EFFECTS OF PESTICIDES ON SMALL MAMMAL POPULATIONS. PHASE I

by

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INTRODUCTION

Scientists have been concerned with the possible harmful effects of synthetic organic pesticides on wildlife since 1943 when production of DDT first began (DeWitt and George, 1960:1). Decker (1960:31) reported that because the food, fiber and public health needs in the future will assure expanded use of pesticides, the effects of pesticides must be known.

Because of this situation, a broad research program was begun by Kansas State University in 1965 to determine the effects on an ecosystem of normal pesticide applications. This broad program was entitled the "Reduction of hazards associated with the presence of residues of insecticidal chemicals in the environment". The major cooperating agencies involved in this project included the Kansas Agricultural Experiment Station (project 481, NC-85), and the departments of Entomology and Zoology of Kansas State University, Manhattan. Other agencies involved with the ground and surface water analysis were the Kansas Water Resources Research Institute, the Office of Water Resources Research of the Department of the Interior, and the Kansas Department of Health.

The terrestrial ecology portion of the overall project was conducted by the Department of Zoology, Kansas State University and consisted of a study of small mammal population dynamics.

This paper presents results of a comparative study of population dynamics on two areas in western Kansas. The impact of pesticides will be reported at a later date.

LITERATURE REVIEW

The majority of the work dealing with pesticidal effects has concerned birds and fish. The few studies that have dealt with pesticide effects on mammals (Coburn and Treichler 1946, DeWitt et al. 1962 and DeWitt 1966) have been conducted primarily in the laboratory (Rudd, 1964:112). Leedy (1962:26) indicated definite limitations of such laboratory studies but also reported laboratory experiments yield the quickest reliable information of pesticide effects (Leedy, 1962:25). However, to fully understand the effects of pesticides on wild populations they must be studied under natural conditions.

Wildlife in its natural habitat may contact pesticides by ingestion, inhalation and absorption (Decker, 1963:16-17). Kieth and Hunt (1966:174) reported contamination of food to be the primary source of exposure. Mulla (1966:21) reported pesticide applications change the dynamic relationships in the immediate environment. The magnitude of the impact on wildlife depends upon the stability of materials employed, method of application, drainage and movement of water and the extent and frequency of treatment (Mulla, 1966:23). DeWitt et al. (1960: 277) believed the greatest problem in determining the effects of pesticides was obtaining positive evidence that the mortality was actually the results of exposure to the pesticide.

DeWitt and George (1960:16) and Hunt and Bischoff (1960:91) reported that effects on wildlife are insidious and often entirely unnoticed or are not discernable for a long time after initial contact with a toxic material. Rudd (1964:132-140) listed the following sublethal effects of pesticides: loss of vigor, adverse behavior, impaired growth and slowing of reproduction. Storer (1946:182) reported the effect of DDT was cumulative.

Because of this indirect effect either in reproduction or in some other fashion, one cannot simply expect to find great numbers of dead or dying animals following an application of a toxic chemical. Therefore, a method must be used whereby a continuing census is carried out. A correlation between applications of DDT and dieldrin and a population decline of Lepus europeus was found by van Klingeren et al. (1966:130). However, they concluded this was not proof of a causal relationship but an indication that it may have been.

The many variables affecting population size may alter the data collected from such a study, shielding or perhaps increasing the actual effects of pesticide applications. Davenport (1964:110) reported variations in density at various times in the same place should be expected more often than a stable population. Blair (1948:397) found populations varied considerably from one year to another. Variables affecting population size include: precipitation (Bradshaw, 1956:47, Rolan, 1961:56), food (Brown, 1953:238, Fitch, 1954:47, Jameson, 1953:54, Jameson, 1955:207), competition (King, 1957:356, Rudd, 1964:130), disease (Rolan, 1961:62) and predation (Rolan, 1961:62). Blair (1948:414) found species with generally similar habits showed concurrent trends in population density.

However, one cannot simply compare densities of populations. The rate of population turnover must also be considered in a population dynamics study. Hamilton (1942:218) found a distinct turnover in small mammal population each winter. Odum (1955: 377) reported a complete population turnover occurred in _Sigmodon hispidus_ every six months. Blair (1948:414-415) believed less than 10 percent of the population loss was due to dispersal. He further indicated that predation was the primary cause of a small mammal's short life span. Getz (1960:404) found highest mortality occurred in the first month of life.

In order to obtain the most useful information on small mammal population densities and rates of turnover the most suitable type of trap must be chosen. While Goodnight and Koestner (1942:437) and Buckner (1957:97) believed snap traps gave a population estimate as equally reliable as live traps, others such as Dice (1938:121), Manville (1949:27), Stickel (1946:158) and Zippin (1958:90) believed live traps gave a more reliable estimate.

In addition to the type of trap employed most estimates also depend upon the placement and spacing of traps and the length and frequency of the trapping period. Most authorities (Dice, 1938:128, Stickel, 1948a:161) reported grid patterns to be more effective than lines when estimating populations. Blair (1941:149) reported trap placement, pattern and spacing depends upon the habitat and species encountered. Murray (1957:442) reported quadrats are frequently unsuited to special situations. Dice (1938:128) found straight lines of traps provided reliable indices to population.

Blair (1940a:274) set live traps in parallel lines with the traps spaced 60 feet apart when studying Peromyscus maniculatus in Michigan. He found this distance was close enough to catch all resident animals yet far enough apart to trap large areas.

Goodnight and Koestner (1942:437) found live traps provided a population estimate in six to seven days. Baker (1946:399) reported new mice still appearing at the end of a 9-day trapping period. Sanderson (1950:25) found 10 days of trapping sampled only about 50 percent of the population.

Getz (1960:392) reported samples of the population should be taken at least at monthly intervals and samples taken too frequently (intervals of less than one month) disturbed the population in the area.

When one conducts a trapping study involving the trap, mark and recapture procedure there are several assumptions that must be made. According to Dice (1941:401-402), one must assume random distribution of marked animals throughout the population and no loss of marked animals or gain of unmarked animals. Adams (1951:13-14) listed the assumptions necessary for this type of population study as follows: same mortality for marked and unmarked animals, sampling should include marked and unmarked animals at random, animals must be randomly mixed, and there should be negligible recruitment. Zippin (1958:82) assumed the population was stationary, the probability of capture was the same for each animal and the probability of capture remained the same from trapping to trapping. The assumptions listed by Hayne

(1949b:400) were similar to those mentioned. However, Evans (1949:362) reported marked individuals were not dispersed at random throughout the population and found large differences in the frequency of capture of various mice. Hayne (1949b:400) also questioned whether or not all animals were exposed to a set of traps with the same probability of capture. Gies (1955: 471) reported heterogenious trap response displayed by cottontail rabbits caused a low estimate of the population when uniform trap response was assumed. Sealander et al. (1958:541) found only about 50 percent of approaches to traps resulted in captures. Morris (1955:34), Sealander et al. (1958:542), Tanaka (1951:452) and Young et al. (1952:171-172) concluded marked animals showed a greater probability of capture than unmarked animals. Johnson (1927:280) and Webb (1965:484) reported mice of the genus *Microtus* to be more wary or timid than *Peromyscus*. This would cause *Microtus* to be more difficult to trap. Sealander and James (1958:215) found exclusive use of one type of trap will tend to bias a population estimate due to varying amounts of selectivity capturing the different species of rodents. Sealander et al. (1958:542) reported behavioral responses to traps may be altered by trap confinement. Webb (1965:484) found variations in probability of capture are large and more related to weather, season and random fluctuations than to population density.

Probability of capture is also partially dependent upon the home range of the animals concerned. In order to sample all the animals a trap must be included in each animal's home range.

Home range depends upon habitat, breeding condition, population density and food supply (Stickel, 1960:438). Hayne (1950:39) concluded many determinations of home range are of doubtful reliability. Burt (1943:351) reported any calculated home range is merely a convenient index to the true home range of the animal in question. Davis (1953:353) and Young et al. (1950:404) preferred using the linear distance between successive captures for their home range data. However, Allred and Beck (1963:190) and Evans and Holdenried (1943:249) used the straight line distance from the two most widely separated points of an animal's capture. Stickel (1954:11) found that when using the distance between captures, the individual captured more frequently had more weight in the calculations. Other difficulties associated with this method, according to Davis (1953:353-354) are (1) animals do not travel in straight lines between captures, (2) animals may learn to enter traps for food (giving too many short distances), (3) traps may not be suitably spaced to indicate maximum movement, (4) transients are included and (5) resulting data gives only an index to true home range. Hayne (1949a:3) did not consider those animals that were caught in traps in a straight line in his home range calculations while Stumpf and Mohr (1962) showed long, narrow home ranges do actually exist under natural conditions. Shadowen (1963:105) differentiated between resident and transient rodents. He defined a resident animal as one having three or more captures in one trapping period. Davenport (1964:98) in his home range calculations used only those animals captured five or more times. Harvey and Barbour (1965:398) found overlapping home ranges in their studies on M. ochrogaster. According to Getz (1961:34) about 20 percent of the population shifted their home ranges each month. However, Davenport (1964:111) reported mice once established tended to stay in the same place.

Stickel (1948b:212) reported no evidence of mice leaving their home ranges because of attraction of bait in nearby areas. Baily (1921:64) reported a mixture of rolled oats and peanut butter appeals to the greatest number of small mammals and most other authorities agreed with this finding. According to Fitch (1954:39) some small mammals may take bait well at times but may become indifferent to the same bait in certain seasons. This indifference would cause reduced captures even though the animals were abundant; with a resulting lower population estimate. Fitch (1954:47) also stated trapping results may vary from one trapping period to another depending on the food supply of the animals in question. Sealander et al. (1958:542) reported the placement of bait in the trap may have an influence on trapping success.

Llewellyn (1950:84-85) advocated the use of corn as a bait supplement as it reduced mortality in the trap. Howard (1951:300) reported many small mammals confined in traps in cold weather succumb to a phenomenon he called "cold weather starvation" which he defined as the combined effect of low temperature and insufficient food to maintain body temperature. In his laboratory studies, Howard (1951:306) found small rodents could survive freezing temperatures without nesting material if a supply of palatable and nutritious food was available. Eskridge and Udall (1955:139) also found food was much more important to survival at cold temperatures than nesting material. However, Burt (1927:303) recommended the use of nesting material in the traps to reduce mortality. Llewellyn (1950:84) concluded although food was more important to survival in the trap than nesting material, the debilitating effect of trap confinement may be cumulative.

Other effects of live trapping are reduced chance of death from predators, unknown consequences of liberating nocturnal animals in daylight, spread of infection, reduced chance of meeting a mate and death of young in the nest through absence of mother.

METHODS AND MATERIALS

Study Area

The study area consisted of two fields located in the Cedar Bluff Irrigation District. One field (hereafter referred to as the "untreated area") consisted of 22.7 acres and was located in N 1/2, NW 1/4, NW 1/4, Section 31, R19W, T14S, Ellis County, Kansas (Fig. 1).

The second field (hereafter referred to as the "treated area") consisted of 19.5 acres and was located approximately one mile north-northeast of the untreated area, in S 1/2, SW 1/4, SE 1/4, Section 7, R19W, T14S, Ellis County, Kansas. The treated area received a variety of pesticides at various times and rates (Tables 1, 2 and 3). Three major terraces 7 to 10 feet wide transected this field (Fig. 2).

Vegetation around the field perimeters and along the various terraces was quite dense with the exceptions of the east border of the treated area and the east and west borders of the untreated area. Roads along the above mentioned borders resulted in relatively sparse vegetation, consisting primarily of small Kochia (*Kochia scoparia*).[1]

Principal crops grown on the study area have been corn (*Zea mays*) and sorghum (*Sorghum vulgare*). The more common non-agricultural plants of the study area consisted of downy bromegrass (*Bromus tectorum*), japanese bromegrass (*Bromus japonicus*), cocklebur (*Xanthium pennsylvanicum*), dandelion (*Taraxacum officinale*), giant foxtail (*Setaria faberii*), yellow foxtail (*Setaria lutescens*), goldenrod (*Solidago* spp.), horseweed (*Erigeron canadensis*), kochia, ragweed (*Ambrosia* spp.) and sandbur (*Cenchrus pauciflorus*). Of these plants listed, kochia was predominant.

Soil of the study area was dominantly silty clay loam (Kansas Agricultural Experiment Station, 1937:62). The elevation was approximately 2065 feet above sea level.

Dew formation and other meteorological conditions were similar for the two areas since they were located so close together. Therefore, meteorological conditions were assumed not to have differential effects on the mammal populations of the two study areas.

[1] All common and scientific plant names follow Anderson (1961).

Traps and Trapping Procedure

The live traps employed in this study were a slight variation of the type described by Scheffer (1934), consisting of an empty quart oil can, a Museum Special snap trap, a trap door of perforated aluminum alloy and an elongated trigger mechanism. Traps were set with the open end inclined slightly downward to prevent the interior from becoming wet in the event of rain. On cold, windy nights the open end of the traps were pointed in a leeward direction for further protection to the captured animals.

Seventy-three traps were placed around the perimeter of the treated area and 26 additional traps placed along the top of each of the three major transecting terraces (Fig. 2). Sixty-seven live traps in 1965 and 64 traps in 1966 and 1967 were placed around the perimeter of the untreated field (Fig. 1). As the areas on which the traps were located were intensive agricultural areas, lines of traps were all that could be used due to the activity of farm machinery. Traps were placed at 60-foot intervals along each line.

Trap locations were marked with 2 1/2-x 3 1/2-inch red plastic flags attached to 3-foot wire staffs. Individual trap numbers were printed on the plastic. The numbering system is shown in Figs. 1 and 2.

Traps were baited with a mixture of rolled oats and peanut butter. The peanut butter and rolled oats used for bait in the traps were mixed together just prior to the time it was distributed. Approximately one pound of peanut butter and one half pound of rolled oats were normally used each day in baiting the traps. A ball of this mixture approximately 1/2 to 3/4 inch in diameter was placed in each trap late in the afternoon. The operation of baiting and setting the traps started at approximately 4:30 P.M. CST and was completed in approximately 3 1/2 hours. On colder days the quantity of bait placed in the traps was increased as recommended by Howard (1951).

Animals were identified according to Hall (1955). When possible, captured animals were sexed and classified as either adult or juvenile. Reproductive condition was also recorded whenever possible.

All animals captured were marked by clipping toes and notching the ears in various combinations. Toes were clipped beginning from the left in 1965 and from the right side in 1966 and 1967 as described by Taber and Cowan (1963:274). Various portions of the animals' ears were notched in order to increase the potential number that could be marked with the system of toe clipping employed. Ears were notched in either the front, back or top.

