole" or "scratch-up" sets were constructed. The dirt-hole is a simulation of a spot at which a fox buried a food scrap (Clouser 1967:33). Scratch-ups were prepared by loosening soil in a area approximately 18 inches in diameter and raking a portion of the soil over baits placed in the center. Loosened soil at both types of sets improved tracking conditions. Under snow conditions, sets were simply constructed in the snow instead of soil. Baits were transported in plastic containers and handled with bare hands.

Preliminary bait applications were mainly exploratory in an effort to refine techniques for the crucial applications of treated baits. In the first pre-treatment application, baits were distributed on all the selected roads one time (November 27, 1967) and on the FAA road (mountain road or upper section) a second time (November 28, 1967). Single-set stations (one set per station) were used almost exclusively. Fifty-three of 96 sets were baited with a mixed selection of bait-types (three baits per set). Single types of bait were alternated consecutively at the remaining sets. Sets were checked within 24 to

48 hr after baiting for evidence of species visits and bait acceptance.

In the second and third pre-treatment applications the procedure was altered in favor of tri-set stations (three sets per station) and single bait-type sets. A total of 228 sets were employed, representing 65 tri-set and 30 single-set stations. Each set at tri-set stations contained a different bait-type. Tri-set stations were considered an improvement over single-set stations containing mixed baits for indicating acceptance rates of different baits. Baits were distributed on the fire lanes one time during a 2-day period (December 13-14, 1967). They were distributed on the FAA road and Valleydale farm twice (December 15 and 22, 1967). The latter areas were given precedence in bait applications because they supported most of the foxes on the Havens area. Results were recorded.

The final pre-conditioning application was made in January just prior to the first treatment application. The procedure was again modified. A final system of 44 bait stations was selected for all remaining bait applications. Only two sets per station and two baits per set were used to reduce the concentration of baits per area. Baits coated with both sugar and oil were used exclusively. The entire research area was baited once during a 2-day period (January 23-24, 1968). Results were recorded.

Applying Treated Baits

Treated baits were identical to baits used in the final pre-baiting except that each contained an encapsulated mixture of DES, DMCT, and filler (confectioners sugar). A minimum dose of 50 mg of

DES (Linhart and Enders 1964:357) and 35 mg of DMCT (10 mg/kg for a 7-8 lb animal; Linhart and Kennelly 1967:318) per bait was used. The formula for preparation of 100 No. 4 gelatin capsules was 5,000 mg DES, 3,500 mg DMCT, and 4,200 mg sugar (based on average capsule capacity = 127 mg). Ingredients were blended with mortar and pestle and stirred until texture and color were uniform. Each capsule was filled by "pecking" at the mixture by hand with the open capsule end. Every fifth capsule was checked by weight against an acceptable minimum standard using an Ainsworth "Right-a-Weigh" scale (nearest 0.1 mg). (The theoretical formula for 100 capsules never produced more than 90 actual capsules.) Filled capsules were inserted into half completed baits still in the mold. Baits were then completed, extruded, coated, and refrigerated.

The period of treatment application was determined from an estimate of the breeding period for foxes in this region. Based on the literature, the estimated breeding period for gray foxes was mid-January to mid-April (peak in mid-February). The estimated breeding period for red foxes was mid-December to mid-March (peak in late January or early February). The estimated fox population on the Havens area consisted primarily of gray foxes. Consequently, the breeding season of that species was the principal treatment target. The objective was to treat gray foxes throughout the major portion of their breeding season to affect the maximum number of animals. The treatment would also subsequently include the important period following peak of breeding in red foxes. (See Linhart et al. 1968:

319.) Based on an effective treatment range of approximately 10 days either side of estrus (Linhart and Enders 1964:360), treated baits were distributed seven times from late January to late March at approximately 10-day (6-14) intervals. A total of 614 sets were employed during the 8-week period. Sets were identical to those described for pre-baiting. A single bait per set was used to reduce the probability of an animal consuming an overdose of treatment. The 44 stations were checked within 24 hr after baiting, weather permitting. A field chart was used to record 1) evidence of visits, 2) number of visits, 3) probability of visits, 4) tracking conditions, 5) bait take, 6) probability of take, and 7) bait acceptance. Probability of take per species was estimated for every missing bait. The number of baits actually taken per species was determined by mathematical expectation based on probability estimates of species take per set. (The sum of the estimated probabilities of take per set for each species was divided by total baits available to give percent of baits taken per species.)

Collecting and Processing Specimens

This phase also consisted of three principal steps: 1) collecting animals, 2) processing vital parts, and 3) analysing data.

Collecting Animals

All animals were collected with steel traps. The principal trap used was the Victor No. 2 coil spring, manufactured by the Animal Trap Company, Lititz, Pennsylvania. Traps were staked at sets with 12-inch sections of angle iron or 9-inch metal tent pegs. Equipment used for set construction included a small garden trowel for digging bait holes, a hatchet for loosening soil and driving stakes, a home-made dirt sifter for covering traps, and canvas gloves for handling equipment. Trap pan covers consisted of 5-x6-inch sections of paper towel which were aired outdoors. All equipment was periodically treated with logwood dye to reduce rusting and contamination from foreign odors. The principal set was the conventional dirt-hole set with occasional variations (Clouser 1967:33). Untreated, coated baits were the primary attractants used on the treated area. However, commercial fox urine and lures were used as supplements during later stages of the trapping period. Commercial attractants were used exclusively on reference areas. All trapping on the Havens and Salem dump areas was conducted by the investigator. Trapping on the Broad Run area was conducted by Mr. Carl Bannock, a trapper employed by the Virginia Department of Health.

The treated area (Havens) was trapped continuously from April 21 to June 3, 1968, although not all sections were trapped simultaneously. All sections were trapped intensively one time, but the centers of fox activity were trapped twice to insure maximum catches. The Broad Run area was trapped continuously from May 2 to May 21, 1968, and the Salem dump area was trapped from June 1 to June 3, 1968.

On the Havens area, the most productive sets in terms of fox visits during treatment baiting were used for trap sites. In addition, some new sets were constructed to provide thorough coverage of the area. (A few animals may have developed an aversion to regular bait stations.) Locations showing evidence of fox activity were selected as trap sites on reference areas. All sets were checked daily. Foxes, skunks, opossums, and feral cats found alive in traps were killed. Dogs were also killed unless presence of collars or friendly behavior indicated that they were house pets. Female raccoons were killed for processing, but males were released to appease local public sentiments. Records were kept of species visits, captures, escapes, and retensions.

All sets were visited as early as possible each day to reduce trap losses and spoilage of dead animals. All retained animals were identified by number according to road location, station number, set number, and number of captures at each set. Carcasses of foxes and female raccoons were taken to the laboratory for processing. Portions of feet left in traps by escaped foxes were also collected and numbered. Only mandibles were collected from dogs, skunks, and opossums; however, some females were checked in the field for reproductive condition.

Processing Vital Parts

In the laboratory, whole fox carcasses were weighed to the nearest 0.1 lb. Females were checked for evidence of lactation (Layne 1958: 159 and Sheldon 1949:241). Reproductive tracts were removed from female foxes and raccoons, labeled, and preserved in 10 percent formalin. Mandibles from all animals were removed, labeled, bagged, and frozen until processed for DMCT identification. Feet from escaped foxes were similarly handled. Fox eyeballs were preserved in 10 percent formalin preliminary to using eye lens weights as age criteria. Foxes with apparent physical abnormalities were taken to Dr. Keith

Libke, Department of Veterinary Science, V.P.I., for necropsies.

Preserved reproductive tracts were later examined grossly for numbers of corpora lutea, placental scars, and fetuses. Each ovary was sliced longitudinally several times to insure accurate counts of corpora lutea. Similarly, uteri were opened longitudinally to facilitate identification of placental scars and fetuses. Each tract was classified as non-parous, pregnant, or post partum. Supplementary data collected included greatest width and length of ovaries and width of uteri (between swellings).

Frozen bone specimens were scraped clean and examined under long-wave ultra-violet light (2540 A to 3660 A) for the fluorescence characteristic of DMCT (Linhart and Kennelly 1967:317). Degree of fluorescence was classified as 1) no evidence, 2 evidence, or 3) abundant evidence. In addition, general tooth-wear of each mandible was recorded to serve as a supplementary age criterion according to an abbreviated form of Wood's (1958:76) technique (upper teeth were not examined). Degree of tooth-wear was recorded as 1) none, 2) light, or 3) heavy.

