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THE EFFECTS OF A CHEMOSTERILANT (MESTRANOL) ON POPULATION AND BEHAVIOR IN THE RICHARDSON'S GROUND SQUIRREL (Spermophilus richardsonii) IN ALBERTA

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ABSTRACT: A chemosterilant, mestranol, was administered to three populations of Richardson's ground squirrel in southeastern Alberta. Mestranol was given to all squirrels in one plot, to only 50 percent in another plot, while a third plot remained as control. In all plots social behavior and population dynamics were followed over two seasons by live trapping and visual observations.

Mestranol sterilized all females who received the drug shortly before or in early pregnancy; accordingly the birth rates were reduced. Levels of total aggression were also reduced but increased survival and immigration rates nullified the effects of the treatment during the first season.

During the second season, low birth rates due to repeated treatment in one plot and to adult emigration and unknown causes in the other, were not compensated for by immigration. As a result of the repeated mestranol treatment and in one case also of adult emigration, the numbers of squirrels were reduced in the vicinity, thus limiting potential immigration in the treated plots. As a consequence both treated populations crashed demonstrating the effectiveness of mestranol.

INTRODUCTION

The Richardson's ground squirrel (Spermophilus richardsonii) is a sciurid rodent considered to be a pest in southeast Alberta. In this region, characterized by low annual precipitation and short grass prairie vegetation, ranching and farming are the main activities. Ground squirrels not only compete with cattle in grazing pastures but can also damage crops. Possible control of this species was consequently considered by the Alberta Department of Agriculture and different techniques were experimented with: one of these was based on the use of an antifertility agent called mestranol (Alsager, 1972).

Mestranol (17-ethynyl-3-methoxyestra-1,3,5(10)-trien-17-ol), a steroid hormone, has been shown to be effective in creating sterility in some rodents when fed to them or when passed on to the nursing offspring by a treated lactating female (Howard, 1969). The use of a chemosterilant such as mestranol is potentially a good means of controlling ground squirrels because they are territorial and colonial animals which breed only once a year in early spring. Thus, large numbers can be treated at once in a small area; moreover as the breeding occurs in early spring, the bait is more easily accepted due to the lack of new vegetation. Territoriality may prevent the invasion of a treated area by squirrels from adjacent areas.

The object of the present study is to investigate the effect of mestranol on natural populations of ground squirrels; any changes in fecundity, population densities and social behavior will be considered.

MATERIAL AND METHODS

The effect of mestranol on the population density and behavior of ground squirrel populations was studied in an area a few miles east of Youngstown, Alberta. Three observation plots, at least half a mile apart, were established on selected areas of relatively high ground squirrel density. Field work was conducted from the end of March to the end of August in 1972 and 1973.

Plot 1 (1.6 acre), plot 2 (1.7 acre), and plot 3 (2.1 acres) were each surrounded by a ten acre area (1A, 2A, and 3A) which was live trapped in early spring to determine relative squirrel densities. All plots were live trapped repeatedly during the two seasons and all squirrels within the plot boundaries were marked with both an eartag and an individual dye pattern (Nyanzol D, Nyanza Inc., Lawrence, Massachussetts). National Live traps or a nylon noose were used for trapping. All squirrels were marked and released as soon as they were caught and no mortality occurred.

In April 1972, 50 percent of the females on plot 2 and 100 percent of the females on plot 3 were force-fed with mestranol. One mg of mestranol was dissolved in one ml of peanut oil and fed to each female or male through a syringe and a plastic tube. In April 1973, 50 percent of females were treated in plot 2; three lactating females and three juveniles were also fed with the drug in May. No squirrel was treated in plot 3 during the 1973 season. Most females present in the areas immediately adjacent to plot 2 (1973) and plot 3 (1972) also received mestranol mixed in rolled oat baits; these were distributed at burrow entrances where squirrels were observed in early April. The purpose of this treatment was to attempt to limit the immigration of young into the plots from adjacent areas. Few males were also given the drug each year on the plots or outside the plots. Other squirrels located at some distance from the observation plots were force-fed with mestranol in April, 1972. They were killed later in the summer or in the next year and their gonads were preserved for histological analysis. Plot 1 received no treatment and was used as a control in both years.