Animals captured were classified as new captures, recaptures and new recaptures. Recaptures included animals captured two or more times during a trapping period. New recaptures included animals captured for the first time in any trapping period following their initial trapping period.

Other recorded data included presence of dew, wind velocity, moon phase, number of days since rain, amount of precipitation occurring on the individual day, sky conditions and approximate height of vegetation.

Trapping was conducted for 10-day periods during June, July, August and September 1965 and 1966, and in April and May 1967. Trapping was conducted in 1965 by Larry W. Robinson whereas the author trapped the study area in 1966 and early 1967.

Residue Analysis

Usually one animal of each species was collected from each area during each trapping period and analyzed by the Pesticidal Residue Laboratory at Kansas State University. However, since *P. maniculatus* was the major species encountered, two of this species were usually collected for analysis from each trapping period by the author in 1966 and 1967.

Animals collected were analyzed for residues of diazinon, parathion, malathion, endrin, aldrin, dieldrin, heptachlor E, DDE, DDT D,P and DDT P,P. Gas-liquid chromatography was used to analyze the collected specimens. Residues less than 0.01 ppm were not detected with this process.

In 1965 and 1966 only a portion of each animal collected was analyzed for pesticidal residues. In 1967 the entire animal was homogenized in a high speed blender and a portion of the resultant mixture analyzed as recommended by van Genderen (1966:272).

Treatment of Data

All data collected were placed on IBM cards and populations estimated with the use of an IBM 1410-1401 computer. The format for punching the IBM cards was similar to that described by

Brotzman and Giles (1966:288). Format for punching of the cards is shown in Table 31. An IBM Card Sorting Machine was also employed to process much of the collected data.

The Schnabel method (Schnabel, 1938) and the Schumacher-Eschemeyer method (Schumacher and Eschemeyer, 1943) were used to estimate populations. Population estimates for both areas were made on the total rodent population and separately for Peromyscus maniculatus, Mus musculus and Sigmodon hispidus. Estimates were also made for a composite group consisting of Microtus ochrogaster, Onychomys leucogaster, Reithrodontomys megalotis, R. montanus, Perognathus flavus, P. flavesens, P. hispidus, Spermophilus tridecemlineatus, Dipodomys ordii and Sylvilagus floridanus. Although not enough of each of the later species was captured in each trapping period to make individual species population estimates, the combined number was a significant portion of the total population. Population estimates of the two areas were compared on an average 1000 feet of trap line. The actual numbers compared were derived by dividing the average of the two population estimates by the number of 1000-foot trap line units in each particular area.

Appearance rates were plotted on a semilogarithmic scale (Davis, 1956:30-32) for the total rodent population and the P. maniculatus population in each area. These curves were constructed by plotting the average number of animals recaptured out of 100 for one, two and three months following their initial capture.

Sex ratios for each species were calculated for each trapping period when 10 or more individuals were captured.

RESULTS

The data collected for this study were the result of 15,100 trap-nights on the treated area and 6,520 trap-nights on the untreated area for a total of 21,620 trap-nights.

In the treated area there were 1,528, 1,596 and 1,051 captures in 1965, 1966 and 1967, respectively. Of these captures the new individuals not previously marked totaled 500 in 1965, 644 in 1966 and 495 in 1967. In addition, 207 of the individual animals caught in 1965, 213 in 1966 and 102 in 1967 had been captured and marked during a previous trapping period and therefore were new recaptures.

There were 605, 574 and 236 captures in the untreated area in 1965, 1966 and 1967, respectively. Of these captures, unmarked individuals totaled 210 in 1965, 264 in 1966 and 141 in 1967. New recaptures totaled 87 in 1965, 94 in 1966 and 18 in 1967.

The largest number of total animals captured during a trapping period was 638 on the treated area in April 1967. The largest number of captures on the untreated area was 180 in each trapping period in June and July 1966. The smallest numbers captured during a trapping period were 175 in September 1966 and 86 in May 1967 for the treated and untreated areas, respectively (Table 4).

Trapping success for the 10-day trapping periods in June, July, August and September 1965, 1966 and April and May 1967 on both areas averaged 24.6 percent. Highest trapping success (42.2 percent) was recorded on the treated area during April 1967. On the untreated area the highest trapping success (28.1 percent) occurred in June and July 1966. Lowest success (11.6 and 13.4 percent) was recorded in September 1966 and May 1967 for the treated and untreated area, respectively. Trapping periods earlier in the year, i.e., June and July 1965, 1966 and April 1967, yielded higher trapping success than subsequent periods (Table 5).

Species captured included Peromyscus maniculatus, Microtus ochrogaster, Mus musculus, Sigmodon hispidus, Onychomys leucogaster, Reithrodontomys megalotis, R. montanus, Perognathus flavus, P. flavesens, P. hispidus, Spermophilus tridecemlineatus, Dipodomys ordii and Sylvilagus floridanus. Summaries of all captures for all species except D. ordii and S. floridanus are shown on Tables 6 through 15. Only one D. ordii and two S. floridanus were captured in this study. One S. floridanus had to be destroyed after being injured in a trap on the treated area in September 1965. The other S. floridanus, a juvenile, was captured and released on the untreated area in May 1967. The only D. ordii encountered in this study was found dead in a trap and collected for analyses in May 1967 from the untreated area.

Peromyscus maniculatus was the most common species captured in this study. It comprised from 33 to 86 percent (averaging 69.4 percent) of the total captures during each 10-day trapping period (Tables 6, 16 and 17). A total of 1,307 different individuals of this species were marked (57.6 and 59.0 percent of all individuals marked on the treated and untreated areas, respectively) (Tables 18 and 19).

Numbers of M. ochrogaster captures were highest in July 1966 and September 1965 on the treated and untreated areas, respectively (Tables 7, 16 and 17). Microtus ochrogaster comprised an average of 5.5 percent of total captures on both areas (Table 18). A total of 179 individual M. ochrogaster were marked (8.8 and 5.9 percent of all individuals marked on the treated and untreated areas, respectively) (Table 19).

Mus musculus captures varied considerably, ranging from 0 to 86 per trapping period and comprising from 0 to slightly over 37 percent of the total captures (Tables 8, 16 and 17). This species comprised 10.2 and 11.7 percent of the total captures on the treated and untreated areas, respectively (Table 18). Three hundred and fifty-eight individual M. musculus (14.8 and 18.3 percent of the different individuals marked during this study) (Tables 16, 17 and 19).

Captures of S. hispidus were also variable but appeared to be highest during trapping periods late in the summer (Tables 9, 16 and 17). An average of 6.4 percent of total captures consisted of S. hispidus (Table 18). One hundred and ninety-four individuals of this species were marked in this study (Table 19).

Individual numbers of each of the remaining species (O. leucogaster, R. megalotis, R. montanus, P. flavus, P. flavesens and S. tridecemlineatus) captured were quite small (Tables 10 through 19).

Sex ratios were calculated on all species for each period within which 10 or more were captured (Tables 20 and 21). The percentage of males for all species during the entire length of the study was 51.7 percent in the treated area and 53.1 percent in the untreated area. This did not differ significantly ($P = 0.05$) from a 1:1 ratio.

Age ratios of rodents captured varied from 2.8 to 18.5 juveniles per 100 adults. Lowest juvenile to adult ratios were in June 1966 (8.1) on the treated area and July 1966 (2.8) on the untreated area. April 1967 had the highest juvenile to adult ratio (18.5) on the treated area while May 1967 had the highest on the untreated area (17.2). The untreated area had a slightly lower juvenile to adult ratio than the treated area (10.3 and 12.5 juveniles per 100 adults on the untreated and treated areas, respectively). However, these ratios did not differ significantly ($P = 0.05$). Numbers of juveniles per 100 adults on the treated area during 1966 were 8.1, 8.4, 16.3 and 12.4 for June, July, August and September, respectively. Juveniles per 100 adults on the treated area during 1967 were 18.5 and 11.1 for April and May, respectively. Numbers of juveniles per 100 adults on the untreated area in 1966 were 7.6, 2.8, 14.1 and 4.4 for June, July, August and September, respectively. Juveniles per 100 adults on the untreated area in 1967 were 15.8 and 17.2 in April and May, respectively.

Movements of the animals captured ranged from 0 to 870 feet on the untreated area and from 0 to 1500 feet on the treated area. The mean movement was approximately 230 feet and the mode was 60 feet.

Appearance curves were plotted on a semilogarithmic scale for the total rodent populations, the P. maniculatus populations, and the populations of all other rodents combined occurring on both areas (Figs. 3, 4 and 5). Numbers of small mammals appearing out of 100 on the treated area were 23.8, 13.6 and 7.9 at one, two and three months following initial capture, respectively. For the total population on the untreated area the numbers of animals appearing out of 100 were 24.3, 15.4 and 11.7 at one, two and three months following initial capture, respectively. The numbers of P. maniculatus appearing out of 100 at one, two and three months following initial capture were 26.9, 15.9 and 9.8, respectively. The numbers of all other rodents appearing out of 100 were 17.8, 7.1 and 3.0 on the treated area and 21.6, 11.3 and 17.1 on the untreated area at one, two and three months after initial capture, respectively.

Estimates of the total small mammal population on the treated area averaged 260, 328 and 467 in 1965, 1966 and 1967, respectively. For the untreated area the averages for the same time periods were 112, 153 and 147. Monthly estimates for the total small mammal populations are shown in Tables 26 and 27 for the treated area and Tables 28 and 29 for the untreated area. When these estimates were compared on an equal base, i.e., population per 1000 feet of trap line, the population on the untreated area was consistantly higher. The highest average estimates of the two indices of the total small mammal population per 1000 feet of trap line (39.1 and 49.5 for the treated and untreated areas, respectively) occurred in April 1967. The lowest average estimate of the two indices on the treated area (9.9 animals per 1000 feet of trap line) was in September 1966 while the low on the untreated area (22.5 animals per 1000 feet of trap line) occurred in June 1965. Total population estimates for the treated area during all three years showed a steady decline as the year progressed. On the untreated area however, this trend was only partially indicated in 1966 and almost reversed in 1965 (Tables 22 - 25 and Fig. 6).

For 1965, 1966 and 1967, average estimates of the P. maniculatus population on the treated area were 139, 179 and 378, respectively. The averages for the untreated area for the same periods were 67, 82 and 108 (Tables 26 through 29). Estimates of the P. maniculatus population per 1000 feet of trap line were higher on the untreated area (Fig. 6). Average highs of 31.6 and 37.1 animals per 1000 feet of trap line for the treated and untreated areas, respectively, occurred in April 1967. Lowest average estimate on the treated area (6.9 animals per 1000 feet of trap line) was in September 1966 while the low on the untreated area (11.6 animals per 1000 feet of trap line) occurred in September 1965. The treated area showed a steady decline of P. maniculatus numbers as it did total numbers as the year progressed. No such trend was obvious on the untreated area (Tables 22 - 25 and Fig. 6).

Mus musculus populations averaged an estimated 81, 37 and 23 for the treated area in 1965, 1966 and 1967, respectively. Estimates of this species for the untreated area averaged 24 in

1965, 32 in 1966 and 19 in 1967. Monthly estimates of the *M. musculus* populations on both areas are shown in Tables 26-29. Estimates of the *M. musculus* population were quite variable from trapping period to trapping period. Highs in both areas occurred in September 1965. No *M. musculus* were captured in June 1965 and May 1967 on the untreated area or in September 1966 and May 1967 on the treated area. Estimated numbers of this species showed an increase as the year progressed in 1965. In 1966 numbers on the untreated area showed a net gain (Tables 22-25 and Fig. 7).

The averages of the *S. hispidus* population estimates for the treated area were 19, 44 and 17 in 1965, 1966 and 1967, respectively. For the untreated areas these averages were 5, 19 and 5 for the same periods. Monthly estimates of the *S. hispidus* populations on both areas are shown in Tables 26 through 29. On the untreated area no captures of *S. hispidus* were recorded in July and August 1965 and April and May 1967 (Tables 22-25 and Fig. 7). *Sigmodon hispidus* was more common on the treated area as only one month, July 1965 yielded no captures.

Estimates of all the other small mammals but *P. maniculatus*, *M. musculus* and *S. hispidus* averaged 48 in 1965, 87 in 1966 and 50 in 1967 on the treated area. The averages of these same species for the untreated area for the same periods were 20, 32 and 0. Monthly estimates are shown in Tables 26-29. Highs of these species numbers were recorded in July 1966 on the treated area and September 1966 on the untreated area. A steady increase in numbers was observed as the year progressed on the untreated area, however, no trend was detectable on the treated area (Tables 22-25 and Fig. 7).

A total of 55 rodents from the treated area were submitted to the Pesticide Residue Laboratory at Kansas State University for analyses. Twelve of these 55 (21.8 percent) had pesticides present in their tissues. From the untreated area 39 rodents were submitted for analyses and 4 of these (10.3 percent) had pesticides present. Dieldrin and heptachlor epoxide were the only two types of pesticides occurring in the submitted specimens. Dieldrin was the most commonly occurring pesticide and was found in concentrations ranging from 0.01 to 0.24 ppm. Heptachlor epoxide ranged in concentrations from 0.01 to 0.02 ppm and was found in only three animals. The highest concentration of any detected pesticides (0.24 ppm dieldrin) was found in a _S. tridecemlineatus_. _Peromyscus maniculatus_ was the species most commonly found with detectable residues (8 of the 16 positive specimens) however, concentrations were quite low, averaging less than 0.02 ppm dieldrin and 0.01 ppm heptachlor epoxide. The five positive _M. musculus_ averaged almost 0.07 ppm dieldrin. Species, sex, date of collection and results of the analyses on those animals collected are shown in Table 30.

DISCUSSION

Trapping operations were conducted for 10 consecutive days each month in June, July, August and September in 1965, June, July, August and September in 1966 and May in 1967. In April, 1967, trapping operations were conducted for ten days but they were not consecutive. Trapping operations were temporarily suspended on April 23 because of extremely cold, windy weather. Temperatures dropped to 23° F and excessive mortality could have resulted to captured animals subjected to such conditions. Traps were removed from the areas during the periods trapping was not in progress.

The aluminum alloy sheet used for trap doors on the traps employed in this study did not prove to be very substantial. Captured rodents, especially _P_. _maniculatus_ and _R_. _megalotis_, gnawed holes through the doors large enough to allow the rodents to escape. Approximately 25 trap doors had to be replaced during each trapping period in this study. Although the aluminum doors are easily removed and new ones attached, a heavier metal perhaps would eliminate the need for such frequent replacement.