Eye lenses were processed as the principal aging technique as described by Lord (1961b:109; 1966:536) and Friend and Linhart (1964:58).

Condition of reproductive tracts after parturition was used to estimate approximate parturition and breeding dates. (See Layne and McKeon 1956:59.)

Analysing Data

Sample sizes were relatively small due to the scope of the study;

consequently, no statistical design was incorporated. However, wherever appropriate, evaluations of totals were made by comparing percentages and using chi-square tests for significance. In addition, evidence of trends in correlation was sought when warranted.

Specific determinations concerning bait applications included 1) bait preference by species, 2) number of visits by species, 3) percentage of baits taken by species, and 4) percentage of treated baits rejected by species.

Specific determinations concerning effectiveness of treatment included 1) percentage of marked animals by species and by sex, 2) percentage of marked females which reproduced by species, 3) reproductive success on the treated versus reference areas by species, and 4) reproductive success of marked versus unmarked females from the treated area by species. Consideration was also given to the role of non-breeding yearlings.

Additional analyses of fox data included 1) sex ratios, 2) species ratios, 3) relative area densities, 4) estimated breeding and parturition dates, and 5) population age structure.

RESULTS

Application of Baits

Pre-baiting

In the intital pre-treatment application of baits (November 27-28, 1967) only 87 sets were checked due to muddy, impassable roads. Tracking conditions at nearly all sets were relatively poor. Evidence of visits indicated that foxes (red and gray) visited 16 (18.4 percent), dogs visited 12 (13.8 percent), foxes or dogs (indeterminable) visited 6 (6.9 percent), and unidentified animals visited 21 (24.1 percent). A total of 32 (36.8 percent) of the sets were not visited within the 24 hr after bait placement (Table IV). Foxes consumed all baits from 11 sets at which one type of bait was offered. Foxes visited only five of 52 sets at which a mixed bait selection was offered; however, on one occasion only the oil-coated bait was taken. In two other instances, only the sugar-coated and oil-coated baits were consumed by unidentified visitors. In total, plain baits were available 64 times, sugar-coated baits were available 64 times, and oil-coated baits were available 63 times (baits of a single type at one set or one time available for each type of bait of a mixed selection). Foxes consumed nine (14.1 percent), nine (14.1 percent), and six (9.5 percent) of these, respectively (Table V).

In the second (December 13-15, 1967) and third (December 22, 1967) pre-treatment applications, poor visitor identification and small sample size continued to be problems. Foxes visited 43 (18.9 percent) of the sets; but in only one instance did evidence suggest

Table IV. Percent of bait sets visited by species on the Havens area, Roanoke County, Virginia, Nomvember 26, 1967, to March 28, 1968

Application dates	Bait[@] type	No. sets	Percent of sets visited by species					Percent sets undistrubed
			Fox	Dog	Dog-fox*	Others	Unknown	
11/26-28/67	p,s,o	87	18.4	13.8	6.9	0.0	24.1	36.8
12/12-22/67	p,s,o	228	18.9	24.1	6.1	0.0	25.0	25.9
1/23-27/68	s-o	86	73.9	20.5	--	0.0	0.0	5.7
1/30-3/28/68[#]	s-o	614	36.2	3.4	--	0.5	40.2	21.5
	Total	1015	34.1	10.4	2.0	0.3	32.0	22.3

@ Symbols: p = plain; s = sugar-coated; o = oil-coated; s-o = sugar-oil coated
* Indeterminable
# Baits contained DMCT and DES

Table V. Percent of bait-types consumed by species on the Havens area, Roanoke County, Virginia, November 26, 1967, to March 28, 1968

Application* dates	Bait type	Times bait available	Percent of baits consumed by species					Percent baits undisturbed
			Fox**	Dog	Dog-fox#	Other	Unknown	
11/26-28/67##	plain	64	14.1	15.6	6.3	0.0	20.3	43.8
	sugar	64	14.1	15.6	7.8	0.0	26.6	35.9
	oil	63	9.5	19.0	7.9	0.0	27.0	36.5
12/12-22/67	plain	75	17.3	26.7	8.0	0.0	22.7	25.3
	sugar	78	17.9	21.8	2.6	0.0	30.8	26.9
	oil	75	21.3	24.0	8.0	0.0	21.3	25.3
1/30-3/28/68@	sugar - oil	614	21.1	2.0	--	0.5	54.8	22.1
Summary	plain	139	15.8	21.6	7.2	0.0	21.6	33.8
	sugar	142	16.2	19.0	4.9	0.0	28.9	31.0
	oil	138	15.9	21.7	8.0	0.0	23.9	30.4
	sugar -oil	614	21.1	2.0	--	0.5	54.8	22.1
	Total	1033	19.1	9.6	2.7	0.2	42.6	26.0

* Does not include sugar-oil bait distribution on 1/23-27/68 because snow obliterated visitor evidence

** Includes red and gray foxes

\# Indeterminable

\## Based on mainly a mixed selection of bait-types per set

@ Treated bait determinations by mathematical expectation: $B = (\Sigma Pi/N)100$ (B = percent of baits consumed by a species; Pi = probability of take by a species per set; N = total number of baits available) that foxes selected, or detected, one bait over another. Other totals of sets visited included 55 (24.1 percent) by dogs, 14 (6.1 percent) by foxes or dogs (indeterminable), and 57 (25.0 percent) by unidentified species (Table IV). A total of 59 sets (25.9 percent) were not visited within the 48 hr after bait placement. Foxes consumed baits 13 (17.3 percent) of 75 times plain baits were available, 14 (17.9 percent) of 78 times sugar-coated baits were available, and 16 (21.3 percent) of 75 times oil-coated baits were available (Table V).

During the final pre-treatment application, a snow storm caused a 2 and 3 day delay in checking sets. The fresh snow cover made tracking conditions excellent; however, falling snow may have obliterated tracks of the original visiting animals. Consequently, assignment of bait take by species was not considered valid. Nevertheless, 158 total visits were recorded for 83 (94.3 percent) of 86 total sets. All visits were attributable to gray foxes or dogs. Foxes visited 65 (73.9 percent) of all sets and accounted for 127 (80.4 percent) of the total visits (some sets were visited more than once). Dogs visited 18 (20.5 percent) of the sets and represented 31 (19.6 percent) of the total visits (Table IV). At many sets foxes dug the snow away as if searching for baits. No baits were found remaining at any sets, but conceivably some were overlooked in the snow.

Treatment Baiting

(Due to the apparent high rate of acceptance in the final pre-baiting, baits coated with oil and sugar were used in all treatment applications.) During the 8-week period 482 (78.5 percent) of the sets were visited 540 total times by one or more animals or species. Foxes visited 222 (36.2 percent) of the sets and accounted for 266 (49.3 percent) of the total visits. Dogs and other identifiable species represented only 29 (5.4 percent) of all visits at only 24 (3.9 percent) sets visited. However, at least 247 (40.2 percent) of all sets were visited by unidentified visitors. (See Tables IV and VI.) Based on mathematical expectation, foxes were credited with 130 (21.2 percent) of the 614 total baits (Table V). (This figure is misleading when contrasted with number of sets visited by foxes. The apparent discrepancy is due to mathematical assumptions, not real values.) Number of baits credited to foxes for one baiting ranged from 5.1 percent to 40.4 percent for the entire area. Red foxes accounted for only 1.0 percent of all baits. (Fig. 2 shows the maximum, expected, and minimum number of baits consumed by species.) Baits were taken at 478 (99.2 percent) of all sets visited (77.9 percent of all sets), with an acceptance rate of 99.2 percent. In only four known instances were baits not taken at sets visited, and in only four known instances were capsules rejected after baits were taken. Tooth marks on rejected capsules and other evidence of visits indicated that capsules were rejected by foxes three times and by a rodent once. On two occasions gray foxes visited sets without taking baits. Table VII shows baits consumed per baits visited by species.