Each plot was divided by a grid consisting of 10 m x 10 m quadrats marked with numbered sticks. The position, activity, and identity of squirrels present in the plot were recorded in 45 minute observation units from 16' high towers by using binoculars (8 x 32 Leitz). Behavioral observations were made from April 21 to August 15 in 1972, and from April 16 to August 28 in 1973. An equal amount of observation time was spent on all three plots, and observation units were rotated throughout the day between 8 a.m. and 6 p.m. Midday hours were avoided when the temperature was higher than 80°F in a nearby Stevenson screen as this reduced ground squirrel activity. A census of all active squirrels was made at 15 minute intervals within an observation unit and all agonistic interactions, or interactions tending to space individuals within their habitat (Scott, 1956), were recorded. The interactions included chases, fight, threat, avoidance, and "bite". The "bite" is an interaction occurring between young of the year and an adult female: the latter bites the young but does not subsequently chase it away or fight with it as the young assumes a submissive posture. Either one or both squirrels walk away and resume their feeding activity. The total of agonistic interactions was divided by the number of observation units occurring during a ten day period to give an average number of aggressive acts per observation unit. This figure was then divided by the average number of squirrels present during the observation units for the corresponding ten day period, so that the mean number of aggressive acts per squirrel could be determined. The average number of squirrels seen per ten day period was divided by the area of the plots to give the average densities of ground squirrels. Each ten day period was designated by a number (0 to 13), starting April 10.

RESULTS AND DISCUSSION

Effects Of The Mestranol Treatment

A. Effectiveness as a chemosterilant

In April 1972, ten females were fed with mestranol on plot 2. Of the seven treated females which were still present in May, none were lactating and no young were seen in a mother/young bond with the females. Similarly ten females were fed mestranol on plot 3 in 1972. Of the eight left in May, seven did not reproduce. The remaining female was given mestranol in late pregnancy and in May was found to be lactating; only one young was seen with her. In 1973, seven females treated in plot 2 also did not reproduce. Three females from outside the plots, treated in early April 1972, were killed one to three weeks after the treatment and their reproductive tracts were preserved. None was lactating, two had all embryos resorbing and one had necrotic placenta and dead embryos *in utero*.

Of the 27 females treated in plot 2 and plot 3 in 1972, six survived and were trapped in April, 1973; all were palpably pregnant. One was treated with mestranol again in early April and did not subsequently produce a litter. The remaining five females were not re-treated in April and were all lactating in May. One of them was given mestranol when lactating and was not seen with any young; only two of the four other females were subsequently observed with two and one young respectively above ground. Another female from outside the plots was also treated in April, 1972 and, when killed in April, 1973, was found to have five viable uterine embryos.

Mestranol was also given in 1973 to four lactating females, three in plot 2 and one outside the plots. This latter was killed in June; histological preparation showed normal ovaries and eight placental scars in the uterus. Seven young had been observed with this female. However, only one of the three lactating females from plot 2 was seen with a single young. This part of the study was designed to determine the effect of mestranol on young, as it was known that mestranol can be transmitted through the mother's milk (Rudel and Kinel, 1966). None of the young given mestranol directly or through their mother's milk were killed in 1973 but the reproductive status of these animals will be determined in the 1974 spring.

Very few young were observed in the areas around plots 2 and 3 after the rolled oat baits were given in April although many females were still present in May. Thus it would seem that rolled oat baits containing mestranol can effectively inhibit reproduction.

Mestranol did not seem to affect males; histological sections of testes did not show any difference between treated males and untreated males. However, the sample was very small and a more extensive collection of gonads from treated males could possibly demonstrate an effect of mestranol on males.

Over the two-year study, 27 females were given mestranol in plots 2 and 3 in early April; only one of these females, already in late pregnancy when given the drug, was seen with one young. All females treated in April, 1972 and still present in April, 1973 were pregnant: but only two of them were seen with young in 1973. The effect of mestranol on the juveniles still has to be determined, while the drug does not seem to affect adult males. It can thus be said that mestranol is an effective way to sterilize adult females, although it suppresses fertility for a single breeding season only.

B. Secondary effects

Treated females were as active as untreated females. The proportion of observation units in which a given squirrel was active -- individual activity -- was calculated by dividing the number of observation units where this particular squirrel was present by the total number of observation units. The averages of individual squirrel activity showed that treated females were active during 77 percent of the observation units, which did not differ significantly from the untreated females who were present in 83 percent of the observation units ($N = 24$, $t = 1.5169$).