Plastic flags used to mark trap locations proved quite adequate in this study. They were easily handled during both the operations of placing the traps and removing them from the areas. However, after each trapping period the number printed on the flag was so severely faded it had to be reprinted. Some flags were torn during each trapping period and had to be replaced. This was especially true when strong winds were accompanied by cool temperatures.

The method of toe clipping (Taber and Cowan, 1963:274) and ear notching proved fairly successful for marking the captured animals. Ears could be notched successfully in front, back or on top of both ears and the mark be discernable. Some problems were encountered when certain individuals had lost a toe or had a previously notched ear. Sigmodon hispidus was the most common species having previously notched ears at the time of their initial capture. Meyer and Meyer (1944:115) could not use ear notching to mark laboratory S. hispidus because the ears of most individuals were severely torn during fighting, a condition which resulted in incorrect identification of several individuals.

Data collected from this study were placed on IBM cards. A variation of the format proposed by Brotzman and Giles (1966: 288) was employed (Table 31). An IBM Card Sorting Machine was used to process much of the data. This speeded up the rather laborious job of sorting through the data for one particular aspect.

Peromyscus maniculatus, was by far the most commonly encountered species accounting for 69.4 percent of the total captures. Peromyscus maniculatus, Mus musculus, Sigmodon hispidus and Microtus ochrogaster together accounted for 92.3 percent of the total captures on both areas. Therefore, the remaining species (Onychomys leucogaster, Reithrodontomys megalotis, R. montanus, Perognathus flavus, P. flavesens, P. hispidus, Spermophilus tridecemlineatus, Dipodomys ordii and Sylvilagus floridanus) did not have a great effect on the total numbers captured or total rodent population for the two areas.

More rodents were captured in 1966 than in 1965. This may have been caused by a greater carry-over in the population, earlier reproduction or both. As the winter between the 1965 and 1966 trapping periods was quite mild it may be assumed the greater populations in 1966 were the result of both earlier reproduction and a greater carry-over. Insufficient data were collected in 1967 to compare with 1965 and 1966 (Table 4).

A general decrease occurred in the number of captures (new captures, new recaptures, recaptures and total captures) during each year of trapping, i.e., captures numbered more in June than in September of each year (Tables 4 and 5).

Since the food supply of the small mammals was increasing as the summer progressed, perhaps the bait used was not as attractive at the later trapping dates as it was in the early trapping periods. Fitch (1954:47) reported baits are least attractive at times when natural foods are abundantly available. This general trend toward a decreasing number of captures as the summer progressed holds true with most species on both areas in 1966 but was not as evident in 1965. On the treated area the number of captures and population estimates remained practically constant throughout 1965 and slight increases were recorded on the untreated area. However, *Peromyscus maniculatus*, the most commonly occurring species, displayed a general seasonal decrease in numbers captured each year on both areas, not just in 1966 and 1967.

Therefore, as one would expect, the number of captures of the remaining species actually increased during 1965, thus resulting in the appearance of stability for the total small mammal populations in 1965. The numbers of these species captured were quite variable during 1966 and 1967 and had the effect of counteracting each other, i.e., M. musculus numbers were high when S. hispidus were low (April 1967) and vice versa (June 1966).

The Schnabel method (Schnabel, 1938) and the Schumacher and Eschemeyer method (Schumacher and Eschemeyer, 1943) were used to provide indices to the population in this study. As a result of the large difference in the number of trap-nights on the treated and untreated areas, the populations were compared on a 1000 feet of trap line basis. The Schnabel method and Schumacher-Eschemeyer method provided only an index to the number of animals on each area and were not intended to be used as accurate population estimates of mammals present on each area.

The standard error for the Schnabel method of population estimation is calculated by using the reciprocal of the estimate because the estimate is not distributed normally (Brotzman and Giles, 1966:289). Confidence limits for the Schnabel method are calculated (Brotzman and Giles, 1966:289), by the following formula: $\frac{1}{N} \pm \left(S\,\frac{1}{N}\right)t$, when $S\,\frac{1}{N}$ is the estimated standard error, N the population estimate and "t" the value of "Student's t" with the proper degrees of freedom.

The Schumacher-Eschemeyer method gave consistantly lower estimates than the Schnabel method (Tables 26 through 29). However, the proportions the various species' estimates constituted of the total population estimates remained quite consistant throughout. As has been previously stated, these estimates were not intended to be used on a per acre basis. Since the primary purpose of this study was to determine if a difference could be detected between the populations on the two areas, either method of estimation should be adequate. However, one should not compare results of different estimates.

Great variability existed in the populations of each area between and during the years (Figs. 6 and 7 and Tables 22-29). Blair (1948:397) also reported populations varied considerably from year to year. The peaks in the total small mammal population in 1965 occurred in June and September on the treated and untreated areas, respectively (Fig. 6). In 1966 population peaks occurred in June and July on the treated and untreated areas, respectively (Fig. 6). Population peaks occurred in April 1967 on both areas (Fig. 6). However, trapping operations were conducted only during the months of April and May, 1967. The 1967 peak in numbers of the total small mammal population was caused primarily by large numbers of P. maniculatus (Fig. 6) as the other species concerned were at a relatively low level (Fig. 7). Since trapping operations were not conducted during all months of the year the month in which the maximum in the population occurred cannot be defined. Davenport (1964:105) found a peak in the Peromyscus polionotus population in early May followed by a steady decrease in numbers. Stickel and Warbach (1960:273) found a peak in P. leucopus numbers in December and a low occurring in April.

The total populations on both areas were actually quite similar (Fig. 6). Each population exhibited maxima or minima during approximately the same periods. Since P. maniculatus was the most common species it would seem that a graph of this population would closely follow the graph of the total population. Comparing the two graphs in Fig. 6 appears to show this is true.

Although maxima and minima of the populations of _M. musculus_, _S. hispidus_ and the composite group of the other rodents on both areas follow each other to a certain extent (Fig. 7), they are not nearly as similar as the total population and the _P. maniculatus_ population on both areas (Fig. 6). Because these species constituted only a small portion of the total small mammal population, their fluctuations had a small effect upon the over-all population fluctuations.

A higher population of small mammals existed in the early summer of 1966 than during the same time in 1965 (Fig. 6 and Tables 22 through 29). However, there appeared to be a greater drop in numbers in the latter portion of 1966 than in 1965. In September of 1966 in the treated area the lowest number of rodents per 1000 feet of trap line was recorded.

Population estimates are inherently related to trapping success. Poor trapping success will usually yield a poor estimate of the population. During this study, trapping success averaged 24.8 percent for the two areas; 27.6 and 21.9 percent for the treated and untreated areas, respectively (Table 5). While the highest trapping success on the treated area (42.2 percent) occurred in April, 1967, results for June 1966 were almost as high (41.5 percent). June and July 1966 were the periods exhibiting the highest trapping success on the untreated area (28.1 percent each). The high trapping success in April

1967 may have been due to greater reproduction earlier in 1967 compared to 1966. Although the carry-over between years was relatively equal (1.4 percent from 1965 to 1966 and 1.2 percent from 1966 to 1967) more juvenile mice were captured in April 1967 (18.5 juveniles per 100 adults) than in June 1966 (8.1 juveniles per 100 adults).

The different species captured may also have had some effect on trapping success. Although _P. maniculatus_ accounted for almost 70 percent of the total captures (Table 18), they made up only slightly over 60 percent of the individuals trapped (Table 19). _Microtus ochrogaster_, on the other hand, comprised about 5 percent of the total captures (Table 18) but accounted for approximately 7 percent of the different individuals captured (Table 19). This would seem to indicate that _P. maniculatus_ were more prone to recapture than _M. ochrogaster_. This tendency was also found by Johnson (1927:280) who reported _Microtus pennsylvanicus_ more difficult to trap than _P. maniculatus_ because the _Microtus_ were more wary or timid. Tables 18 and 19 also indicate _S. hispidus_ and _M. musculus_ were more prone to recapture than _M. ochrogaster_.

The total number of individuals marked indicates that the ratio of _M. ochrogaster_ to _P. maniculatus_ was not nearly as great on the untreated area as on the treated area (Table 19). This may have been due to the difference in cover and food supply present on the two areas. Hall (1955:148) reported _M. ochrogaster_ require a vegetative cover dense enough to conceal them in their runways while Jameson (1955:207) found _P. maniculatus_ could thrive in a variety of habitats. As the cover was thicker on the treated area it was perhaps a more preferred habitat for *M. ochrogaster*.

In a study of population dynamics such as this, differences in sex ratios may be just as important as differences in total numbers. Even though none of the sex ratios was significantly different from 1:1 for any of the species of which more than 10 individuals were captured, there was a tendency to capture more males than females (Tables 20 and 21). A slightly disproportionate (but not significantly so) sex ratio in favor of males has also been reported by Blair (1940b:150), Rolan (1961:31) and others. Therefore, the slightly greater number of male captures (52.7 percent) may have been due to (1) a slightly greater number of males in the population, (2) males being more susceptable to trapping or, (3) males having a greater wandering tendency than females.

Another aspect that must be considered in a comparative study of population is the age ratio. Sufficient age data were not collected in 1965 to justify age ratio calculations. The average number of juveniles per 100 adults was 12.5 and 10.3 on the treated and untreated areas, respectively. These figures were not significantly different ($P = 0.05$). The treated area had a lower juvenile to adult ratio than the untreated area every trapping period except May 1967. The ratios were 17.2 and 11.1 juveniles per 100 adults during the May 1967 trapping period on the untreated and treated areas, respectively. The numbers of juveniles per 100 adults were also high in August

1966 (16.3 and 14.1 on the treated and untreated areas, respectively). This reflects greater reproduction during early April through May and also in mid-July than during the balance of the 1966 and 1967 study period.

When comparative studies of populations are conducted, survival of individuals or of segments of the population is extremely important. In this study appearance rate was used in place of the actual survival rate. According to Davis (1956:54), however, to translate appearance into survival it is necessary to assume no emigration and that animals of all ages live for a length of time after last seen that is proportional to the total length of life. Under these conditions appearance rate and survival rate should be identical. The appearance curves were computed by calculating the total number of animals recaptured one, two or three months after their initial capture and dividing by the total number of animals released for the specific month in question (Figs. 3, 4 and 5). Rather than show these curves for each individual month all months were grouped together since survival tends to be constant during any given season (Blair, 1948:15).

Individuals remained on the areas for an average of less than one month (Fig. 3). This is a shorter time than the average of 4.5 months reported by Blair (1948:399,405) but closer to the average of 2 months reported by Getz (1960:404). It can be seen from Fig. 3 that the average appearance curve of the treated area for the total population is slightly steeper than that of the untreated area, indicating the average rodent remained on the untreated area for a slightly longer period of time than its cohort on the treated area.

The average P. maniculatus remained on the areas less than one month (Fig. 4). This was considerably less than the average of 4.88 months reported by Blair (1948:399) for this species. The average appearance curve for P. maniculatus populations in both areas is slightly different than that of the total population. The P. maniculatus population of the untreated area disappeared at a faster rate for the first two months after initial capture but the curves approach each other near the end of the third month. Although being the most common species encountered in this study, the P. maniculatus average appearance curves are not the same as the curves for the total population.

The average appearance curve for the entire population except P. maniculatus is similar to the previous two plotted for the treated area (Fig. 5). However, it shows a high rate of disappearance of individuals from the untreated area the first month after their initial capture. Following this sharp drop, the curve becomes almost horizontal. The survival of P. maniculatus was practically the same on both areas (Fig. 4). However, the other species involved had a higher rate of disappearance on the untreated area than their cohorts on the treated areas during the first month after their initial capture (Fig. 5). The species other than P. maniculatus remaining on the untreated area after the first month tended to be there for the remaining two months. Their cohorts on the treated area, however, had an almost uniform rate of disappearance throughout the three months. This disappearance may have been caused by emigration or mortality. Blair (1948:414-415) believed less than 10 percent of population loss was due to dispersal and the majority due to predation. Getz (1960:404) found highest mortality occurred in the first month of life. It would seem the data presented here also indicate high mortality of the young, however, emigration cannot be excluded.

Although the curves shown in Figs. 3, 4 and 5 are not exactly alike, they reveal no difference in longevity of the small mammal populations of the two areas.

Recapture data showed movements of small mammals on the study areas averaged about 230 feet and ranged up to 1500 feet. This was considerably smaller than the average of 428 feet reported for P. maniculatus by Allred and Beck (1963:195). Differences between the two average movements, i.e., 230 and 428 feet, may have been due to trap placement since Allred and Beck (1963:190) used a 75-foot trap interval whereas a 60-foot interval was used in this study. The data collected in this study indicated animals on the treated area tended to move longer distances (255 feet) than those on the untreated area (205 feet). However, this was not a significant difference ($P = 0.05$). Home ranges were not calculated for any of the species because a grid pattern of trap placement was not used. Davis (1953:353) and Allred and Beck (1963:190) used only straight line distances in their home range calculations. Therefore, a range of the distances moved, along with the mean and the mode provide sufficient information on movements for this study. The mode of the distances moved by rodents captured was 60 feet, exactly the distance from one trap to the next. Hayne (1950:38) found a positive relationship between apparent size of home range and the distance between traps. This would seem to indicate the distance between traps in this study was too great to accurately measure the distance moved by the rodents. However, a distance of 60 feet between traps was needed to adequately cover both areas and still enable one individual to conduct the trapping operation. Blair (1940a:274) found 60 feet close enough to trap all resident animals but far enough apart to trap large areas.

If significant differences had been found in the population dynamics of mammals on the two areas, one would immediately suspect that the differences were due to accumulation of pesticidal residues in the mammals on the treated area. With this in mind representative mammals were collected each month and analyzed for pesticidal residues. In 1965 and 1966 only random portions of the animals collected were analyzed. Two separate analyses were made on each of these animals and the average of the two used as the amount of residue in the analyzed portion. In 1967 the entire animal was placed in a blender and the analyses made on a random sample of the homogenized animal. The results on the 94 rodents analyzed are shown in Table 30. Only residues of 0.01 ppm or greater could be detected by the gas-liquid chromatography technique.