Collection of Animals

Trapping

A total of 717 trapnights (1 trapnight = one trap in operating

Table VI. Total visits at treated bait* sets visited by species on the Havens area, January 31 to March 29, 1968

		Species visits (sets visited/total visits)				
Area	No. sets	Gray fox	Red fox	Dog	Other	Unknown
lower[@] section	306	74/90	3/3	8/12	2/2	162/162
FAA road	308	141/169	4/4	13/14	1/1	85/85
Totals	614	215/259	7/7	21/26	3/3	247/247

* Baits contained DMCT and DES
@ Includes fire lanes and Valleydale farm

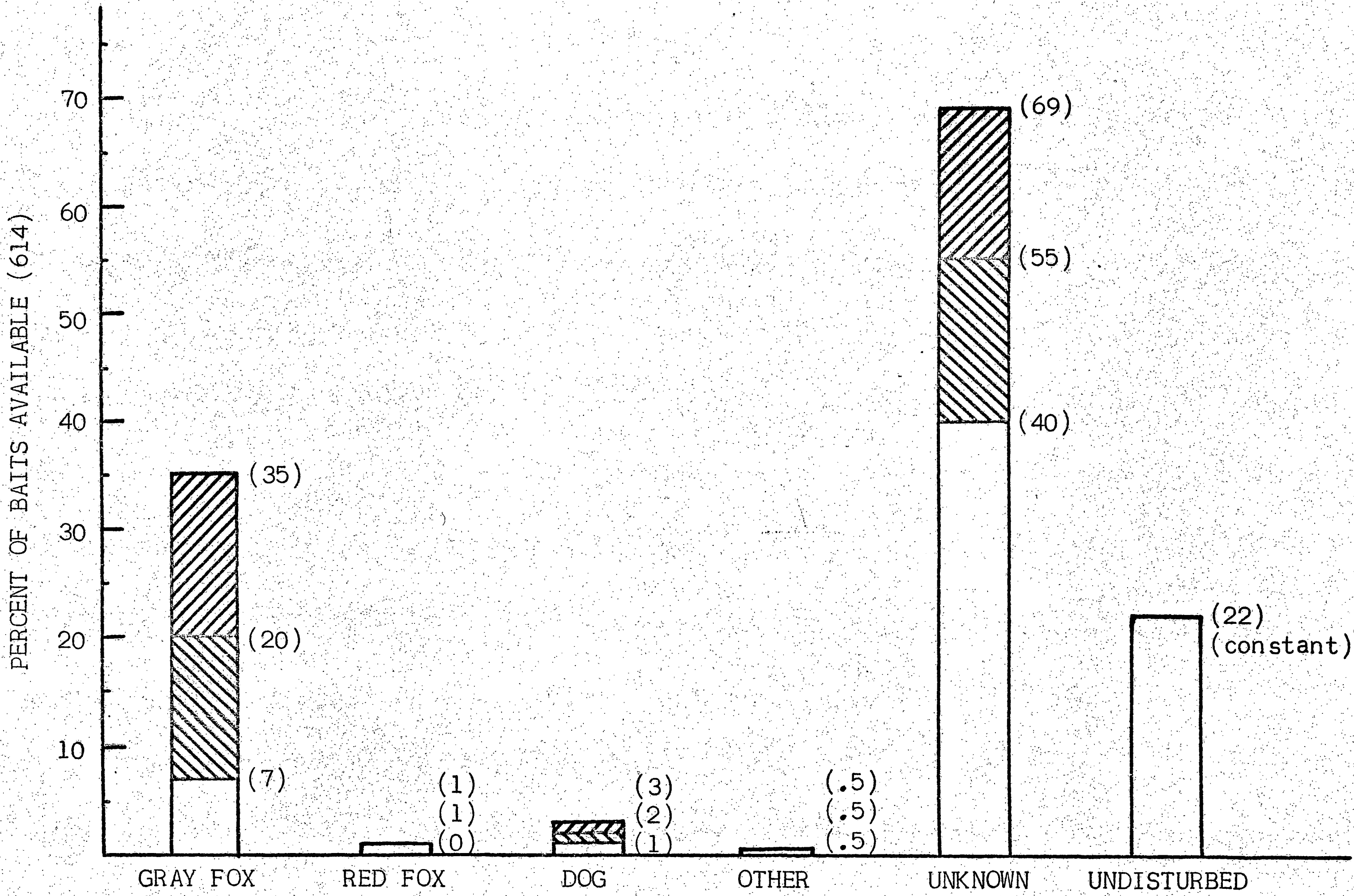

Fig. 2. Percent of treated baits consumed by species on the Havens area, Roanoke Co., Virginia, January 31 to March 29, 1968. Percents in parenthesis from top to bottom = maximum (total sets visited), expected (mathematical expectation), and minimum (cases of 100 percent probability of take)

Table VII. Consumption of bait-types by species per number of species visits on the Havens area, Roanoke County, Virginia, November 26, 1967, to March 28, 1968

Bait type	Times bait available	Bait consumption per species visits (baits consumed/baits visited)					Totals
		Fox	Dog	Dog-fox*	Other	Unknown	
plain	139	22/24	30/30	10/10	0/0	30/32	92/96
sugar	142	23/24	27/27	7/7	0/0	41/41	98/99
oil	138	22/22	30/30	11/11	0/0	33/33	96/96
sugar@ - oil	614	(130)/222	(12)/21	--	(2)/3	(336)/247	478/482

* Indeterminable

@ Treated bait consumption determined by mathematical expectation (figures in parenthesis): $B = (\Sigma Pi/N)100$ (B = percent of baits consumed by a species; Pi = probability of take by a species per set; N = total number of baits available). Does not include sugar-oil pre-baiting because snow obliterated visitor evidence condition for 1 night) were expended on the treated area (Havens), resulting in the collection of 19 gray foxes, 4 red foxes, 8 dogs, 7 striped skunks, 7 opossums, 5 raccoons, 5 feral cats, 9 crows, 1 woodchuck, 1 woodrat, and 1 flicker. In addition, two gray foxes escaped, leaving amputated feet in the traps. Approximately 890 trap-nights were expended on the combined reference areas, resulting in the collection of 12 gray foxes, 2 red foxes, 9 dogs, 22 striped skunks, 1 opossum, 1 feral cat, 4 crows, 3 buzzards, 2 cottontails, 1 weasel, 1 grouse, and 1 woodpecker (Table VIII). One gray fox escaped leaving a foot. Numbers of trapnights per fox (red and gray, including positive escapees) were 28.7 on the Havens area, 72.8 on the Broad Run area, and 5.7 on the Salem dump area. Table IX presents a summary of fox catch by species and sex from all study areas. Fig. 3 shows distributions of bait stations and fox capture sites.

Although sample sizes were very small, both the Havens area (2:2) and the Broad Run area (1:1) showed the expected 100:100 sex ratio among red foxes. The Salem dump area produced no red foxes. In addition, the ratios of males to females among gray foxes did not differ significantly from 100:100 on the Broad Run area (5:4) and the Salem area (1:2). However, the treated area (Havens) produced 13 males to only six females, a significant different at the $P<0.10$ level (1 d.f., chi-square = 3.05).

Results, including positive escapees, gave a gray fox to red fox ratio of 5.2:1 on the treated area and 5.0:1 on the Broad Run area. (No red foxes were captured on the Salem dump area).