However, treated females went into hibernation before untreated females. Treated females disappeared from the plots an average of 52 days after the beginning of the observations, while untreated females were present for an average of 15 more days ($N = 24$, $t = 3.1860$). This might be explained by the fact that treated females increase their weight significantly faster than untreated females. From April to June, 1972, treated females increased their weight by 45 percent whereas untreated females increased by only 20 percent ($N = 13$, $t = 2.622$). No significant difference in weight increase was observed between treated and untreated males.

Thus, it seems that mestranol not only sterilizes treated females but as a result also reduces their metabolic requirements. Treated females do not go through pregnancy and lactation; consequently they increase their weight faster and can go into hibernation earlier than untreated females.

Population Dynamics

A total of 402 different squirrels were trapped, marked, and released on the study site during the two field seasons. In the Youngstown study area, in 1972 and 1973, Richardson's ground squirrels came out of hibernation about mid-March and a short breeding season occurred mainly during the first two weeks in April. The number of squirrels present in April was reduced as males and then females established their territories; only adult residents were left in May. Adults were considered as residents in the plots if their territorial area was wholly or partially enclosed by the plot boundaries. Young of the year emerged during the first two weeks of May from the burrows of resident females. Adult males and most adult females returned into hibernation in June although a few adult females were still active in late July. The number of young in a particular area decreased sharply in May, and then decreased at a much lower rate until young entered into hibernation.

A. Year 1972

Trapping on all plots showed that there was a decline in the number of adults between early April and May. In plots 1, 2, and 3 respectively 9, 18 and nine females remained as residents, although 16, 26, and 11 females were trapped in these plots in April (Table 1). No females were fed mestranol on plot 1. On plot 2, ten females were treated and seven of these remained as residents while another 11 untreated females were also residents. Similarly ten females were originally given the drug on plot 3 but the resident population in May consisted of eight treated females and one untreated female.

Table 1. Population changes.

	Plot 1	Plot 2	Plot 3
1972 Adults			
Marked in April	6♂♂:26♀♀	7♂♂:26♀♀	2♂♂:11♀♀
Resident in May	2♂♂:9♀♀	3♂♂:18♀♀	1♂ :9♀♀
Females sterilized	0	7	8
Females with emergent young	9	10	1
1972 Young			
Number born (May)	58	41	5*
Immigrated into plot (July-August)	7(4)	10(4)	8(8)
Resident (August)	16(13)	21(17)	9(9)
1972-1973 Overwinter Survival			
Survivors marked as adults in 1972	1♂:5♀♀(2)	7♀♀(4)	4♀♀(4)
Survival as percentage of adults 1972 marked	27%	21%	31%
Survivors marked as young in 1972	12♀♀(0)	4♂♂:5♀♀(3)	2♀♀ (2)
Survival as percentage of 1972 marked	19%	19%	17%
Lost tags	1♂:3♀♀	1♀	1♀
Total survivors marked in 1972	2♂♂:20♀♀	4♂♂:13♀♀	7♀♀
Survival rate as percentage of total 1972 marked	22/84-26%	17/78-22%	7/25-27%
1973 Adults			
Marked in April	3♂♂:34♀♀	10♂♂:20♀♀	6♂♂:14♀♀
Resident in May	1♂ :16♀♀	2♂♂:13♀♀	3♂♂:11♀♀
Females sterilized	0	7	0
Females with emergent young	9	3	2
1973 Young			
Number born (May)	71	6	2
Immigrated into plot (July-August)	5(4)	7(4)	4(4)
Resident (August)	16(15)	6(3)	3(3)

* one died.
( ) indicate number of animals marked.

In plot 1, the nine resident females gave birth to a minimum of 58 young which were trapped in early May; 18 females were resident in plot 2 but only ten of them reproduced and 41 young were trapped on the plot. In plot 3, the single untreated female produced three live young and another which was found dead beside the burrow entrance, while a treated female was seen with one young; the remaining seven treated females did not reproduce.

While the average litter size did not differ greatly -- 6.4 in plot 1, 4.1 in plot 2, and 4.0 in plot 3 -- the total production of young was considerably lower in plots 2 and 3 due to the presence of sterilized females. Only 2.2 young and 0.4 young were produced for each resident female in plot 2 and 3 respectively, while 6.4 young were produced by each female on plot 1. It would thus appear that mestranol was effective in reducing the ground squirrel population as far as the number of young produced is concerned.