In 1965 three of 33 specimens analyzed had detectable residues. All specimens containing pesticide residues were collected on the treated area. These specimens with detectable residues consisted of a S. tridecemlineatus which contained 0.24 ppm of dieldrin; a P. maniculatus and a M. musculus, both containing 0.01 ppm of dieldrin. Aldrin, which quickly converts to dieldrin in the environment (DeWitt and George, 1960:14), was applied to bench 3b on May 10 and to bench 4a on May 11. Dieldrin was used as a seed treatment at planting time, approximately the same time as the aldrin applications. The three specimens which had detectable residues of dieldrin were collected two months after application of these compounds. Kieth and Hunt (1966:174) reported that consumption of contaminated food was the primary pathway of pesticides into wild animals. According to Williams (1959:419) seeds and insects composed 70 to 95 percent of the stomach contents of P. maniculatus. Whitaker (1966) found seeds to be the most important food of P. maniculatus and M. musculus. Therefore, the P. maniculatus and M. musculus may have contacted the dieldrin in the same manner as the S. tridecemlineatus.

Of specimens analyzed in 1966, five specimens collected from the treated area and two from the untreated area had detectable residues. Dieldrin treated seed was planted in the untreated area in 1966 and the residues found in the tissues of the two animals from this area contained low amounts of dieldrin. Therefore, the contaminated specimens from the untreated area probably accumulated pesticides by consuming the dieldrin treated seeds. Heptachlor was applied to bench 2 on the treated area on May 12 (Table 3). A P. maniculatus captured in July 1966 (specimen #21) approximately 180 feet north of bench 2 on the treated area contained 0.02 ppm heptachlor epoxide.

In 1967, 5 of 13 animals from the treated area and 1 of 7 from the untreated area had detectable residues. A P. maniculatus from the untreated area had 0.01 ppm dieldrin, again probably resulting from consumption of dieldrin treated seeds. Three of the animals (two P. maniculatus and one M. musculus) from the treated area were found to have 0.01 ppm dieldrin each. A S. hispidus and a P. maniculatus (numbers 51 and 52) had 0.01 ppm heptachlor epoxide.

Although none of the animals analyzed had large concentrations of pesticides, there were detectable amounts. Thus small mammals can directly or indirectly receive a certain portion of pesticides normally applied to agricultural areas.

Even though the concentrations of pesticides in the mammal's tissues were low, effects of sublethal dosages of pesticides (if they in fact exist) may not be detectable for several years. Differences were found in juvenile to adult ratio (lower ratio on the untreated area), in longevity (in favor of the untreated area), and in movements on the two areas (more movement on the treated area). These differences were not significant at the $P = 0.05$ level. Continued research will be of great assistance in the proper evaluation of the population-pesticide relationship.

SUMMARY

In 1965 an intensive study of the possible effects of

pesticides on small mammal populations was initiated. Two areas in the Cedar Bluff Irrigation District, Ellis County, Kansas, were selected for this study. One area received applications of pesticides (treated area) whereas the other was relatively free of pesticides (untreated area).

Both areas were trapped during 10-day periods for the months of June through September 1965 and 1966 and April and May 1967 to the extent of 21,620 trap-nights on the two areas. During this time 5,590 captures were made and 2,254 animals marked.

Animals captured included *Peromyscus maniculatus*, *Microtus ochrogaster*, *Mus musculus*, *Sigmodon hispidus*, *Onychomys leucogaster*, *Reithrodontomys megalotis*, *R. montanus*, *Perognathus flavus*, *P. flavesens*, *P. hispidus*, *Spermophilus tridecemlineatus*, *Dipodomys ordii* and *Sylvilagus floridanus*.

Captured animals were marked by a system of toe clipping and notching of ears.

Trapping success totaled 24.6 percent, and was higher in June and July than in August and September 1965 and 1966. Highest success (42.2 percent) was recorded in April 1967 on the treated area.

Peromyscus maniculatus constituted 69.4 percent of the total captures. The remaining species ranked in a decreasing order in frequency of appearance in the traps as follows: *M. musculus*, *S. hispidus*, *M. ochrogaster*, *O. leucogaster*, *R. megalotis*, *P. flavesens*, *S. tridecemlineatus*, *R. montanus*, *P. flavus*, *P. hispidus*, *D. ordii* and *S. floridanus*.

Sex ratios did not differ significantly ($P = 0.05$) from a 1:1 ratio. Age ratios averaged 11.4 juveniles per 100 adults and did not differ significantly ($P = 0.05$) between the two areas.

The mean movement of the animals recaptured was 230 feet with a range of 0 to 1500 feet.

Appearance curves were plotted for (1) all small mammals, (2) for P. maniculatus only and (3) for all other species combined. The average animal remained on the areas less than one month.

A total of 94 rodents were collected from the two areas and analyzed for pesticidal residues. Slightly over 21 percent of those animals collected from the treated area and 10 percent of those from the untreated area had residues greater than 0.01 ppm, mostly small concentrations of dieldrin.

Estimates of the total small mammal population, P. maniculatus population, M. musculus population, S. hispidus population and the population of all other rodents combined were made by the Schnabel method and the Schumacher-Eschemeyer method. Highest estimates of the total small mammal population per 1000 feet of trap line occurred in April 1967 on both areas. Lowest estimates occurred in September 1966 and June 1965 on the treated and untreated areas, respectively. The population on the treated area declined from June to September in each year of the study, and succeedingly higher populations occurred each year. Neither of these trends were evident on the untreated area.

Although differences were found in the juvenile to adult ratio (lower ratio on the untreated area), in longevity (in favor of the untreated area), and in the movements on the two areas (more movement on the treated area), these differences were not significant at the $P = 0.05$ level.

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APPENDIX

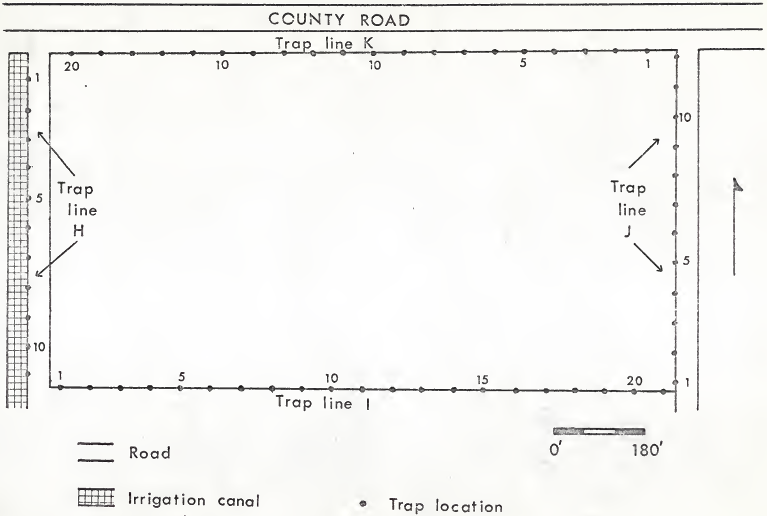

Fig. 1. Map of the untreated area showing locations of trap lines and traps.

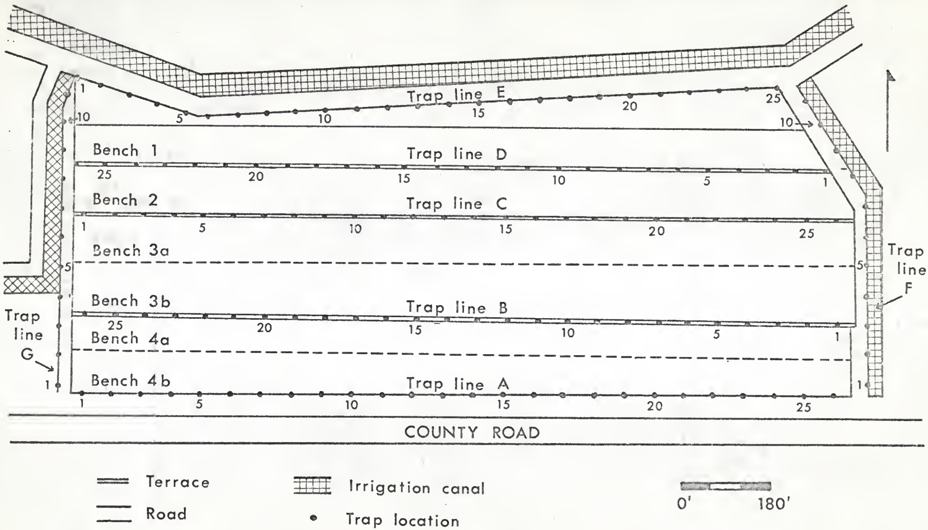

Fig. 2. Map of the treated area showing locations of trap lines and traps.

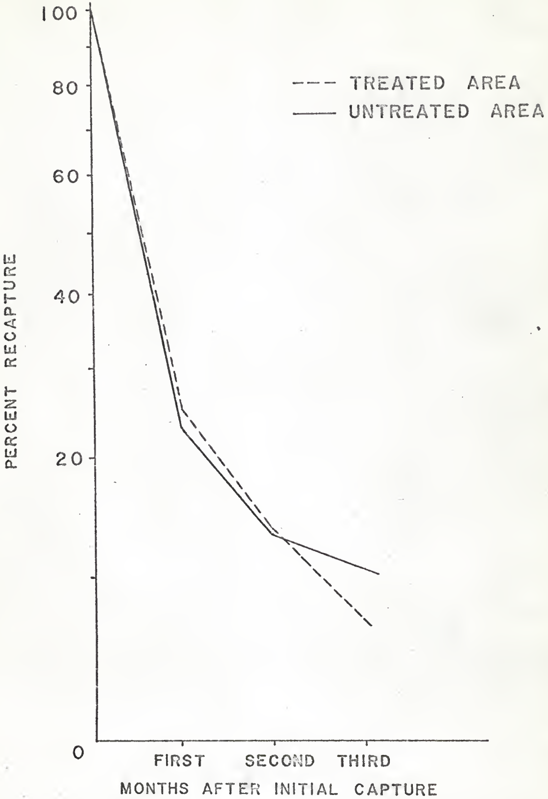

Fig. 3. Percentage of captures and subsequent recaptures of all small mammals plotted against time period in months.

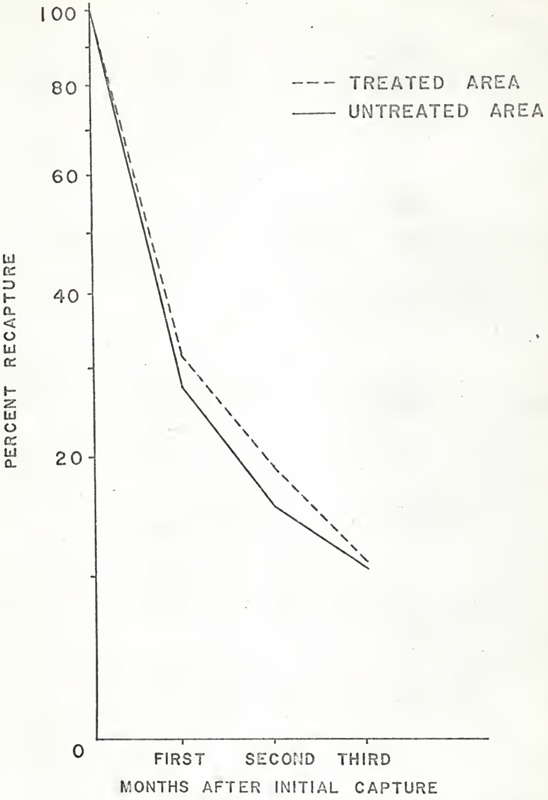

Fig. 4. Percentage of captures and subsequent recaptures of Peromyscus maniculatus plotted against time period in months.

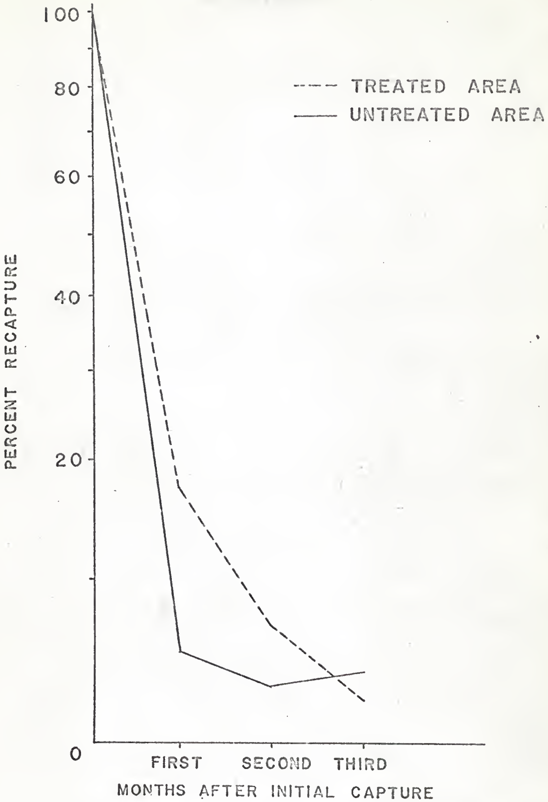

Fig. 5. Percentage of captures and subsequent recaptures of all species except Peromyscus maniculatus plotted against time period in months.

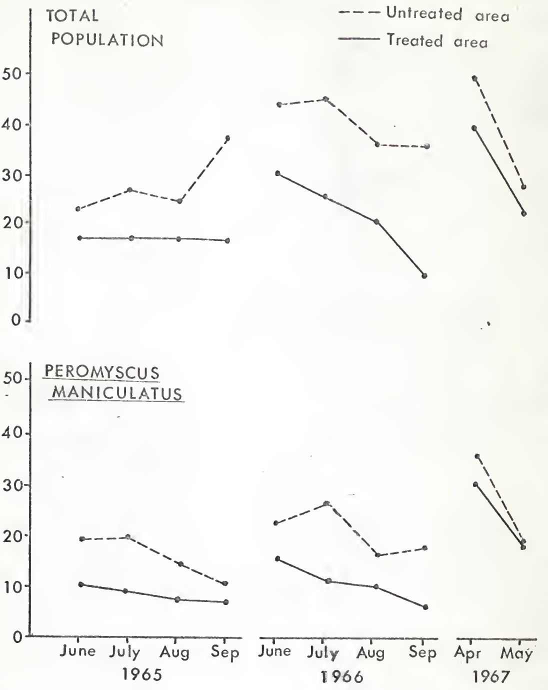

Fig. 6. Total population and population of Peromyscus maniculatus per 1000 feet of trapline on the treated and untreated portions of the study area.