Table VIII. Total captures by species from three study areas in Virginia, April 21 to June 3, 1968

Area	Species								Total trapnights*
	Foxes	Dogs	Skunks	Opossums	Raccoons	Feral cats	Crows	Miscellaneous	
Havens[@]	25[#]	11[#]	7	7	5	5	9	3	717
Broad Run	12[#]	9	22	0	0	1	4	7	873
Salem dump	3	0	0	1	0	0	0	1	17
Totals	40[#]	20[#]	29	8	5	6	13	11	1607

* 1 trapnight = one trap in operating condition for 1 night
@ Treated area
# Includes known escapees

Table IX. Fox catch by species and sex from three study areas in Virginia, April 21 to June 3, 1968

Area	Gray fox			Red fox			Total foxes	Total trapnights*	Trapnights per fox
	Male	Female	Total	Male	Female	Total			
Havens@	13	6	21#	2	2	4	25	717	28.7
Broad Run	5	4	10#	1	1	2	12	873	72.8
Salem dump	1	2	3	0	0	0	3	17	5.7
Totals	19	12	34#	3	3	6	40	1607	40.2(mean)

* 1 trapnight = one trap in operating condition for 1 night

@ Treated area

\# Includes unsexed escapees (animals which left a foot in a trap)

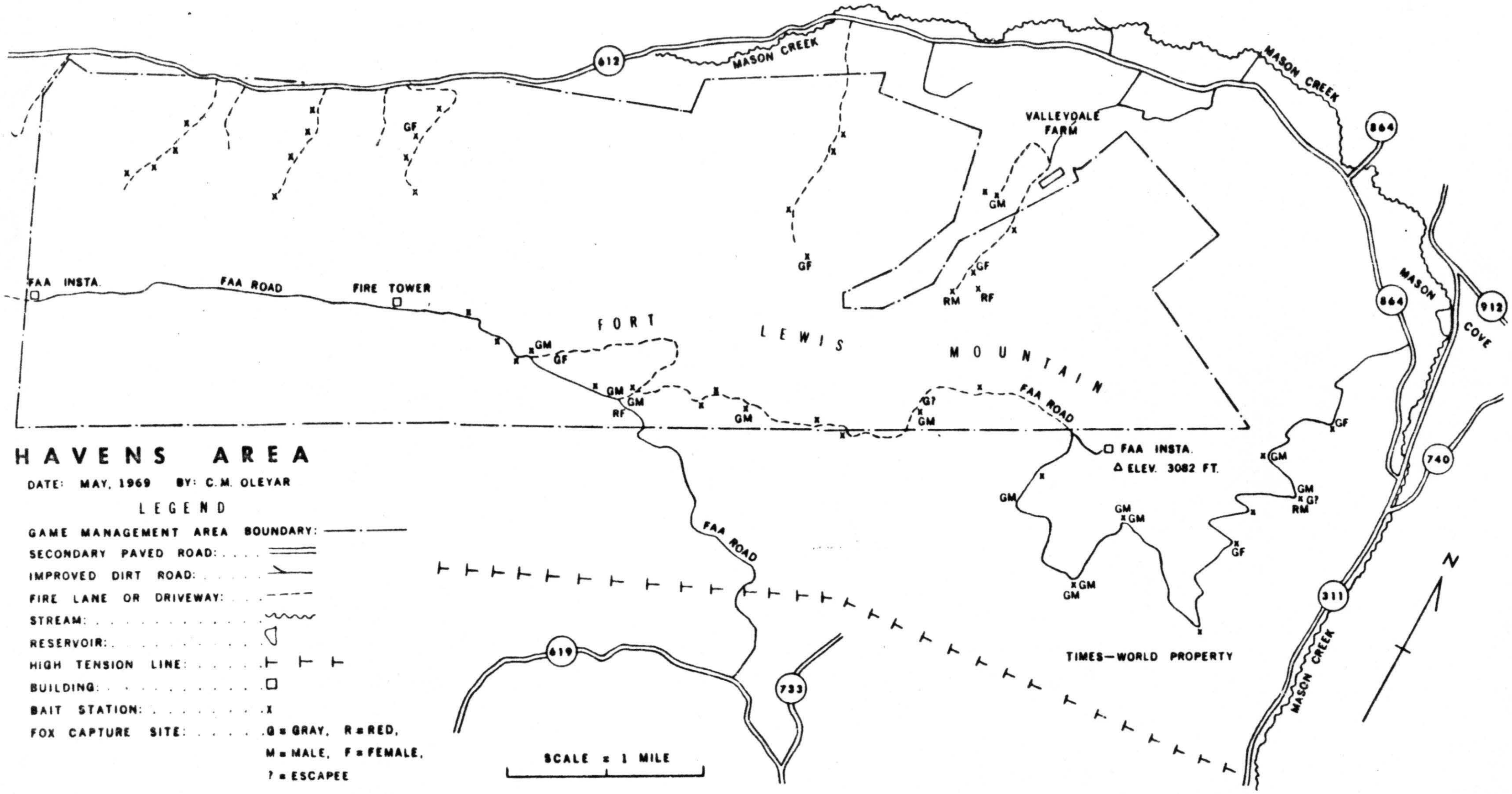

Fig. 3. Distribution of bait stations and fox capture sites on the Havens area, Roanoke County, Virginia, during evaluation of a technique employing DES for suppressing reproduction of wild foxes, January to June, 1968

Based on total land area (20.3 sq miles), the treated area produced 1.0 gray foxes per square mile, 0.2 red foxes per square mile, and 1.2 total foxes per square mile. The Broad Run area (17.8 sq miles) produced 0.6 gray foxes per square mile, 0.1 red foxes per square mile, and 0.7 total foxes per square mile. (The small land area and small trapping effort on the Salem dump area did not justify a comparative density value.)

Incidence of Marking

Apparently DMCT was a satisfactory marker. A clear-cut demarcation was observed between marked and unmarked animals; specimens showed either obvious evidence or no evidence of fluorescence. However, some specimens showed a greater degree of fluorescence than others. Eleven (52.4 percent) of the 21 gray foxes from the treated area (including one of two escapees) showed evidence of the marker. Five (38.5 percent) of 13 males and five (83.3 percent) of six females were marked. At the $P<0.10$ level, a significantly greater number of females were marked than males (1 d.f., chi-square = 3.66). Only one (25.0 percent) of four red foxes was marked. The marked animal was one of two males. Twelve (48.0 percent) of 25 total foxes (red and gray) were marked (Table X). Marked foxes were evenly distributed throughout the area. No evidence of marker was observed for seven striped skunks, two dogs, one opossum, and one raccoon taken from the treated area. No evidence of marker was observed for animals collected from reference areas.

Reproductive Success

The treatment had no obvious effect on reproductive success of

Table X. Incidence of marked male and female foxes captured on the Havens area, Roanoke County, Virginia, April 21 to June 3, 1968*

Item	Gray fox	Red fox	Total
Female			
Number captured	6	2	8
Number marked	5(83.3)[@]	0(0.0)	5(62.5)
Male			
Number captured	13	2	15
Number marked	5(38.5)	1(50.0)	6(40.0)
Unsexed[#]			
Number captured	2	0	2
Number marked	1(50.0)	0	1(50.0)
Total			
Number captured	21	4	25
Number marked	11(52.4)	1(25.0)	12(48.0)

* Animals were marked with treated baits containing DMCT (and DES)

@ Percentages in parentheses

\# Animals which escaped, leaving a foot in the trap the red fox population. All (three) red females, two from the treated area and one from Broad Run, successfully reproduced. None were marked. Among female gray foxes from the treated area, six (100.0 percent) of six failed to reproduce. Five were marked (Table XI). Perhaps most significant was that none of the six animals ovulated as evidenced by absence of corpora lutea. Age criteria indicated that at least two of the marked animals were yearlings. The unmarked anovulatory animal was older (4+ years). Five (83.3 percent) of six gray females from reference areas successfully reproduced. The non-producing animal was an anovulatory yearling. Based on reproductive success from reference areas, a chi-square test indicated that unsuccessful reproduction on the Havens area was associated with the treatment ($P<0.025$, 1 d.f., chi-square = 5.49 based on all six females or $P<0.025$, 1 d.f., chi-square = 5.17 based on the five marked females). (Calculations included a continuity factor described by Steel and Torrie 1960:357-358.) Apparently females of other species from the treated area, including two skunks and one raccoon, successfully reproduced. Two female dogs captured on the area were in estrus. No animals other than foxes were marked. Table XII shows reproductive data from females of species collected on the treated area. Table XIII shows reproductive data from female foxes collected on reference areas.