The movement of young into and out of the plots was also different among the three plots. Of the 58 young born in plot 1, 11 were still present in August with five other young that moved in during July or August. Similarly nine new young were added to the

12 young born in plot 2 and still present in August, while the four young born in plot 3 were all left with five immigrating young. Thus the August populations in plots 1, 2, and 3 consisted of 19 percent, 29 percent, and 100 percent of the young born in these plots, and of immigrant young that represented 31 percent, 43 percent, and 56 percent of the August populations. Young immigrating into the plots during the period May-August represented 11 percent, 20 percent, and 67 percent of all young trapped in plots 1, 2, and 3 during that summer.

A lower productivity in the mestranol treated plots was compensated for by a lower emigration or lower mortality of the young born in the plot and by a higher immigration of young from adjacent areas. Thus, by the end of the summer the treated plots had populations comparable to that of the untreated plot. As shown in Table 1, the number of young left in each plot in August was roughly the same as the number of adult residents in the same plot in May.

B. 1972-1973 Overwinter survival

No significant difference can be shown among plots as far as total overwinter survival is concerned, neither for yearlings or adults (Table 1). Treated females do not have a significantly lower survival than normal females; six out of a total of 20 treated females (30 percent) survived in plot 2 and 3, while nine females out of a total of 20 untreated females (45 percent) were left in plots 1 and 2 (x^2= 0.96).

However, despite the lack of difference in survival as far as treatment or age classes are concerned, the sex ratios were considerably altered by overwinter survival. Only on plot 2 were both yearling males (four) and females (five) recaptured which had been marked the previous year along with 16 and 17 other young males and females. No yearling males were recaptured on the other two plots; 12 and two yearling females were present in April 1973 in plots 1 and 3 respectively. Only five young males and seven young females were marked in plot 3 in 1972 so that the probability of recapture in 1973 was low; but on plot 1 where more than 20 young males were marked in 1972 their lack of survival on the plot is striking. Thus it would appear that juvenile males had better chances to maintain themselves on a mestranol treated plot.

The overwinter survival to 1973 of animals considered resident in 1972 also differs between the plots. In plot 1, 18 marked squirrels survived to 1973 but only two were classified as residents in 1972. In plot 2, seven of the 16 survivors were 1972 residents and all survivors in plot 3 were 1972 residents. It was thus apparent that resident squirrel had a much better chance to maintain themselves on treated plots.

The mestranol treatment affected overwinter survival within the plot by changing immigration and survival on the plot; the effect was probably at its maximum in the spring 1973 when squirrels were establishing territories. Due to the lack of competition in treated plots, most resident squirrels and even yearling males were able to maintain themselves on the plot.

C. Year 1973

In April 1973 an increase in numbers was observed on plots 1 and 3 as compared to the April 1972 population, while fewer squirrels were trapped in plot 2. More females than in 1972 were classed as residents in plot 1 and 3, but in plot 2 there were less. On plots 1, 2, and 3 respectively, 16, 13 and 11 females were residents in May out of the 34, 20, and 14 females trapped on the plots in April. Another characteristic of these April 1973 populations was the difference in sex ratio between the control plot (1), and the treated plots (2,3). There were 11 females per male in plot 1, while there were only two females per male in plots 2 and 3.

No mestranol was given in plot 1 and 3 while seven of the 13 resident females received it in plot 2. Only nine of the 16 resident females reproduced in plot 1 giving birth to 71 young. This lack of reproduction in adult females was also observed by Wehrell (1973) in a ground squirrel population S.E. of Edmonton: she showed that non-reproducing females were non-dominant squirrels in the colony. Thus in plot 1 exactly the same number of females reproduced in 1972 as in 1973 despite the fact that there were many more resident females in 1973. In plot 2, two of the six untreated females were seen with three and two young each; the four remaining females were given mestranol when lactating and subsequently one of these females was seen with one young. In plot 3 no female was treated. Although at least eight of the 11 resident females were observed to be either pregnant or lactating and were still present at parturition time, only two, one of which received mestranol in 1972, were subsequently seen with one young each.