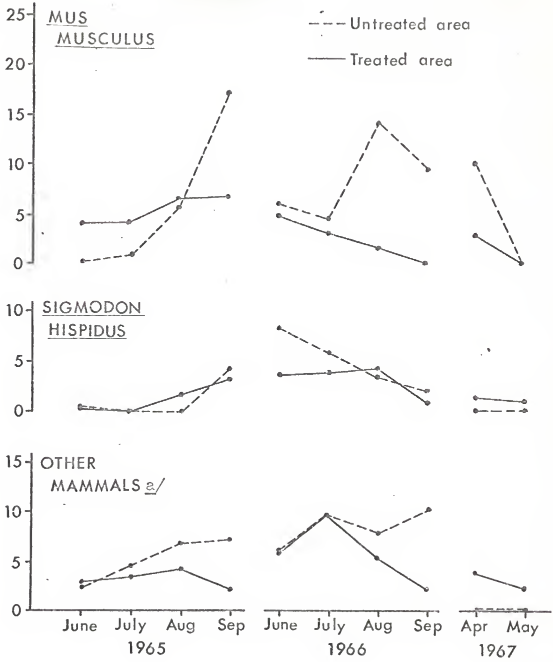

Fig. 7. Populations of Mus musculus, Sigmodon hispidus and other mammals per 1000 feet of trapline on the treated and untreated portions of the study area.

a/ Includes Microtus ochrogaster, Onychomys leucogaster, Reithrodontomys megalotis, R. montanus, Perognathus flavus, P. flavesens, P. hispidus, Spermophilus tridecemlineatus, Dipodomys ordii and Sylvilagus floridanus.

Table 1. Dates, types and application rates of pesticides on the treated area for 1965. (All rates reported as lbs/acre).

	SOIL	SURFACE	FOLIAR	SEED TREATMENT INSECTICIDE	SEED TREATMENT FUNGICIDE
Bench #1	Diazinon 10% Granules 0.6 lbs/A May 10, 1965	None	2,4-D Amine 0.5 lbs/A June 22, 1965 Parathion 6 oz/A July 29, 1965	None	Captan
Bench #2	Thimet 10% Granules 1.1 lbs/A May 10, 1965	Atrazine 80% WP 2.1 lbs/A May 29, 1965	Sevin 80% WP 1 lb/A July 29, 1965	None	Captan
Bench #3a	Disyston 10% Granules 1.1 lbs/A May 10, 1965	None	None	None	Captan
Bench #3b	Aldrex (Parathion and Aldrin) 10% Granules 1 lb/A May 10, 1965	None	None	Malathion north 4 rows, remainder not treated	Captan
Bench #4a	None	Aldrin 3.9 lbs/A May 11, 1965 Herban 80% WP 2.4 lbs/A May 29, 1965	None	Dieldrin	Thiran
Bench #4b	None	None	None	Dieldrin	Thiran

Table 2. Dates, types and application rates of pesticides on the treated area for 1966. (All rates reported as lbs/acre.)

	SOIL	SURFACE	FOLIAR	SEED TREATMENT INSECTICIDE	SEED TREATMENT FUNGICIDE
Bench #1	Diazinon 10% Granules 0.89 lbs/A May 12, 1966	2,4-D Amine 0.5 lbs/A June 14, 1966	Diazinon 1.4 lbs/A emulsion Endrin 0.3 lbs/A August 3, 1966	None	Captan
Bench #2	Heptachlor 10% Granules 0.67 lbs/A May 12, 1966	Atrazine 80% WP 3.4 lbs/A June 14, 1966	Carbaryl 80% WP 1.25 lbs/A August 3, 1966	None	Captan
Bench #3a	Parathion 10% Granules 1.4 lbs/A May 12, 1966	None	Methyl para- thion 6 oz/A August 3, 1966	None	Captan
Bench #3b	Aldrin 10% Granules 1.2 lbs/A May 12, 1966	None	None	None	Captan
Bench #4a	None	Herban 80% WP 2.4 lbs/A June 14, 1966	None	Malathion 1%	Captan 75%
Bench #4b	None	None	None	None	Captan

Table 3. Pesticides applied on the treated area in 1967, to July 1.

	SOIL	SURFACE	FOLIAR	SEED TREATMENT INSECTICIDE	SEED TREATMENT FUNGICIDE
Bench #1	Diazinon 0.93 lbs/A May 15, 1967	None	None	None	Captan
Bench #2	Heptachlor 0.43 lbs/A May 15, 1967	None	None	None	Captan
Bench #3a	Parathion 0.79 lbs/A May 15, 1967	None	None	None	Captan
Bench #3b	Aldrin 1.04 lbs/A May 15, 1967	None	None	None	Captan
Bench #4a	None	None	None	None	Captan
Bench #4b	None	None	None	None	Captan

Table 4. Summary of captures of all small mammals for each trapping period.

	June, 1965		July, 1965	
	Treated	Untreated	Treated	Untreated
New captures	184	61	94	43
New recaptures	0	0	82	30
Recaptures	275	60	185	105
Total captures	459	121	361	178
	Aug., 1965		**Sept., 1965**	
	Treated	Untreated	Treated	Untreated
New captures	108	36	114	69
New recaptures	68	32	57	25
Recaptures	178	80	183	64
Total captures	354	148	354	158
	June, 1966		**July, 1966**	
	Treated	Untreated	Treated	Untreated
New captures	300	105	158	69
New recaptures	8	0	98	38
Recaptures	318	75	206	73
Total captures	626	180	462	180
	Aug., 1966		**Sept., 1966**	
	Treated	Untreated	Treated	Untreated
New captures	120	43	66	47
New recaptures	76	35	31	21
Recaptures	138	40	77	28
Total captures	334	118	174	96
	April, 1967		**May, 1967**	
	Treated	Untreated	Treated	Untreated
New captures	366	99	129	42
New recaptures	6	2	96	16
Recaptures	266	49	188	28
Total captures	638	150	413	86

Table 5. Trapping success for each trapping period on both areas.

Trapping Period	Trapping Success a/			
	Treated Area		Untreated Area	
	Total Captures	Success	Total Captures	Success
1965				
June	459	30.4	135	20.1
July	361	23.9	178	26.6
August	354	23.4	147	21.9
September	354	23.4	158	23.6
1966				
June	626	41.5	180	28.1
July	462	30.6	180	28.1
August	334	22.1	118	18.4
September	175	11.6	97	15.1
1967				
April	638	42.2	150	23.4
May	413	27.4	86	13.4
Pooled	420	27.6	142	21.9

a/ Success expressed in percent; total capture/trap nights. Treated area = 1510 trap nights for 10-day period; Untreated area = 670 and 640 trap nights for 10-day period for 1965 and 1966-67, respectively.

Table 6. Summary of captures of Peromyscus maniculatus for each trapping period.

	June, 1965 Treated	June, 1965 Untreated	July, 1965 Treated	July, 1965 Untreated
New captures	111	54	39	27
New recaptures	0	0	63	29
Recaptures	199	53	132	91
Total captures	310	107	234	147
Percent of total catch	67.5	88.4	64.8	82.6
	Aug., 1965 Treated	**Aug., 1965 Untreated**	**Sept., 1965 Treated**	**Sept., 1965 Untreated**
New captures	36	16	38	16
New recaptures	46	25	41	14
Recaptures	139	68	132	22
Total captures	221	109	211	52
Percent of total catch	62.4	73.6	62.4	32.9
	June, 1966 Treated	**June, 1966 Untreated**	**July, 1966 Treated**	**July, 1966 Untreated**
New captures	169	60	51	40
New recaptures	5	0	79	29
Recaptures	215	52	146	58
Total captures	389	112	276	127
Percent of total catch	62.1	62.2	59.6	70.6
	Aug., 1966 Treated	**Aug., 1966 Untreated**	**Sept., 1966 Treated**	**Sept., 1966 Untreated**
New captures	53	12	43	25
New recaptures	61	28	28	15
Recaptures	107	23	72	22
Total captures	221	63	143	62
Percent of total catch	66.2	53.4	82.2	64.6
	April, 1967 Treated	**April, 1967 Untreated**	**May, 1967 Treated**	**May, 1967 Untreated**
New captures	301	81	103	32
New recaptures	5	1	84	13
Recaptures	234	47	169	28
Total captures	540	129	356	73
Percent of total catch	84.6	86.0	86.2	84.9

Table 7. Summary of captures of Microtus ochrogaster for each trapping period.

	June, 1965		July, 1965	
	Treated	Untreated	Treated	Untreated
New captures	7	1	17	10
New recaptures	0	0	1	1
Recaptures	1	1	15	9
Total captures	8	2	33	20
Percent of total catch	1.7	1.6	9.1	11.2
	Aug., 1965		Sept., 1965	
	Treated	Untreated	Treated	Untreated
New captures	7	7	8	7
New recaptures	5	1	0	5
Recaptures	6	0	5	12
Total captures	18	8	13	24
Percent of total catch	5.1	5.4	3.7	15.2
	June, 1966		July, 1966	
	Treated	Untreated	Treated	Untreated
New captures	35	4	44	1
New recaptures	0	0	8	1
Recaptures	16	2	19	0
Total captures	51	6	71	2
Percent of total catch	8.2	3.3	15.4	1.1
	Aug., 1966		Sept., 1966	
	Treated	Untreated	Treated	Untreated
New captures	24	5	0	2
New recaptures	10	0	1	2
Recaptures	14	0	0	2
Total captures	48	5	1	6
Percent of total catch	14.4	4.2	0.6	6.2
	April, 1967		May, 1967	
	Treated	Untreated	Treated	Untreated
Total captures	None	None	None	None

Table 8. Summary of captures of Mus musculus for each trapping period.

	June, 1965 Treated	June, 1965 Untreated	July, 1965 Treated	July, 1965 Untreated
New captures	42	0	23	3
New recaptures	0	0	11	0
Recaptures	37	0	15	4
Total captures	79	0	49	7
Percent of total catch	17.2	0.0	13.6	3.9

	Aug., 1965 Treated	Aug., 1965 Untreated	Sept., 1965 Treated	Sept., 1965 Untreated
New captures	40	10	39	34
New recaptures	8	5	6	5
Recaptures	18	9	14	20
Total captures	66	24	59	59
Percent of total catch	18.6	16.2	16.7	37.3

	June, 1966 Treated	June, 1966 Untreated	July, 1966 Treated	July, 1966 Untreated
New captures	48	15	22	8
New recaptures	2	0	2	1
Recaptures	36	10	9	4
Total captures	86	25	33	13
Percent of total catch	13.7	13.9	7.1	7.2

	Aug., 1966 Treated	Aug., 1966 Untreated	Sept., 1966 Treated	Sept., 1966 Untreated
New captures	12	9	9	7
New recaptures	0	2	0	1
Recaptures	5	1	0	1
Total captures	17	12	9	9
Percent of total catch	5.1	10.2	5.2	9.4

	April, 1967 Treated	April, 1967 Untreated	May, 1967 Treated	May, 1967 Untreated
New captures	19	12	4	2
New recaptures	0	0	2	0
Recaptures	5	2	0	0
Total captures	24	14	6	2
Percent of total catch	3.8	9.3	1.4	2.3

Table 9. Summary of captures of Sigmodon hispidus for each trapping period.

	June, 1965 Treated	June, 1965 Untreated	July, 1965 Treated	July, 1965 Untreated
New captures	1	2	2	2
New recaptures	0	0	1	0
Recaptures	2	4	0	0
Total captures	3	6	3	2
Percent of total catch	0.6	5.0	0.8	1.1

	Aug., 1965 Treated	Aug., 1965 Untreated	Sept., 1965 Treated	Sept., 1965 Untreated
New captures	11	1	21	11
New recaptures	0	0	4	0
Recaptures	3	0	10	9
Total captures	14	1	35	20
Percent of total catch	4.0	0.7	9.9	12.6

	June, 1966 Treated	June, 1966 Untreated	July, 1966 Treated	July, 1966 Untreated
New captures	32	19	28	7
New recaptures	0	0	9	4
Recaptures	40	9	30	4
Total captures	72	28	67	15
Percent of total catch	11.5	15.6	14.5	8.3

	Aug., 1966 Treated	Aug., 1966 Untreated	Sept., 1966 Treated	Sept., 1966 Untreated
New captures	24	8	5	2
New recaptures	3	1	0	2
Recaptures	7	5	2	1
Total captures	34	14	7	5
Percent of total catch	10.2	11.9	4.0	5.2

	April, 1967 Treated	April, 1967 Untreated	May, 1967 Treated	May, 1967 Untreated
New captures	10	0	8	0
New recaptures	0	0	3	0
Recaptures	5	0	10	0
Total captures	15	0	21	0
Percent of total catch	2.4	0.0	5.1	0.0

Table 10. Summary of captures of Onychomys leucogaster for each trapping period.

	June, 1965		July, 1965	
	Treated	Untreated	Treated	Untreated
New captures	1	0	3	0
New recaptures	0	0	1	0
Recaptures	1	0	6	0
Total captures	2	0	10	0
Percent of total catch	0.4	0.0	2.8	0.0

	Aug., 1965		Sept., 1965	
	Treated	Untreated	Treated	Untreated
New captures	5	0	5	0
New recaptures	1	0	3	0
Recaptures	7	0	18	0
Total captures	13	0	26	0
Percent of total catch	3.7	0.0	7.3	0.0

	June, 1966		July, 1966	
	Treated	Untreated	Treated	Untreated
New captures	3	4	1	6
New recaptures	1	0	0	3
Recaptures	7	2	0	6
Total captures	11	6	1	15
Percent of total catch	1.8	3.3	0.2	8.3

	Aug., 1966		Sept., 1966	
	Treated	Untreated	Treated	Untreated
New captures	2	8	1	2
New recaptures	1	3	0	1
Recaptures	0	11	0	1
Total captures	3	22	1	4
Percent of total catch	0.9	18.6	0.6	4.2

	April, 1967		May, 1967	
	Treated	Untreated	Treated	Untreated
New captures	2	0	1	0
New recaptures	0	0	0	0
Recaptures	1	0	1	0
Total captures	3	0	2	0
Percent of total catch	0.5	0.0	0.5	0.0

Table 11. Summary of captures of Reithrodontomys megalotis for each trapping period.