Age Classification

Accuracy of age classification was not expected to be very reliable due to small sample sizes. Results from the eye lens tech-

Table XI. Reproductive success of female foxes collected from treated* and reference study areas in Virginia, April 21 to June 3, 1968

Item	Treated area@	Reference areas@@
Gray females		
Number captured	6	6
Number marked	5(83.3)#	0(0.0)
Number marked that reproduced	0(0.0)	--
Number unmarked that reproduced	0(0.0)	5(83.3)
Red females		
Number captured	2	1
Number marked	0(0.0)	0(0.0)
Number marked that reproduced	--	--
Number unmarked that reproduced	2(100.0)	1(100.0)
Total		
Number captured	8	7
Number marked	5(62.5)	0(0.0)
Number marked that reproduced	0(0.0)	--
Number unmarked that reproduced	2(100.0)	6(85.7)

* Animals were treated with baits containing DMCT and DES
@ Havens Game Management Area, Roanoke County
@@ Includes Broad Run Management Area, Craig County and Salem city dump, Roanoke County
\# Percentages in parentheses

Table XII. Reproductive data from females of species collected on the Havens area, Roanoke County, Virginia, April 21 to June 3, 1968

Ident. no.	Species	Reproductive* condition	No. corpora lutea	No. placental scars	Mean ovary length (mm)	Mean ovary width (mm)	Mean uterine width (mm)
HF01	Gray fox[@]	non-parous	0	0	9.8	5.6	3.7
MR14	Gray fox	non-parous	0	0	10.7	7.5	5.0
OM01	Gray fox[@]	non-parous	0	0	8.8	5.4	3.8
MR02	Gray fox[@]	non-parous	0	0	8.9	5.5	4.5
MR06	Gray fox[@]	non-parous	0	0	10.0	6.0	3.0
PR01	Gray fox[@]	non-parous	0	0	9.2	5.6	3.6
MR17	Red fox	post-partum[#]	5	4	13.3	6.9	4.7
HF03	Red fox	post-partum[#]	6	2	10.3	8.0	4.7
MR17	Raccoon	pregnant[#]	--	--	--	--	--
HF05	Opossum	--[#]	--	--	--	--	--
HF06	Skunk	post-partum[#]	5	4	--	--	--
PR02	Skunk	pregnant	--	--	--	--	--

* Non-parous condition does not necessarily mean virgin
@ Indicates evidence of DMCT (and DES treatment)
# Indicates evidence of lactation

Table XIII. Reproductive data from female foxes collected from two reference areas*, Virginia, May 1 to June 3, 1968

Ident. no.	Species	Reproductive condition	No. corpora lutea	No. placental scars	Mean ovary length (mm)	Mean ovary width (mm)	Mean uterine width (mm)
BR04	Gray fox	post-partum#	3	3	10.7	5.3	12.3
BR03	Gray fox	post-partum#	4	3	11.7	7.7	7.2
BR09	Gray fox	post-partum#	4	4	10.0	6.4	10.6
BR02	Gray fox	non-parous	0	0	10.9	7.9	3.6
BR11	Red fox	post-partum#	5	2	12.0	8.7	3.7
SD01	Gray fox	post-partum#	5	4	9.6	6.3	4.4
SD03	Gray fox	post-partum#	4	3	9.7	5.8	6.6

* Broad Run area (BR), Craig Co. and Salem dump area (SD), Roanoke Co.
\# Indicates evidence of lactation

nique did not show any definite peaks or clumps which would indicate a particular age-class (Fig. 4). Single lens weights, or the mean of both when available, ranged from 224 mg to 277 mg for red foxes. The close proximity of the three lowest values possibly represented the yearling age-class. For gray foxes the weights ranged from 163 mg to 216 mg. The only evaluations that could be made with any certainty for either species were that weights on the lower extreme represented yearlings and those on the upper extreme represented older animals.

General tooth-wear was not as reliable as eye lens weight for age classification. Correlation of tooth-wear with lens weights for red foxes appeared to be very good, but correlation for gray foxes showed little consistency or predictability. However, in conjunction, the two criteria permitted assignment of some animals to discrete age-classes. Two red foxes were classified as yearlings and one was classified as an old animal. Six gray foxes were classified as yearlings and three as old animals. Body weights and size and development of female reproductive tracts offered some confirmation to these classifications. However, the remaining animals were assigned to less precise age classes. Tables XIV, XV, and XVI show age classification of foxes on the basis of all criteria.

Parturition and Breeding Dates

Based on condition of reproductive tracts after parturition, Layne and McKeon (1956:59) classified some animals by approximate parturition dates. Based on their data and relative enlargement of post-partum tracts, estimated parturition dates of the three red

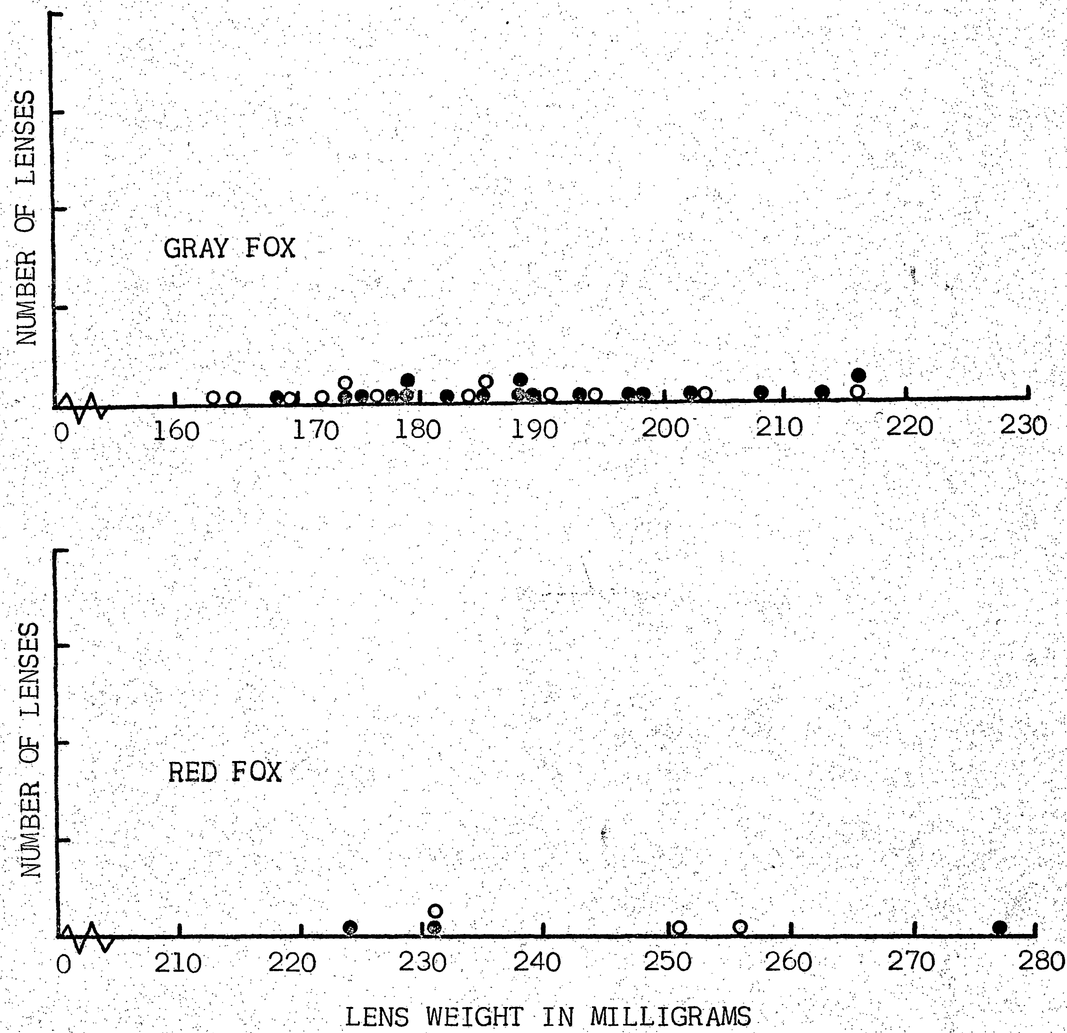

Fig. 4. Distribution of dried eye lens weights from wild foxes collected on three study areas in Virginia, April 21 to June 3, 1968 (Symbols: solid = male; open = female)

Table XIV. Age data for gray foxes collected on the Havens area*, Roanoke County, Virginia, April 21 to June 3, 1968