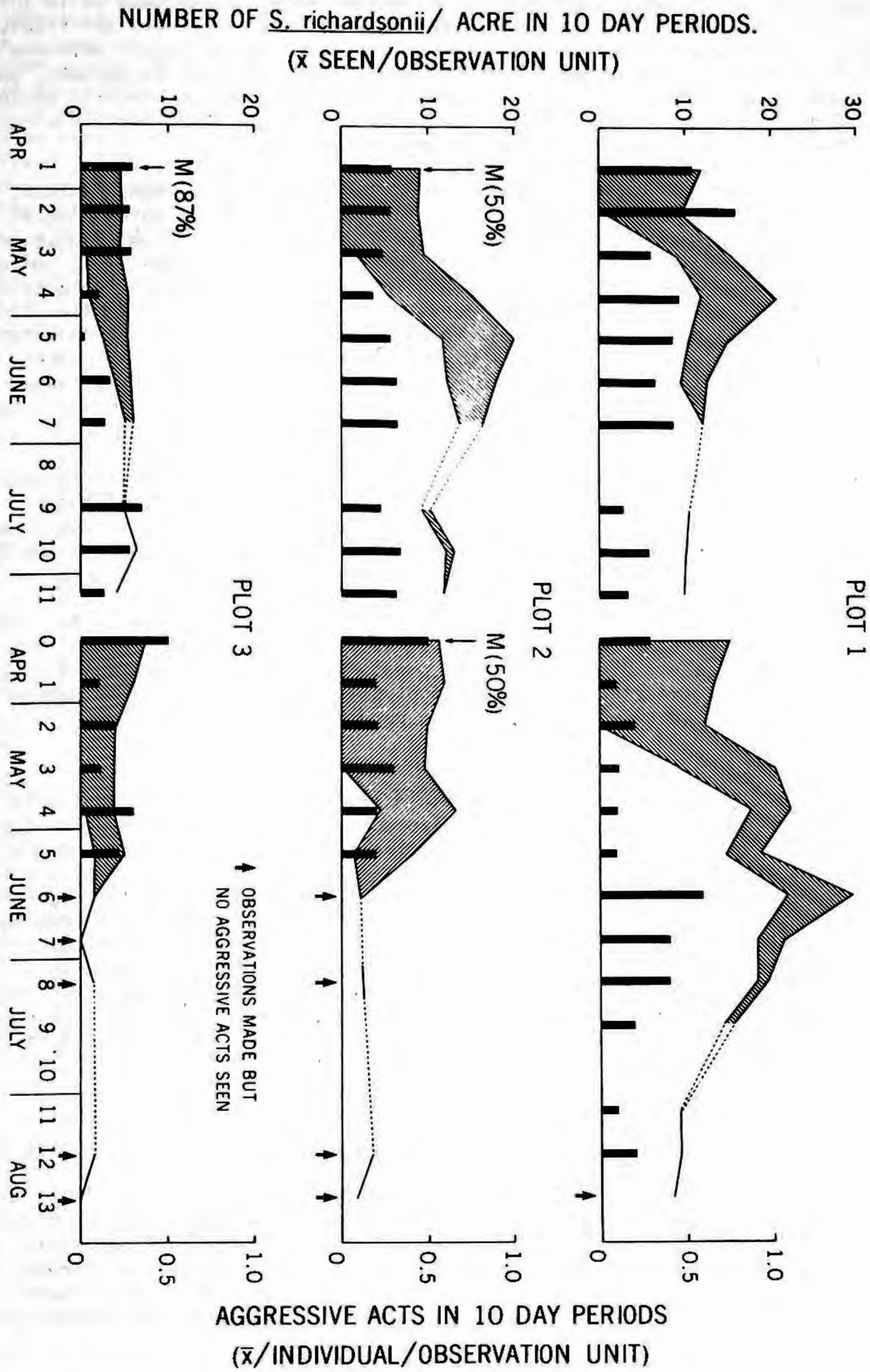

Figure 1. Seasonal changes in density of squirrels and level of aggression over two years. Hatched area indicates number of adults, clear area number of young; bars indicates aggressive acts.

In August, 15 of the 71 young born in plot 1 were still present with one immigrant young, so that the number of young present in August 1973 was the same as in 1972. In plot 2, only one of the six young born in the plot was left in August and five young had immigrated. The two young born on plot 3 were still present in August with one immigrant young. The immigrant young represented respectively six percent, 54 percent, and 67 percent of the summer populations in plots 1, 2, and 3, while they represented six percent, 83 percent, and 33 percent of their August populations. Of the young born in plots 1, 2, and 3, 21 percent, 17 percent, and 100 percent were present in August.