	June, 1965		July, 1965	
	Treated	Untreated	Treated	Untreated
New captures	5	3	0	1
New recaptures	0	0	1	0
Recaptures	12	1	2	1
Total captures	17	4	3	2
Percent of total catch	3.7	3.0	2.8	1.1

	Aug., 1965		Sept., 1965	
	Treated	Untreated	Treated	Untreated
New captures	0	1	1	0
New recaptures	1	1	0	1
Recaptures	1	3	2	1
Total captures	2	5	3	2
Percent of total catch	0.6	3.4	0.8	1.3

	June, 1966		July, 1966	
	Treated	Untreated	Treated	Untreated
New captures	9	3	3	3
New recaptures	0	0	0	0
Recaptures	4	0	0	0
Total captures	13	3	3	3
Percent of total catch	2.1	1.7	0.7	1.7

	Aug., 1966		Sept., 1966	
	Treated	Untreated	Treated	Untreated
New captures	1	0	0	1
New recaptures	0	0	0	0
Recaptures	0	0	0	0
Total captures	1	0	0	1
Percent of total catch	0.3	0.0	0.0	1.0

	April, 1967		May, 1967	
	Treated	Untreated	Treated	Untreated
New captures	33	5	11	3
New recaptures	0	0	7	1
Recaptures	20	0	8	0
Total captures	53	5	26	4
Percent of total catch	8.3	3.3	6.3	4.6

Table 12. Summary of captures of Reithrodontomys montanus for each trapping period. (None captured in 1966 or 1967).

	June, 1965 Treated	June, 1965 Untreated	July, 1965 Treated	July, 1965 Untreated
New captures	11	2	1	0
New recaptures	0	0	4	0
Recaptures	17	1	6	0
Total captures	28	3	11	0
Percent of total catch	6.1	2.5	3.0	0.0

	Aug., 1965 Treated	Aug., 1965 Untreated	Sept., 1965 Treated	Sept., 1965 Untreated
New captures	0	0	0	0
New recaptures	2	0	2	0
Recaptures	0	0	2	0
Total captures	2	0	4	0
Percent of total catch	0.6	0.0	1.1	0.0

Table 13. Summary of captures of Perognathus flavus for each trapping period. (None captured in 1966 or 1967).

	June, 1965 Treated	June, 1965 Untreated	July, 1965 Treated	July, 1965 Untreated
New captures	2	0	2	0
New recaptures	0	0	0	0
Recaptures	0	0	1	0
Total captures	2	0	3	0
Percent of total catch	0.4	0.0	2.8	0.0

	Aug., 1965 Treated	Aug., 1965 Untreated	Sept., 1965 Treated	Sept., 1965 Untreated
New captures	0	1	0	0
New recaptures	0	0	0	0
Recaptures	0	0	0	0
Total captures	0	1	0	0
Percent of total catch	0.0	0.7	0.0	0.0

Table 14. Summary of captures of Perognathus flavesens for each trapping period.

	June, 1965 Treated	June, 1965 Untreated	July, 1965 Treated	July, 1965 Untreated
New captures	2	0	1	0
New recaptures	0	0	0	0
Recaptures	2	0	1	0
Total captures	4	0	2	0
Percent of total catch	0.9	0.0	0.6	0.0

	Aug., 1965 Treated	Aug., 1965 Untreated	Sept., 1965 Treated	Sept., 1965 Untreated
New captures	3	0	2	1
New recaptures	3	0	0	0
Recaptures	2	0	0	0
Total captures	8	0	2	1
Percent of total catch	2.3	0.0	0.6	0.6

	June, 1966 Treated	June, 1966 Untreated	July, 1966 Treated	July, 1966 Untreated
New captures	2	0	1	0
New recaptures	0	0	0	0
Recaptures	0	0	0	0
Total captures	2	0	1	0
Percent of total catch	0.3	0.0	0.2	0.0

	Aug., 1966 Treated	Aug., 1966 Untreated	Sept., 1966 Treated	Sept., 1966 Untreated
New captures	2	1	8	8
New recaptures	1	0	1	0
Recaptures	4	0	3	1
Total captures	7	1	12	9
Percent of total catch	2.1	0.8	6.9	9.4

	April, 1967 Treated	April, 1967 Untreated	May, 1967 Treated	May, 1967 Untreated
New captures	1	0	0	0
New recaptures	1	1	0	1
Recaptures	1	0	0	0
Total captures	3	1	0	1
Percent of total catch	0.5	0.7	0.0	1.2

Table 15. Summary of captures of *Spermophilus tridecemlineatus* for each trapping period.

	June, 1965		July, 1965	
	Treated	Untreated	Treated	Untreated
New captures	2	0	6	0
New recaptures	0	0	0	0
Recaptures	2	0	7	0
Total captures	4	0	13	0
Percent of total catch	0.9	0.0	3.6	0.0
	Aug., 1965		Sept., 1965	
	Treated	Untreated	Treated	Untreated
New captures	4	0	0	0
New recaptures	2	0	1	0
Recaptures	2	0	0	0
Total captures	8	0	1	0
Percent of total catch	2.3	0.0	0.3	0.0
	June, 1966		July, 1966	
	Treated	Untreated	Treated	Untreated
New captures	2	0	8	2
New recaptures	0	0	0	0
Recaptures	0	0	2	1
Total captures	2	0	10	3
Percent of total catch	0.3	0.0	2.2	1.7
	Aug., 1966		Sept., 1966	
	Treated	Untreated	Treated	Untreated
New captures	2	0	0	0
New recaptures	0	0	1	0
Recaptures	1	0	0	0
Total captures	3	0	1	0
Percent of total catch	0.9	0.0	0.6	0.0
	April, 1967		May, 1967	
	Treated	Untreated	Treated	Untreated
Total captures	None	None	None	None

Table 16. Proportions each species contributed to the total animals captured on the treated area during each 10-day period of this study.

	Peromyscus maniculatus	*Microtus ochrogaster*	*Mus musculus*	*Sigmodon hispidus*	*Onychomys leucogaster*	*Reithrodontomys megalotis*	*Reithrodontomys montanus*	*Perognathus flavus*	*Perognathus flavesens*	*Spermophilus tridecemlineatus*	Others a/
1965											
June	67.5 b/	1.7	17.2	0.6	0.4	3.7	6.1	0.4	0.9	0.9	0.6
July	64.8	9.1	13.6	0.8	2.8	2.8	3.0	2.8	0.6	3.6	0.0
Aug.	62.4	5.1	18.6	4.0	3.7	0.6	0.6	0.0	2.3	2.3	0.4
Sept.	62.4	3.7	16.7	9.9	7.3	0.8	1.1	0.0	0.6	0.3	0.0
1966											
June	62.1	8.2	13.7	11.5	1.8	2.1	0.0	0.0	0.3	0.3	0.0
July	59.6	15.4	7.1	14.5	0.2	0.7	0.0	0.0	0.2	2.2	0.0
Aug.	66.2	14.4	5.1	10.2	0.9	0.3	0.0	0.0	2.1	0.9	0.0
Sept.	82.2	0.6	5.2	4.0	0.6	0.0	0.0	0.0	6.9	0.6	0.0
1967											
April	84.6	0.0	3.8	2.4	0.5	8.3	0.0	0.0	0.5	0.0	0.0
May	86.2	0.0	1.4	5.1	0.5	6.3	0.0	0.0	0.0	0.0	0.5

a/ Includes *Perognathus hispidus*, *Dipodomys ordii* and *Sylvilagus floridanus*.
b/ Expressed as percentage of the total number captured each period.

Table 17. Proportions each species contributed to the total animals captured on the untreated area during each 10-day period of this study.

	Peromyscus maniculatus	*Microtus ochrogaster*	*Mus musculus*	*Sigmodon hispidus*	*Onychomys leucogaster*	*Reithrodontomys megalotis*	*Reithrodontomys montanus*	*Perognathus flavus*	*Perognathus flavesens*	*Spermophilus tridecemlineatus*	Others a/
1965											
June	88.4 b/	1.6	0.0	5.0	0.0	3.0	2.5	0.0	0.0	0.0	0.0
July	82.6	11.2	3.9	1.1	0.0	1.1	0.0	0.0	0.0	0.0	0.0
Aug.	73.6	5.4	16.2	0.7	0.0	3.4	0.0	0.7	0.0	0.0	0.0
Sept.	32.9	15.2	37.3	12.6	0.0	1.3	0.0	0.0	0.6	0.0	0.0
1966											
June	62.2	3.3	13.9	15.6	3.3	1.7	0.0	0.0	0.0	0.0	0.0
July	70.6	1.1	7.2	8.3	8.3	1.7	0.0	0.0	0.0	1.7	1.1
Aug.	53.4	4.2	10.2	11.9	18.6	0.0	0.0	0.0	0.8	0.0	0.9
Sept.	64.6	6.2	9.4	5.2	4.2	1.0	0.0	0.0	9.4	0.0	0.0
1967											
April	86.0	0.0	9.3	0.0	0.0	3.3	0.0	0.0	0.7	0.0	0.7
May	84.9	0.0	2.3	0.0	0.0	4.6	0.0	0.0	1.2	0.0	7.0

a/ Includes *Perognathus hispidus*, *Dipodomys ordii* and *Sylvilagus floridanus*.
b/ Expressed as percentage of the total number captured each period.

Table 18. Numbers captured and percentage each species comprised of the total number of captures on both areas.

	Treated Captures	Treated Percent	Untreated Captures	Untreated Percent	Average percent
Peromyscus maniculatus	2901	69.5	981	69.3	69.4
Microtus ochrogaster	243	5.8	73	5.2	5.5
Mus musculus	428	10.2	165	11.7	11.0
Sigmodon hispidus	271	6.5	91	6.4	6.4
Onychomys leucogaster	72	1.7	47	3.3	2.5
Reithrodontomys megalotis	121	2.9	29	2.0	2.4
Perognathus flavesens	41	1.0	13	0.9	1.0
Spermophilus tridecemlineatus	42	1.0	3	0.2	0.6
Other	56	1.3	13	0.9	1.1
TOTALS	4175		1415		

Table 19. Number of individuals marked and the percentage each species comprised of the total number marked on each area.

	Treated Marked	Treated Percent	Untreated Marked	Untreated Percent	Total marked
Peromyscus maniculatus	944	57.6	363	59.0	1307
Microtus ochrogaster	142	8.7	37	6.0	179
Mus musculus	258	15.7	100	16.3	358
Sigmodon hispidus	142	8.7	52	8.4	194
Onychomys leucogaster	24	1.5	20	3.3	44
Reithrodontomys megalotis	63	3.8	20	3.3	83
Perognathus flavesens	22	1.3	10	1.6	32
Spermophilus tridecemlineatus	24	1.5	2	0.3	26
Other	20	1.2	11	1.8	31
TOTALS	1639		615		2254

Table 20. Percent of males of species of which 10 or more were captured in the treated area.

	P. maniculatus	*M. ochrogaster*	*M. musculus*	*S. hispidus*	*R. megalotis*
1965					
June	59.5	--	33.3	--	--
July	55.9	66.7	52.9	--	--
Aug.	59.8	4.7	41.7	54.5	--
Sept.	58.2	--	42.2	45.4	--
1966					
June	49.4	48.6	58.0	--	--
July	59.2	61.5	70.8	--	--
Aug.	53.5	32.4	75.0	--	--
Sept.	53.6	--	--	--	--
1967					
April	48.7	--	47.4	--	54.5
May	45.4	--	--	--	55.6
Pooled	52.7	51.0	49.3	50.8	54.9

Table 21. Percent of males of species of which 10 or more were captured in the untreated area.

	P. maniculatus	*M. ochrogaster*	*M. musculus*	*S. hispidus*	*O. leucogaster*
1965					
June	55.6	--	46.7	--	--
July	57.1	40.0	--	--	--
Aug.	58.5	--	66.7	--	--
Sept.	70.0	50.0	48.7	63.6	--
1966					
June	59.3	--	57.1	47.4	--
July	58.0	--	--	63.6	--
Aug.	70.0	--	90.9	--	50.0
Sept.	62.5	--	--	--	--
1967					
April	43.9	--	58.3	--	--
May	44.4	--	--	--	--
Pooled	56.4	45.4	57.5	56.1	50.0

Table 22. Population estimates (N) made by the Schnabel method and 95% confidence interval (C.I.) for the total, <u>Peromyscus maniculatus</u>, <u>Mus musculus</u>, <u>Sigmodon hispidus</u> and all other rodents captured on the treated area per 1000 feet of trap line.

	Total Population		<u>Peromyscus maniculatus</u>		<u>Mus musculus</u>		<u>Sigmodon hispidus</u>		Others [a]	
	(N)	(C.I.)	(N)	(C.I.)	(N)	(C.I.)	(N)	(C.I.)	(N)	(C.I.)
<u>1965</u>										
June	22.8	20.2-26.3	14.4	12.4-17.0	5.0	3.6- 7.9	0.1	0 -inf[b]	3.6	2.6-5.7
July	21.0	18.0-25.2	12.4	10.4-15.4	4.6	2.9-11.1	0	0 -0	4.3	3.2-6.8
Aug.	21.0	18.0-25.1	10.5	8.8-12.9	7.0	4.6-15.0	1.9	0.8-inf	4.6	3.0-9.7
Sept.	20.4	17.5-24.5	10.0	8.4-12.5	7.3	4.6-18.4	3.6	2.1-12.7	2.6	1.8-4.6
<u>1966</u>										
June	36.5	32.4-41.8	20.8	18.1-24.5	6.0	4.4- 9.6	3.7	2.8-5.8	6.8	4.7-11.9
July	30.8	26.6-36.5	15.3	13.0-18.8	3.4	2.0-14.0	4.3	3.1-7.4	10.4	7.0-20.5
Aug.	24.1	20.3-29.8	13.5	11.1-17.3	1.7	0.8-inf	4.7	2.5-31.9	6.0	4.0-12.4
Sept.	11.6	9.3-15.6	8.4	6.6-11.4	0	---	0.9	0.3-inf	2.1	0.9-inf
<u>1967</u>										
April	45.4	40.5-51.9	37.0	32.4-42.8	3.3	1.6-inf	1.3	0.6-inf	4.6	3.1-9.0
May	27.0	23.5-32.1	22.2	19.0-26.7	0	---	1.3	0.7-4.5	2.9	1.7-9.1

a/ Includes <u>Microtus ochrogaster</u>, <u>Onychomys leucogaster</u>, <u>Reithrodontomys megalotis</u>, <u>R. montanus</u>, <u>Perognathus flavus</u>, <u>P. flavesens</u>, <u>P. hispidus</u>, <u>Spermophilus tridecemlineatus</u>, <u>Dipodomys ordii</u> and <u>Sylvilagus floridanus</u>.

b/ Infinity.