Ident. no.	Sex	DMCT marked	Mean lens weight (mg)	Degree tooth-wear	Body weight (lb.)	Age (years)
PR01	F	+	163	none	5.0	1
MR01	M	+	168	none	5.8	1
MR02	F	+	172	none	5.4	1
MR03	M	+	(175)@	light	7.3	1-2
MR04	M	+	178	light	6.1	1-2
MR05	M	+	182	light	6.0	1-2
MR06	F	+	184	light	7.4	1-2
MR07	M	-	185	light	8.0	1-2
HF01	F	+	(185)	light	--	1-2
MR08	M	-	188	none	8.8	1-2
MR09	M	-	188	heavy	6.6	2-3
HF02	M	+	189	light	7.4	1-2
OM01	F	+	191	none	6.3	1-2
MR10	M	-	197	heavy	7.1	2-3
MR11	M	-	198	light	7.2	2-3
MR12	M	-	202	none	7.2	2-3
MR13	M	-	213	heavy	7.2	4+
MR14	F	-	216	heavy	7.6	4+
MR15	M	-	--	heavy	8.7	4+

* Area treated with baits containing DMCT and DES

@ Figures in parentheses are single lens weights

Table XV. Age data for gray foxes collected on two reference areas* in Virginia, May 1 to June 3, 1968

Ident. no.	Sex	Mean lens weight (mg)	Degree tooth-wear	Body weight (lb.)	Age (years)
BR04	F	165	light	6.5	1-2
BR09	F	169	light	6.8	1-2
BR07	M	174	none	6.6	1
BR02	F	174	none	6.0	1
SD03	F	176	none	6.0	1
BR06	M	177	heavy	7.2	2-3
BR05	M	178	light	7.2	1-2
SD02	M	193	none	7.9	1-2
SD01	F	194	light	6.3	2-3
BR03	F	203	light	7.6	2-3
BR08	M	208	light	7.6	2-3
BR01	M	216	heavy	7.6	4+

* Broad Run area (BR), Craig Co. and Salem dump area (SD), Roanoke Co.

Table XVI. Age data for red foxes collected on two study areas* in Virginia, April 21 to June 3, 1968

Ident. no.	Sex	DMCT marked	Mean lens weight (mg)	Degree tooth-wear	Body weight (lb.)	Age (years)
MR16#	M	+	224	none	7.4	1
BR10	M	--	231	light	8.1	1-2
BR11	F	--	231	none	7.1	1
HF03#	F	-	251	light	7.0	2-3
MR17#	F	-	256	light	6.4	2-3
HF04#	M	-	277	heavy	7.2	4+

* Havens area (MR and HF), Roanoke Co. and Broad Run area (BR), Craig Co.

\# Animals from the treated (DES and DMCT) area (Havens) females were between early March and mid-April. Therefore, on the basis of a 53-day gestation period, breeding dates were sometime between mid-January and the third week of February. The five successful gray foxes apparently parturated between late March and early May. Corresponding breeding dates (based on 53-day gestation) occurred from late January to late March. Observations of paired gray fox trails in late January and early February added further credence to these estimates.

DISCUSSION

Application of Baits

Poor tracking conditions, weak test designs, and small sample sizes did not permit reliable estimates of bait acceptance by species. Perhaps one type of bait was not shown to be more acceptable than another for those reasons. However, a few cases indicated the possibility that coated baits were more easily detected or readily accepted than plain baits by gray foxes. Those cases were the meager grounds for trying baits coated with sugar and oil exclusively during the final pre-baiting, although a more logical selection might have been either sugar or oil coated baits. (Baits coated with sugar and oil were not tested with other bait-types in previous trials.) Nevertheless, results from the final pre-baiting warranted continued use of baits coated with both, even though some other type may have worked just as well. Results from treatment applications showed that baits were not consumed only two known times (0.9 percent) at sets visited by foxes. Gray foxes apparently consumed baits more readily than any other single species. The low incidence of red fox visits and bait consumption was probably due to a low red fox population and a low individual rate of acceptance. The fishy smelling baits may not have appealed to reds as much as grays. The same may have been true for dogs. In New York, tallow baits were not eaten on 41.0 percent of all fox visits, but gray foxes were more apt to take baits than red foxes (Linhart 1964:73). In later New York studies, gray foxes readily consumed high percentages of all baits offered but red foxes showed some aversion to treated baits (Mr. Eugene Parks, Senior Wildlife Biologist, New York State Conservation Department, personal communication).

The pre-conditioning value of pre-baiting was not firmly established. Percentage of times that sets were undisturbed appeared to decrease from initial pre-baiting (36.8 percent) through treatment applications (21.5 percent), and percentage of times baits were consumed by foxes appeared to increase from initial pre-baiting (12.6 percent) through treatment applications (21.2 percent); however, those apparent trends could be due simply to the different methods of value determination for each. Nevertheless, over-all results (including fox diggings in snow for baits, the high percentage of sets visited by foxes during final pre-baiting, evidence of some foxes following bait lines, and range of fox consumption rates during treatment applications) seemed to indicate that pre-conditioning efforts were at least partially successful. The low rate of treated bait rejection by foxes (0.8 percent of baits taken) and the apparent low rate of aversion to treated baits by foxes (0.9 percent of sets visited by foxes) lend further support that some foxes were conditioned to bait acceptance. The author suspects that increased consumption of baits by foxes in New York as winter progressed may have been partially due to the pre-conditioning principle (Linhart 1964:75).

During all bait applications, particularly treatment applications, maximum bait acceptance by foxes was considered more important than maximum identification of visitors. In other words, natural conditions at sets were favored over artificial improvement of tracking conditions to enhance the probability of bait acceptance and to avoid additional aversion factors. Consequently, a possibility exists that foxes consumed more baits than were attributed to them. Proper identification of visiting animals was possibly more of a problem than low rate of bait consumption by foxes. For example, during the final pre-baiting when tracking conditions were good at all sets, 73.9 percent of all sets were visited by foxes and 80.4 percent of all visits were attributed to foxes. If recorded visits were indicative of bait consumption by foxes, foxes consumed 70.3 percent of the baits (mathematical expectation). In addition, results from treatment applications show a visible correlation between improving tracking conditions and probability of baits visited by foxes being taken by foxes. A similar trend is visible between improving tracking conditions and the probability of all baits being taken by foxes (Table XVII). Under good to excellent tracking conditions foxes consumed more than 55 percent of treated baits. This evidence may, or may not, mean that treated bait consumption can be interpolated (proportionately reassigned) from unidentified species to known species. If this is the case, then foxes may have consumed a maximum of 56.0 percent (344), an expected value of 32.7 percent (201), or a minimum of 11.4 percent (70) of all baits. Of course, these evaluations are purely speculative; however, such results were feasible. Other possible evidence that foxes took more baits than visitor evidence indicated includes the observation that foxes were the only marked animals and that few

Table XVII. Probability of treated* baits being taken by foxes under different tracking conditions on the Havens area, Roanoke County, Virginia, January 31 to March 29, 1968

Item	Tracking condition					
	Excel.	Good	Fair	Poor	Unsuit.	Total
No. times sets rated	16	49	225	229	95	614
No. sets visited by foxes	9	40	116	56	1	222
Mean probability of# bait taken by foxes at sets visited by foxes	100.0	70.6	55.4	38.8	25.0	55.6
Mathematically## expected percent of all baits taken by foxes	56.3	57.7	28.6	9.5	0.3	20.1

* Baits treated with DMCT and DES

\# Mean probability of bait take for respective tracking conditions = $(\Sigma Pi/n)100$ (Pi = probability of take per set; n = number of baits taken by foxes for respective tracking conditions)

\## Determinations for respective tracking conditions by mathematical expectation: B = $(\Sigma Pi/N)100$ (B = percent of baits consumed by a species; Pi = probability of take by a species per set; N = total number of baits available) baits remained at sets over 10 days.

On the other hand, however, hard to identify species such as small rodents or crows may have accounted for the disappearance of a number of baits. (During trapping operations 9 crows were captured at bait sets, but during baiting operations crow visits were evident at only a few sets.) Also, low fox populations in some sections may have accounted for low takes of bait by foxes. The sections with the lowest consumption of baits produced very few foxes.

Effectiveness of Marking and Trapping

Incidence of marked female gray foxes (83.3 percent) was very satisfactory, indicating nearly total treatment of the primary target animals. However, incidence of marked gray males (38.5 percent) was significantly lower ($P<0.10$). The difference may have been due to the significantly greater proportion of males than females that were captured ($P<0.10$), which raises a question why a preponderance of males was captured. (On the Broad Run area the sex ratio was approximately the expected 100:100.) Probably not all females on the treated area were captured. Layne and McKeon (1956:53) also found a large imbalance in favor of males from late winter to early summer in New York. They offered the explanation that females were probably more secretive and restricted in their movements during that time because of advancing pregnancy, whelping, and early postnatal care of young. Similarly, Layne (1958:157) found an overall sex ratio of nearly 100:100 in southern Illinois, but noted a marked decrease of females taken in April and May. Another possibility is that a few transient males immigrated into the area in search of mates, after treatment applications. (The last three captures were unmarked males.) However, escapees may have been males also. (The two escapees which each left a foot in the trap very likely were males as evidenced by the large foot size.) The total incidence of marked grays was 52.4 percent. Number of escapees, probability of some animals being untrappable, and tracks and signs of foxes indicated that about five gray foxes remained on the area after trapping operations.

Incidence of marked red foxes (25.0 percent) was relatively low. No females were marked. Paired sites of capture, sex ratio of captures, and lack of tracks and signs indicated that probably only one or two, if any, red foxes remained after trapping operations. The low percentage of marked animals was evidence that baits were not nearly as acceptable to red foxes as gray foxes. Bait trials in New York showed similar results (Parks, personal communication).

The incidence of marking for all foxes was 48.0 percent. This figure is higher than incidence of DMCT-marked coyotes in the Southwest which was 28 percent in 1966 and 34 percent in 1967 (Linhart et al. 1968:321). However, the incidence of achromycin-marked foxes in New York was 68 percent (Parks 1968:111). The honey-tallow baits used in New York may have been superior to suet baits. However, evidence seemed to indicate that some foxes on the Havens area became over-conditioned to bait acceptance. A few individuals may have adapted to the "handouts" by visiting sets regularly in search of baits, thereby reducing the probability that all animals would take baits. Several sets were visited regularly by more than one fox (though not necessarily the same ones), many sets were located and dug out after fresh snowfalls, and occasionally fox trails were observed along roads from one set to another. In addition, some animals showed a much greater degree of fluorescence than others, and some exhibited an unusual type of alopecia. Both conditions may be symptoms of high DES doses (Linhart and Kennelly 1967:320 and Mulligan 1943:22). A remote possibility exists that a few old animals may have eaten baits without showing evidence of the marker. (Linhart and Kennelly 1967:319 reported that quantity and intensity of fluorescence were related to age of the animal.)

Evidence of fox abundance from observations made during preliminary surveys and bait applications indicated that 25 to 30 gray foxes and two or three red foxes were frequenting the Havens area. (Estimates were made prior to trapping.) The estimates were purely subjective, based on previous experience by the investigator. However, the close agreement with trapping results may indicate that the actual population size was close to those levels. In total, 26 gray foxes, including five escapees, and four red foxes were captured.

Reproductive Success

At the $P<0.025$ level, unsuccessful reproduction was associated with the treatment. Reproduction on the treated area was definitely subnormal, but the treatment was not necessarily the causal agent. More certainty can not be placed on the evaluation of results because none of the gray foxes from the treated area ovulated. The primary effect of DES is disruption of pregnancy, not delayed ovulation or estrus (Parks 1968:105). However, if DES was effective, delayed ovulation was the avenue in this study. (Dr. J. J. Kennelly, Animal Physiologist, Denver Wildlife Research Center, personal communication, suggested that ovulation may have been blocked altogether.) The situation is further complicated by the possibility that some yearlings were just reaching sexual maturity. Thus, evaluation of results hinges on two principal factors: 1) the effects of DES on ovulation and 2) the effect of age on sexual maturity.

Estrogens in physiological doses are undoubtedly stimulants of LH release and are probably necessary for ovulation; however, estrogens in large doses completely inhibit all gonadotropin release from the pituitary (van Tienhoven 1968:111). Estrogens can inhibit ovulation if given at the proper time and level in the reproductive cycle. Balser (1964b:357) suspected this effect when two penned coyotes ovulated 30-45 days after administration of a single 100-mg oral dose of DES given about 3 weeks before the normal peak of estrus. In New York, Dr. A. M. Bowerman, animal physiologist at Cornell, found no indication of delay in estrus or ovulation when captive red foxes were given 50 mg of DES every 10 days (personal communication). However, ovulation was delayed for the duration of feeding period (6 weeks) when 1 mg of DES was fed daily. Estrus and ovulation occurred in most animals within 4 weeks after final administration. Estrus was delayed 1 to 4 weeks when animals were fed 50 mg of mestranol (another estrogen) every 10 days. Evidence of estrogen toxicity was observed in most animals fed mestranol. Thus, DES could have delayed ovulation in animals from the Havens area, although exact effects on gray fox reproduction are not known.

No lab studies have been conducted on gray fox reproduction. However, Parks (personal communication) found results very similar to those from the Havens area during DES field trials on gray foxes in New York. Eight of nine marked females were barren. Four did not ovulate. (Results are compared in Table XVIII.) Results from both studies were very unusual when compared to reproductive data from reference areas. In previous New York studies, Sheldon (1949: 241) found only 3.3 percent barren females and Layne and McKeon (1956:63) found only 3.8 percent barren females. And all of those animals had ovulated. Furthermore, Wood (1958:82) found that 92.3 percent of the yearlings bred in Georgia and Florida. In this study, 83.3 percent of the animals from reference areas successfully reproduced.

However, the effect of age on reproduction warrants much consideration. (Sheldon 1949:241 also cited some secondhand reports from trappers that not all gray foxes breed their first year.) One animal (BR02) from a reference area did not ovulate. That animal, two of six anovulatory animals from the treated area, and three of four anovulatory animals from New York appeared to be juvenile, non-parous animals. Three other females from the treated area could have been yearlings. However, age criteria indicated that four of the five ovulatory animals from untreated areas also could have been yearlings.

Table XVIII. Reproduction data from gray foxes collected from DES-treated areas and reference areas in Virginia and New York

Categories	Virginia			New York		
	Treated area*		Reference areas**	Treated area#		Statewide## (reference)
	Marked@	Unmarked		Marked@@	Unmarked	
No. foxes	5	1	6	9	2	53
No. barren	5	1	1	8	1	2
Percent barren	100.0	100.0	16.7	88.9	50.0	3.8
No. anovulatory	5	1	1	3	1	0
Percent anovul.	100.0	100.0	16.7	33.3	50.0	0.0

* Havens area, Roanoke Co.
** Broad Run area, Craig Co. and Salem dump area, Roanoke Co.
\# Parks (personal communication)
\## Layne and McKeon 1956
@ DMCT marker
@@ Achromycin marker

Some anovulatory animals were almost surely yearlings. Layne (1958: 160) suggested that some yearlings may reach sexual maturity too late in the year to breed. (He found one non-pregnant animal, apparently a yearling, that had corpora lutea late in June in southern Illinois.) Consequently, some animals from the treated area likely would not have bred regardless of the treatment. Parks and Bowerman (personal communication) made the same conclusion from their work in New York. However, a possible alternative explanation for both sets of results is that DES delayed ovulation in older animals and onset of sexual maturity (or ovulation) in yearlings. If such were the case, animals would be expected to ovulate later in the year. Of course, a check was not possible. Whether or not such a delay would suppress reproduction for the entire breeding season is only further speculation. However, since fertility of males would have to be coincidental, females probably would not breed until the following season. (Layne 1958:162 found that all males were sexually inactive during May and June in southern Illinois.) Estimates of parturition and breeding dates were not considered very reliable. However, they indicated that gray foxes did not breed much earlier than the first of February. The younger animals in particular appeared to have bred somewhat later. Consequently, treated animals easily could have consumed baits before normal estrus dates.

Regretfully, the problem of an age factor was not anticipated. Aging by the eye lens technique was originally planned mainly as a supplementary exercise because it appeared to be a promising technique. However, Wood's (1958:76) tooth-wear technique would have been an invaluable tool for more precise evaluation of individual age. Records of nipple development and coloration also would have been useful for separating yearlings from adults (Layne 1958:158). Fortunately, a few animals were placed in discrete age classes with some certainty.