Table 23. Population estimates (N) made by the Schumacher-Eschemeyer method and 95% confidence interval (C.I.) for the total, *Peromyscus maniculatus*, *Mus musculus*, *Sigmodon hispidus* and all other rodents captured on the treated area per 1000 feet of trap line.

	Total Population		*Peromyscus maniculatus*		*Mus musculus*		*Sigmodon hispidus*		Others a/	
	(N)	(C.I.)	(N)	(C.I.)	(N)	(C.I.)	(N)	(C.I.)	(N)	(C.I.)
1965										
June	12.9	9.5-16.4	7.5	5.5- 9.5	3.4	2.6-4.3	0.1	0.0-0.1	2.1	1.5- 2.7
July	13.4	9.4-17.3	7.4	5.3- 9.5	3.9	2.4-5.4	0	---	2.8	2.0- 3.6
Aug.	13.6	9.8-17.5	5.5	4.0- 6.9	5.8	4.3-7.3	1.5	0.8-2.3	3.6	2.3- 5.0
Sept.	13.0	9.5-16.4	5.4	4.1- 6.7	6.1	4.2-8.0	2.8	1.9-3.8	1.7	1.2- 2.1
1966										
June	23.9	17.4-30.3	12.8	9.3-16.3	4.4	3.2-5.6	2.3	1.7-2.9	5.3	3.6- 7.0
July	21.6	15.9-27.3	9.7	7.5-11.8	2.7	2.0-3.5	3.0	2.1-3.9	8.5	5.3-11.6
Aug.	17.6	12.8-22.5	9.0	7.0-11.1	1.3	0.8-1.8	3.8	2.6-5.0	4.8	3.2- 6.4
Sept.	8.2	6.0-10.4	5.4	3.9- 6.8	0	---	0.7	---	2.0	1.1- 3.0
1967										
April	32.8	23.1-42.5	26.2	18.3-34.2	2.7	---	1.0	0.6-1.3	3.4	2.4- 4.5
May	18.7	14.0-23.4	15.1	11.4-18.8	0	---	0.9	0.6-1.2	2.2	1.5- 2.8

a/ Includes *Microtus ochrogaster*, *Onychomys leucogaster*, *Reithrodontomys megalotis*, *R. montanus*, *Perognathus flavus*, *P. flavesens*, *P. hispidus*, *Spermophilus tridecemlineatus*, *Dipodomys ordii* and *Sylvilagus floridanus*.

Table 24. Population estimates (N) made by the Schnabel method and 95% confidence interval (C.I.) for the total, Peromyscus maniculatus, Mus musculus, Sigmodon hispidus and all other rodents captured on the untreated area per 1000 feet of trap line.

	Total Population		Peromyscus maniculatus		Mus musculus		Sigmodon hispidus		Others a/	
	(N)	(C.I.)	(N)	(C.I.)	(N)	(C.I.)	(N)	(C.I.)	(N)	(C.I.)
1965										
June	27.1	21.0-38.1	23.9	18.3-34.5	0.0	---	0.6	0.3-inf b/	2.7	1.1-inf
July	33.7	37.6-43.0	36.4	21.4-34.3	1.2	0.6-inf	0.0	---	5.1	3.0-17.8
Aug.	30.5	24.3-40.8	19.4	15.2-26.6	6.6	3.8-27.1	0.0	---	6.8	2.9-inf
Sept.	43.6	34.0-60.7	13.6	9.2-26.2	19.4	12.9-39.3	4.8	2.7-19.4	8.0	4.6-28.0
1966										
June	47.6	37.8-64.3	26.4	20.1-38.4	6.2	3.6-22.6	8.9	5.1-36.2	6.2	2.9-inf
July	49.1	38.9-66.6	30.7	23.7-43.6	4.7	2.2-inf	5.8	2.7-inf	9.4	5.1-64.8
Aug.	38.6	28.4-60.1	17.9	12.3-33.2	15.4	4.8-inf	3.7	1.8-inf	8.4	5.0-26.3
Sept.	36.3	25.5-63.3	19.4	13.1-37.4	8.2	2.5-inf	2.2	0.7-inf	10.4	4.9-inf
1967										
April	51.2	38.8-75.4	39.4	29.6-58.7	10.3	4.0-inf	0	---	0	---
May	28.8	20.3-49.7	20.8	14.7-35.9	0	---	0	---	0	---

a/ Includes Microtus ochrogaster, Onychomys leucogaster, Reithrodontomys megalotis, R. montanus, Perognathus flavus, P. flavesens, P. hispidus, Spermophilus tridecemlineatus, Dipodomys ordii and Sylvilagus floridanus.

b/ Infinity.

Table 25. Population estimates (N) made by the Schumacher-Eschemeyer method and 95% confidence interval (C.I.) for the total, *Peromyscus maniculatus*, *Mus musculus*, *Sigmodon hispidus* and all other rodents captured on the untreated area per 1000 feet of trap line.

	Total Population		*Peromyscus maniculatus*		*Mus musculus*		*Sigmodon hispidus*		Others a/	
	(N)	(C.I.)	(N)	(C.I.)	(N)	(C.I.)	(N)	(C.I.)	(N)	(C.I.)
1965										
June	17.9	13.0-22.8	16.0	11.7-20.2	0.0	---	0.2	0.2- 0.3	2.1	1.3- 2.9
July	19.2	14.6-23.7	14.4	10.9-17.8	0.6	---	0	---	3.6	2.9- 4.3
Aug.	18.8	14.2-23.4	10.4	8.1-12.7	5.0	3.9- 6.2	0	---	6.7	2.6-10.8
Sept.	31.9	23.2-40.6	9.6	7.3-11.8	15.5	10.8-20.3	3.5	2.3- 4.8	5.9	4.2- 7.6
1966										
June	34.5	24.3-44.8	18.2	13.9-22.6	4.6	---	7.0	4.1-10.0	5.0	2.4- 7.5
July	36.2	26.2-46.3	21.4	15.6-27.1	3.5	2.3- 4.7	5.1	2.5- 7.7	8.3	6.2-10.4
Aug.	30.7	22.1-39.3	13.9	11.3-16.6	12.1	4.0-20.2	3.0	2.0- 4.0	6.1	4.2- 8.1
Sept.	31.1	20.0-42.3	15.8	9.3-22.3	9.4	0 -19.8	1.5	---	9.2	6.8-11.6
1967										
April	43.3	29.2-57.3	31.6	21.6-41.6	8.6	3.8-13.4	0	---	0	---
May	22.7	14.2-31.2	15.6	10.1-21.1	0	---	0	---	0	---

a/ Includes *Microtus ochrogaster*, *Onychomys leucogaster*, *Reithrodontomys megalotis*, *R. montanus*, *Perognathus flavus*, *P. flavescens*, *P. hispidus*, *Spermophilus tridecemlineatus*, *Dipodomys ordii* and *Sylvilagus floridanus*.

Table 26. Population estimates (N) made by the Schnabel method and 95% confidence interval (C.I.) for the total, *Peromyscus maniculatus*, *Mus musculus*, *Sigmodon hispidus* and all other rodents captured on the treated area. (Inf = infinity).

Population	N	C.I.	N	C.I.
	June, 1965		July, 1965	
Total	344.2	304.9-396.8	316.6	271.7-378.8
P. maniculatus	216.4	187.3-256.4	186.5	156.2-231.5
M. musculus	74.8	54.6-118.8	69.9	44.1-167.8
S. hispidus	1.5	0.0-inf	0.0	---
All other rodents	54.1	39.5- 86.0	65.5	47.9-103.3
	Aug., 1965		Sept., 1965	
Total	316.3	271.7-378.7	307.9	263.8-369.0
P. maniculatus	157.6	132.6-194.6	151.3	126.6-188.0
M. musculus	106.3	69.4-226.8	110.2	68.8-277.8
S. hispidus	28.7	12.4-inf	54.4	31.7-190.8
All other rodents	68.8	44.8-146.6	39.4	27.4- 69.7
	June, 1966		July, 1966	
Total	549.1	487.8-628.9	463.2	400.0-549.4
P. maniculatus	313.3	272.5-369.0	231.0	195.3-282.5
M. musculus	90.2	65.6-144.3	51.7	29.5-210.5
S. hispidus	56.3	41.7- 86.6	65.5	46.4-111.4
All other rodents	101.8	71.1-179.5	156.8	105.0-308.6
	Aug., 1966		Sept., 1966	
Total	363.0	305.8-448.4	175.6	140.0-235.8
P. maniculatus	203.9	167.8-260.4	126.5	100.0-172.4
M. musculus	25.2	12.5-inf	0.0	---
S. hispidus	70.4	38.0-480.8	13.0	5.0-inf
All other rodents	90.3	59.5-187.6	31.7	13.7-inf
	April, 1967		May, 1967	
Total	684.5	609.6-781.2	407.5	353.4-483.1
P. maniculatus	556.9	487.8-645.2	334.8	286.5-401.6
M. musculus	49.8	24.8-inf	0.0	---
S. hispidus	19.6	9.7-inf	19.3	11.2- 67.8
All other rodents	70.0	47.2-135.1	43.5	25.8-136.8

Table 27. Population estimates (N) made by the Schumacher-Eschemeyer method and 95% confidence interval (C.I.) for the total, *Peromyscus maniculatus*, *Mus musculus*, *Sigmodon hispidus* and all other rodents captured on the treated area.

Population	N	C.I.	N	C.I.
	June, 1965		July, 1965	
Total	194.9	143.1-246.7	201.8	142.4-261.2
P. maniculatus	113.3	83.5-143.1	111.6	79.8-143.4
M. musculus	51.6	38.6- 64.6	58.5	36.1- 80.9
S. hispidus	1.0	0.6- 1.4	0.0	---
All other rodents	31.4	22.0- 40.8	41.9	29.9- 53.9
	Aug., 1965		Sept., 1965	
Total	205.1	146.9-263.3	195.2	143.8-246.6
P. maniculatus	82.5	60.5-104.5	80.8	61.2-100.4
M. musculus	87.7	65.3-110.1	91.7	63.1-120.3
S. hispidus	23.3	11.5- 35.1	42.6	28.2- 57.0
All other rodents	55.0	35.2- 74.8	25.1	18.3- 31.9
	June, 1966		July, 1966	
Total	359.4	262.0-456.8	325.8	240.0-411.6
P. maniculatus	192.8	140.2-245.4	145.6	113.6-177.6
M. musculus	66.3	48.9- 83.7	41.2	29.6- 52.8
S. hispidus	35.1	26.1- 44.1	45.6	32.0- 59.2
All other rodents	79.7	54.3-105.1	127.7	79.9-175.5
	Aug., 1966		Sept., 1966	
Total	265.9	193.5-338.3	123.3	90.1-156.5
P. maniculatus	136.3	104.7-167.9	80.7	59.1-102.3
M. musculus	19.3	11.7- 26.9	0.0	---
S. hispidus	57.2	39.4- 75.0	10.8	---
All other rodents	71.9	47.9- 95.9	30.7	16.5- 44.9
	April, 1967		May, 1967	
Total	493.9	347.7-640.1	282.3	211.5-353.1
P. maniculatus	395.2	275.6-514.8	227.4	172.0-282.8
M. musculus	41.3	---	0.0	---
S. hispidus	14.7	9.9- 19.5	13.3	8.7- 17.9
All other rodents	51.6	35.6- 67.6	32.7	22.7- 42.7

Table 28. Population estimates (N) made by the Schnabel method and 95% confidence interval (C.I.) for the total, *Peromyscus maniculatus*, *Mus musculus*, *Sigmodon hispidus* and all other rodents captured on the untreated area. (Inf = infinity).

Population	N	C.I.	N	C.I.
	June, 1965		July, 1965	
Total	108.9	84.5-153.1	135.3	110.9-173.6
P. maniculatus	96.2	73.6-138.7	106.0	86.2-137.7
M. musculus	0.0	---	5.0	2.3-inf
S. hispidus	2.5	1.2-inf	0.0	---
All other rodents	10.7	4.6-inf	20.4	12.0- 71.6
	Aug., 1965		Sept., 1965	
Total	122.5	97.8-163.9	175.1	136.6-243.9
P. maniculatus	77.8	61.1-107.1	54.7	36.9-105.5
M. musculus	26.7	15.2-109.0	78.1	51.9-158.0
S. hispidus	0.0	---	19.2	11.0- 77.8
All other rodents	27.3	11.8-inf	32.0	18.6-112.4
	June, 1966		July, 1966	
Total	191.2	151.7-258.4	197.3	156.2-267.4
P. maniculatus	106.2	80.9-154.3	123.3	95.1-175.1
M. musculus	25.1	14.6- 90.9	18.8	8.8-inf
S. hispidus	35.9	20.5-145.6	23.5	11.0-inf
All other rodents	24.8	11.6-inf	38.0	20.5-260.4
	Aug., 1966		Sept., 1966	
Total	155.0	114.2-241.5	145.9	102.4-254.4
P. maniculatus	72.0	49.3-133.5	77.9	52.6-150.2
M. musculus	62.0	19.1-inf	33.0	10.1-inf
S. hispidus	15.0	7.4-inf	9.0	2.8-inf
All other rodents	33.7	20.1-105.6	42.0	19.7-inf
	April, 1967		May, 1967	
Total	205.6	155.8-303.0	115.9	81.6-199.6
P. maniculatus	158.1	119.0-235.8	83.6	58.9-144.1
M. musculus	41.5	16.0-inf	0.0	---
S. hispidus	0.0	---	0.0	---
All other rodents	0.0	---	0.0	---

Table 29. Population estimates (N) made by the Schumacher-Eschemeyer method and 95% confidence interval (C.I.) for the total, *Peromyscus maniculatus*, *Mus musculus*, *Sigmodon hispidus* and all other rodents captured on the untreated area.