RECOMMENDATIONS

In continuing studies on the topic of chemosterilants, several modifications in techniques and procedures would enhance effectiveness of treatment and clarity of results. For instance, sophisticated trials of bait acceptance might turn up a more readily accepted bait. Sardine oil-coated suet baits warrant trials on a larger scale for gray foxes. The more economical honey-tallow baits used in New York also warrant consideration. However, chances of finding a "super bait" for red foxes appear slim. (Research in Virginia should probably be directed at gray foxes anyway.) In addition, design of bait sets must be improved if accurate records of visits and bait consumption by species are wanted. But only experience will tell how much artificiality can be afforded at sets without causing aversion to sets by foxes.

Selection of study areas is also an important consideration. Sample sizes can be increased by selecting areas of larger size or areas with greater fox densities. And if time permits, a control area in addition to reference areas would be very meaningful for evaluations of treatment effects. A large natural land feature such as Massanutten Mountain in Rockingham County would probably afford maximum treatment and manipulation of a fox population. Fox movements of any kind are somewhat localized by such features.

Perhaps the best solution to what constitutes normal gray fox reproduction would be supplementary studies (i.e., perhaps by graduate students). Carcasses collected routinely during vital months by state trappers could be analyzed by a lab technician. Data on ages, breeding dates, parturition dates, ovulation rates, and conception rates should be collected. Information from several years would be highly desirable. In addition some future applications of treated baits should be made later in the breeding season (after peak of ovulation) to increase the probability of affecting pregnancy rather than ovulation. (The most effective dates for applying treatment must be determined if this approach to population control is to become practical.) Also, collecting operations subsequent to future treatments could be delayed an additional month to determine if DES does effectively delay ovulation.

If a suitable technique of application can be developed and reproduction can be suppressed in some way (disrupted pregnancy or delayed ovulation), this technique may have great value, particularly as an adjunct to a trapping program. Future promotions of research and application should be directed toward development of the technique as a supplement to trapping, not as a replacement. Once populations are reduced by mortality factors, application of chemosterilants promises to be a practical and effective means of keeping populations below disease supporting levels. For whatever their use in population manipulation, chemosterilants deserve study and development as a practical tool for the population manager.

SUMMARY

Poor tracking conditions at sets and modifications of techniques during successive bait applications weakened evaluations of bait trials. Sets visited during pre-baiting (76.6 percent) included 30.1 percent by foxes, 21.2 percent by dogs, and 19.5 percent by unknown visitors. An additional 5.0 percent of the sets were visited by dogs and/or foxes; positive identification was not possible. In trials of assorted baits (plain, sugar-coated, and sardine oil-coated), foxes showed no preference, having consumed approximately 16 percent of each. Dogs and unknown visitors each consumed slightly more than 16 percent of each bait-type. However, the high percentages of sugar-oil baits visited (73.9 percent by foxes and 20.5 percent by dogs) were not recorded as consumed because snow obliterated original visitor evidence.

Sets visited during treated bait applications (78.5 percent) included 36.2 percent by foxes, 3.4 percent by dogs, and 40.2 percent by unknown visitors. In total, 99.2 percent of the baits visited were taken and 99.2 percent of the baits taken were consumed. However, estimates of bait consumption by identifiable species were rather low as determined by mathematical expectation. Gray foxes consumed 20.2 percent, red foxes consumed 1.0 percent, dogs consumed 2.0 percent, and unknown visitors consumed 54.8 percent.

Trapping results on the treated area totaled 21 gray foxes (including escapees), 4 red foxes, 8 dogs, 7 striped skunks, 7 opossums, 5 raccoons, 5 feral cats, 9 crows, and 3 miscellaneous animals.

Captures on reference areas totaled 13 gray foxes (including 1 escapee), 2 red foxes, 9 dogs, 22 striped skunks, 4 crows, and 10 miscellaneous animals. Sex ratios of red foxes on all areas and gray foxes on reference areas did not differ significantly from the expected 100:100. However, at the $P<0.10$ level the treated area produced a preponderance of male gray foxes (13:6). The ratio of gray foxes to red foxes was 5.2:1 on the treated area and 5.0:1 on the Broad Run area.

Eleven (52.4 percent) of 21 gray foxes from the treated area were marked. At the $P<0.10$ level, a significantly greater number of females (83.3 percent) were marked than males (38.5 percent). One of four red foxes was marked. No other species were marked.

All female red foxes, two from the treated area and one from the Broad Run area, successfully reproduced. None were marked. All (six) female gray foxes from the treated area were barren and anovulatory. At least two of five marked females were yearlings. The unmarked female was 4 or more years old. Five (83.3 percent) of six gray fox females from reference areas successfully reproduced. The barren animal was an anovulatory yearling. At the $P<0.025$ level, unsuccessful reproduction was associated with the treatment. Apparently females of other species from the treated area successfully reproduced.

Results from the eye lens technique did not indicate precise age classes. Based on correlations between eye lens weights and general tooth-wear, two red foxes and six gray foxes were classified as yearlings. One red fox and three gray foxes were classified as old animals. Age determinations of other foxes were less certain.

Apparently red foxes bred between mid-January and the third week of February, and gray foxes bred from late January to late March.

CONCLUSIONS

Due to such factors as poor tracking conditions at sets, varied baiting techniques, varied methods of assigning set visits and bait consumption by species, and small sample sizes, results from bait trials were largely inconclusive. However, in the opinion of the investigator, cumulative evidence indicated that foxes visited more sets and consumed more baits than the respective reported values of approximately 34 percent and 20 percent. Support for these contentions included 1) evidence that some foxes were pre-conditioned to bait acceptance, 2) the high percentages of sets visited and baits consumed by foxes during good tracking conditions, 3) the high percentage of total visits represented by foxes, 4) the percentage of trapped animals that were foxes, and 5) the observation that foxes were the only marked animals. Perhaps foxes consumed 50 percent of all baits. Similarly, the investigator feels that coated baits, particularly sardine oil-coated baits, were very satisfactory for gray foxes. In addition, DMCT was apparently a satisfactory oral marker.

Effects of DES on reproductive success, like results from bait trials, were somewhat unclear. The failure of gray foxes to ovulate was unexpected. One explanation for this phenomenon is that ovulation was affected by DES; another is that animals were sexually immature yearlings. In the investigator's opinion, both explanations were probably responsible factors. Some treated animals likely were non-breeding yearlings as evidenced by the one naturally barren yearling from the Broad Run area. Also, some animals likely experienced delayed ovulation as evidenced by the complete lack of ovulation among gray females from the treated area. The latter explanation is particularly plausible due to the likelihood that some animals consumed high doses of DES before normal ovulation dates.

Results were promising. Although baiting techniques lacked sophistication and precision, the investigator feels that DES did suppress reproduction of gray foxes on the Havens area. However, continuing studies must be conducted to clarify and confirm these conclusions.

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EVALUATION OF A TECHNIQUE EMPLOYING THE
CHEMOSTERILANT DIETHYLSTILBESTROL FOR
SUPPRESSING REPRODUCTION OF WILD FOXES IN VIRGINIA

by

Claude Michael Oleyar

ABSTRACT

A field test using diethylstilbestrol was conducted on the 13,000-acre Havens area on Fort Lewis Mountain, Roanoke County, Virginia; reference areas were also selected. Foxes were pre-conditioned to bait acceptance using molded beef suet. A total of 614 suet baits each containing diethylstilbestrol (50 mg) and oral marker (35 mg of demethylchlortetracycline) were distributed seven times from late January to late March. After a 3-week delay, animals were trapped on all areas and examined for reproductive success and marker evidence.

Foxes consumed at least 20 percent of all baits and other identifiable species consumed 12 percent; however, unidentified visitors consumed 43 percent. Twenty-one gray foxes (11 marked) and four red foxes (one marked) were trapped on the treated area. Two female red foxes from the treated area and one from a reference area successfully reproduced. None were marked. All (six) female gray foxes from the treated area were barren and anovulatory. Two of five marked females probably were yearlings; the unmarked female was 4 or more years old. Five of six female gray foxes from reference areas successfully reproduced. The barren female was an anovulatory yearling. At the $P<0.025$ level (1 d.f., chi-square = 5.17) unsuccessful reproduction

was associated with the treatment. No other species showed evidence of marker or effects of treatment.