Population	N	C.I.	N	C.I.
	June, 1965		July, 1965	
Total	72.0	52.2- 91.8	77.0	58.6- 95.4
P. maniculatus	64.1	47.1- 81.1	57.7	43.9- 71.5
M. musculus	0.0	---	2.3	---
S. hispidus	1.0	0.8- 1.2	0.0	---
All other rodents	8.5	5.3- 11.7	14.6	11.8- 17.4
	Aug., 1965		Sept., 1965	
Total	75.6	57.2- 94.0	128.2	93.4-163.0
P. maniculatus	41.8	32.4- 51.2	38.4	29.2- 47.6
M. musculus	20.2	15.6- 24.8	62.4	43.2- 81.6
S. hispidus	0.0	---	14.2	9.2- 19.2
All other rodents	26.8	10.4- 43.2	23.9	17.1- 30.7
	June, 1966		July, 1966	
Total	138.8	97.6-180.0	145.5	105.1-185.9
P. maniculatus	73.2	55.8- 90.6	85.8	62.8-108.8
M. musculus	18.7	---	14.1	9.3- 18.9
S. hispidus	28.3	16.5- 40.1	20.5	10.1- 30.9
All other rodents	20.0	9.8- 30.2	33.4	25.0- 41.8
	Aug., 1966		Sept., 1966	
Total	123.4	88.8-158.0	125.1	80.3-169.9
P. maniculatus	55.9	45.3- 66.5	63.5	37.5- 89.5
M. musculus	48.7	16.1- 81.3	37.8	0 0- 19.4
S. hispidus	12.1	7.9- 16.3	6.2	---
All other rodents	24.7	16.9- 32.5	37.1	27.5- 46.7
	April, 1967		May, 1967	
Total	173.9	117.5-230.3	91.2	57.2-125.2
P. maniculatus	127.0	87.0-167.0	62.7	40.5- 84.9
M. musculus	34.6	15.4- 53.8	0.0	---
S. hispidus	0.0	---	0.0	---
All other rodents	0.0	---	0.0	---

Table 30. Pesticidal analyses conducted on 94 rodents. (D = dieldrin, H.E. = heptachlor epoxide).

Number	Species	Sex	Trapping period collected	Area where collected	Results ppm
1a	M. ochrogaster	F	June, 1965	Treated	0
2a	M. musculus	M	June, 1965	Treated	0
3a	P. flavus	M	June, 1965	Treated	0
4a	P. maniculatus	M	June, 1965	Treated	0
5a	M. musculus	M	June, 1965	Untreated	0
6a	S. hispidus	F	June, 1965	Untreated	0
7a	R. megalotis	M	June, 1965	Untreated	0
8a	M. ochrogaster	M	June, 1965	Untreated	0
9a	P. maniculatus	F	June, 1965	Untreated	0
10a	M. ochrogaster	F	July, 1965	Untreated	0
11a	P. maniculatus	M	July, 1965	Untreated	0
12a	P. maniculatus	M	July, 1965	Untreated	0
13a	S. hispidus	M	July, 1965	Treated	0
14a	S. tridecemlineatus	F	July, 1965	Treated	.24 D
15a	M. musculus	F	July, 1965	Treated	0
16a	M. musculus	M	July, 1965	Treated	0
17a	M. ochrogaster	F	July, 1965	Treated	0
18a	M. ochrogaster	F	July, 1965	Treated	0
19a	M. ochrogaster	M	Aug., 1965	Untreated	0
20a	P. maniculatus	M	Aug., 1965	Untreated	0
21a	P. maniculatus	M	Aug., 1965	Untreated	0
22a	P. maniculatus	F	Aug., 1965	Treated	0
23a	O. leucogaster	F	Aug., 1965	Treated	0
24a	P. maniculatus	F	Aug., 1965	Treated	0
25a	M. ochrogaster	F	Aug., 1965	Treated	0
26a	P. flavesens	M	Aug., 1965	Treated	0
27a	S. hispidus	F	Aug., 1965	Treated	0
1	M. ochrogaster	M	Sept., 1965	Untreated	0
2	M. musculus	M	Sept., 1965	Untreated	0
3	S. hispidus	F	Sept., 1965	Treated	0
4	P. maniculatus	M	Sept., 1965	Treated	.01 D
5	P. maniculatus	M	Sept., 1965	Untreated	0
6	M. musculus	M	Sept., 1965	Treated	.01 D
10	S. hispidus	F	June, 1966	Treated	0
11	P. maniculatus	M	June, 1966	Treated	0
12	M. musculus	M	June, 1966	Treated	0
13	R. megalotis	M	June, 1966	Treated	0
14	P. flavesens	M	June, 1966	Treated	0
15	M. ochrogaster	M	June, 1966	Treated	0

Table 30. (cont'd).

Number	Species	Sex	Trapping period collected	Area where collected	Results ppm
16	M. ochrogaster	M	June, 1966	Untreated	0
17	P. maniculatus	F	June, 1966	Untreated	0
18	R. megalotis	F	June, 1966	Untreated	.03 D
19	S. hispidus	F	June, 1966	Untreated	0
20	M. ochrogaster	M	July, 1966	Treated	0
21	P. maniculatus	M	July, 1966	Treated	.03 D & .02 HE
22	M. musculus	M	July, 1966	Treated	.13 D
23	S. hispidus	M	July, 1966	Treated	0
24	S. tridecemlineatus	M	July, 1966	Treated	0
25	S. hispidus	M	July, 1966	Untreated	0
26	M. musculus	M	July, 1966	Untreated	.17 D
27	P. maniculatus	M	July, 1966	Untreated	0
28	O. leucogaster	M	July, 1966	Untreated	0
29	P. maniculatus	M	Aug., 1966	Treated	0
30	M. ochrogaster	F	Aug., 1966	Treated	0
31	P. flavesens	M	Aug., 1966	Treated	0
32	P. maniculatus	M	Aug., 1966	Treated	0
33	S. tridecemlineatus	M	Aug., 1966	Treated	0
34	M. musculus	M	Aug., 1966	Treated	0
35	O. leucogaster	F	Aug., 1966	Treated	.02 D
36	S. hispidus	M	Aug., 1966	Treated	0
37	P. maniculatus	M	Aug., 1966	Untreated	0
38	S. hispidus	M	Aug., 1966	Untreated	0
39	O. leucogaster	F	Aug., 1966	Untreated	0
40	P. flavesens	F	Aug., 1966	Untreated	0
41	M. musculus	M	Aug., 1966	Untreated	0
42	M. ochrogaster	F	Aug., 1966	Untreated	0
43	P. maniculatus	F	Sept., 1966	Untreated	0
44	P. maniculatus	F	Sept., 1966	Untreated	.01 D
45	M. musculus	M	Sept., 1966	Untreated	0
46	P. flavesens	M	Sept., 1966	Untreated	0
47	P. maniculatus	F	Sept., 1966	Treated	0
48	P. flavesens	F	Sept., 1966	Treated	0
49	P. maniculatus	F	Sept., 1966	Treated	0
50	M. musculus	M	Sept., 1966	Treated	.02 D
51	S. hispidus	F	April, 1967	Treated	.01 HE
52	P. maniculatus	M	April, 1967	Treated	.01 HE
53	O. leucogaster	M	April, 1967	Treated	0

Table 30. (cont'd).

Number	Species	Sex	Trapping period collected	Area where collected	Results ppm
54	*P. maniculatus*	M	April, 1967	Treated	0
55	*P. maniculatus*	F	April, 1967	Treated	.01 D
56	*R. megalotis*	F	April, 1967	Treated	0
57	*P. maniculatus*	M	April, 1967	Untreated	.01 D
58	*P. maniculatus*	M	April, 1967	Untreated	0
59	*M. musculus*	F	April, 1967	Untreated	0
60	*P. maniculatus*	M	May, 1967	Untreated	0
61	*M. musculus*	M	May, 1967	Untreated	0
62	*R. megalotis*	M	May, 1967	Untreated	0
63	*P. maniculatus*	F	May, 1967	Untreated	0
64	*P. maniculatus*	M	May, 1967	Treated	0
65	*P. maniculatus*	M	May, 1967	Treated	.01 D
66	*R. megalotis*	M	May, 1967	Treated	0
67	*R. megalotis*	M	May, 1967	Treated	0
68	*M. musculus*	M	May, 1967	Treated	.01 D
69	*S. hispidus*	M	May, 1967	Treated	0
70	*O. leucogaster*	F	May, 1967	Treated	0

Table 31. FORMAT USED IN PUNCHING IBM CARDS

Column number

1-2: Month
3-4: Day
5-6: Year
7: Observer
- (1) Larry Robinson
- (2) Clayton Stalling

8: Sky conditions
- (0) Clear
- (1) Partly cloudy
- (2) Light overcast
- (3) Heavy overcast
- (4) No observation

9: Locations where weather observations were made
- (1) Study area (unofficial)
- (2) Ft. Hays Experiment Station (official)

10: Wind direction
- (0) No observation
- (1) North
- (2) Northeast
- (3) East
- (4) Southeast
- (5) South
- (6) Southwest
- (7) West
- (8) Northwest
- (9) Calm (no direction)

11: Wind speed
- (0) 0 mph.
- (1) Less than 5 mph.
- (2) 5 - 10 mph.
- (3) 10 - 15 mph.
- (4) 15 - 20 mph.
- (5) 20 - 25 mph.
- (6) 25 - 30 mph.
- (7) 30 - 40 mph.
- (8) 40 - 50 mph.

12: Dew
- (0) None
- (1) Light
- (2) Moderate
- (3) Heavy
- (4) No observation

Table 31. (cont'd).

13-15: Number of days since last rain
16-18: Maximum temperature
19-20: Minimum temperature
21: Moon phase
- (0) No observation
- (1) First quarter
- (2) Full moon
- (3) Last quarter
- (4) New moon

22-24: Number of traps sprung in particular study area
25: Height of vegetation
- (0) No observation
- (1) 0 inches
- (2) 0 - 4 inches
- (3) 4 - 8 inches
- (4) 8 - 12 inches
- (5) 12 - 16 inches
- (6) 16 - 20 inches
- (7) 20 - 24 inches
- (8) 24 - 28 inches
- (9) 28+ inches

26-27: Species
- (01) Peromyscus maniculatus
- (02) Microtus ochrogaster
- (03) Mus musculus
- (04) Sigmodon hispidus
- (05) Onychomys leucogaster
- (06) Reithrodontomys megalotis
- (07) Reithrodontomys montanus
- (08) Perognathus flavus
- (09) Perognathus flavesens
- (10) Spermophilus tridecemlineatus
- (11) Perognathus hispidus
- (12) Sylvilagus floridanus
- (13) Dipodomys ordii

28: Recapture code
- (0) Unknown
- (1) New capture
- (2) New recapture (first time captured in this period but previously marked)
- (3) Recapture

29: Age and Sex
- (1) Adult male
- (2) Juvenile male
- (3) Adult female
- (4) Juvenile female
- (5) Adult unknown
- (6) Juvenile unknown
- (7) Male, age unknown
- (8) Female, age unknown
- (9) Unknown

Table 31. (cont'd).

30: Reproductive code
- (0) No observation
- (1) Lactating female
- (2) Non-lactating female
- (3) Male, testes descended
- (4) Male, testes ascended
- (5) Pregnant female
- (6) Female in gestation (young in trap also)

31: Release code
- (1) Released
- (2) Dead in trap; not collected
- (3) Collected (alive)
- (4) Dead in trap and collected

32-24: Number assigned to animals collected

35-39: Trap location
- (001) A
- (002) B
- (003) C
- (004) D
- (005) E
- (006) F
- (007) G
- (008) H
- (009) I
- (010) J
- (011) K

40-61: Results of analysis expressed in .00 ppm
- 40 - 41: Diazinon
- 42 - 43: Parathion
- 44 - 45: Malathion
- 46 - 47: Endrin
- 48 - 49: Aldrin
- 50 - 51: Dieldrin
- 52 - 53: Heptachlor
- 54 - 55: Heptachlor E
- 56 - 57: DDE
- 58 - 59: DDT D,P
- 60 - 61: DDT P,P

62-64: Precipitation
- 62: Inches
- 63: Tenths of inch
- 64: Hundredths of inch

65-73: Not in use

74: Area where animal was taken
- (1) Moore area (treated)
- (2) Younger area (untreated)

75-77: Ear mark given animal
- (000) No ear mark
- (001) Left ear clipped
- (002) Right ear clipped

Table 31. (cont'd).

(003) Both ears clipped
(004) Right ear notched in front
(005) Left ear notched in front
(006) Right ear notched on top
(007) Left ear notched on top
(008) Right ear notched in back
(009) Left ear notched in back

78-80: Toes clipped on animals

EFFECTS OF PESTICIDES ON SMALL MAMMAL POPULATIONS. PHASE I

by

CLAYTON DON STALLING

B. A., Wayne State College, 1965

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Zoology

Division of Biology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

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In 1965 an intensive study of the possible effects of pesticides on small mammal populations was initiated. Two areas located in the Cedar Bluff Irrigation District, Ellis County, Kansas, were selected for this study. One of these areas received applications of pesticides (treated area) whereas the other area was relatively free of pesticides (untreated area).

Intensive live trapping was employed on both areas during 10-day periods in the months of June through September 1965 and 1966 and April and May 1967.

Captured animals were marked by a system of toe clipping and notching of ears.

Animals captured included *Peromyscus maniculatus*, *Microtus ochrogaster*, *Mus musculus*, *Sigmodon hispidus*, *Onychomys leucogaster*, *Reithrodontomys megalotis*, *R. montanus*, *Perognathus flavus*, *P. flavesens*, *P. hispidus*, *Spermophilus tridecemlineatus*, *Dipodomys ordii* and *Sylvilagus floridanus*.

Data collected were the result of 6,520 trap-nights on the untreated area and 15,100 trap-nights on the treated area. During this time 1,415 and 4,175 captures were made on the untreated and treated areas, respectively, yielding an overall trapping success of 24.6 percent. Individuals marked totaled 615 and 1,639 on the untreated and treated areas, respectively.

Peromyscus maniculatus was the most common species captured (averaging 69.4 percent of the total captures).

Indices to the populations were made by the Schnabel method and the Schumacher-Eschemeyer method. These indices were compared per 1000-feet of trap line.

Sex ratios were calculated on all species for each period within which 10 or more were captured. There were slightly more males than females captured (not significant at the $P = 0.05$ level).

Age ratios were calculated in 1966 and 1967. Although there was a larger juvenile to adult ratio on the treated area, this difference was not significant ($P = 0.05$).

Movements of the rodents captured ranged from 0 to 1500 feet with a mean movement of 230 feet. Animals on the treated area moved slightly longer distances than those on the untreated area (not significant at the $P = 0.05$ level).

Appearance curves were plotted for the animals on the two areas. The animals on the untreated area remained on the area a slightly longer period of time than those on the treated area (not significant at the $P = 0.05$ level).

A total of 94 rodents were collected from the two areas (55 from the treated area and 39 from the untreated area) and analyzed for pesticidal residues. Slightly over 21 percent of those collected from the treated area and 10 percent of those from the untreated area had detectable residues (greater than 0.01 ppm). The majority of these were found to contain small concentrations of dieldrin.

Continued research will be of great assistance in the proper evaluation of the population-pesticide relationship.