On plot 1 the numbers of young born, young immigrating, and young resident in August are all very comparable to the 1972 figures. On plot 2 few young were produced in 1973 and immigration did not compensate for this low production nor for the poor subsequent survival of those born on the plot. Although survival of young on plot 3 was high, immigration did not compensate for the original low production of young on the plot. Immigration into plot 2 in 1973 was limited by the fact that mestranol baits were given to females surrounding one side of the plot. The plot was bordered on the three other sides by habitat unfavorable to squirrels, i.e., low areas with tall grass and cultivated fields. A number of squirrels marked around plot 3 were observed to move in late April to a nearby cultivated field with a growing crop. Thus the number of young that could have potentially moved into plot 2 and 3 was reduced in 1973.

Although mestranol was ineffective in reducing the number of squirrels occupying the plots in August 1972, the number of squirrels living in the vicinity of the treated plots was reduced. Thus the capacity of these plots to compensate for losses due to mortality or emigration was also reduced. Consequently the 1973 populations in plots 2 and 3 already weakened by the previous year's treatment were unable to compensate in 1973 for either one more mestranol treatment (plot 2) or an emigration of adults before parturition time, from the area surrounding the plot (plot 3). Also the fact that males had better chances to maintain themselves on or around the plot (1:2 sex ration in 1973) reduced the relative productivity of these two plots. The 1973 population crash in plots 2 and 3 is attributed here to the mestranol treatment, as not only plot 1 but also three other untreated plots were studied in 1973 and all had normal young populations.

Agonistic Behavior

Richardson's ground squirrel lives in colonies where both males and females defend territories. In early spring male territories cover the burrows of three to five females (Yeaton, 1972). After breeding, male territories are reduced in size as females become aggressive and establish their own territories. Young emerge in early May and stay in their mother's territory for at least two weeks; during this time most adult-young interactions are cohesive as they occur mostly between mother and young. Females are very aggressive towards each other at that time. As young start to move around, they encounter female aggression. The peaks of inter-juvenile and adult young aggressive encounters occur one month after the emergence of the young; both decrease as population densities are reduced by the return of adult females into hibernation and by the emigration and/or mortality of young. By the end of the summer, few juveniles occupy an exclusive area in the plot and defend it against intruders.

A. Year 1972

During the summer 1972, there was not as much aggressive activity in plot 2 and 3 as in plot 1 (Figure 1).

In plot 2 where treated and untreated females are equally present, each untreated female averaged during the study period (April 21 to August 15) 1.25 aggressive encounters with other females, in contrast to only 0.25 agonistic interactions per treated female. Notenough untreated females were present in plot 3 to obtain comparable figures. Moreover no aggression to young was ever observed from treated females in both treated plots (Figure 2).

Aggression was also lowered in plots 2 and 3 because untreated females in these plots were not as aggressive towards each other and towards young (Figure 2), as females from plot 1. For the duration of the observations (April 21-August 15), each untreated female in plot 1 was taking part in an average of 2.7 aggressive encounters with other females, while untreated females in plots 2 and 3 were active in only 1.4 and 0.6 aggressive encounters. Untreated females from plots 2 and 3 are not as aggressive towards young either. The average number of aggressive adult-young interactions per present female -- treated and untreated females -- is higher in plot 1 than in plot 2, and higher in plot 2 than in plot 3 (Figure 2). This sequence corresponds inversely to the intensity of the mestranol treatment in the three plots -- 0, 50 percent, and 100 percent treated females. When the number of aggressive adult-young interactions per untreated female is calculated -- treated females were not aggressive to young -- then the level of aggression of females towards young is higher in plot 2 than in plot 1, and higher in plot 1 than in plot 3. (Figure 2). This sequence corresponds to the densities of resident adults in the plots, i.e., 12.4 resident adults per acre in plot 2, 6.9 in plot 1, and 4.8 in plot 3. The two plot sequences remain the same even when the number of aggressive adult-young interactions per squirrel -- young + adults -- is calculated. Thus, even the lower probability of adult-young interactions -- due to the lower densities of young in treated plots -- did not change the fact that: (1) There is a higher degree of adult-young aggression in an untreated plot as contrasted to a treated plot because treated females are not aggressive to young. The effect is directly related to the intensity of the mestranol treatment. (2) Untreated females living or coming into treated plots are not as aggressive towards young in plots of lower densities. Thus the overall effect of the treatment is to lower aggression in treated plots due to the reduction of aggression in untreated females.

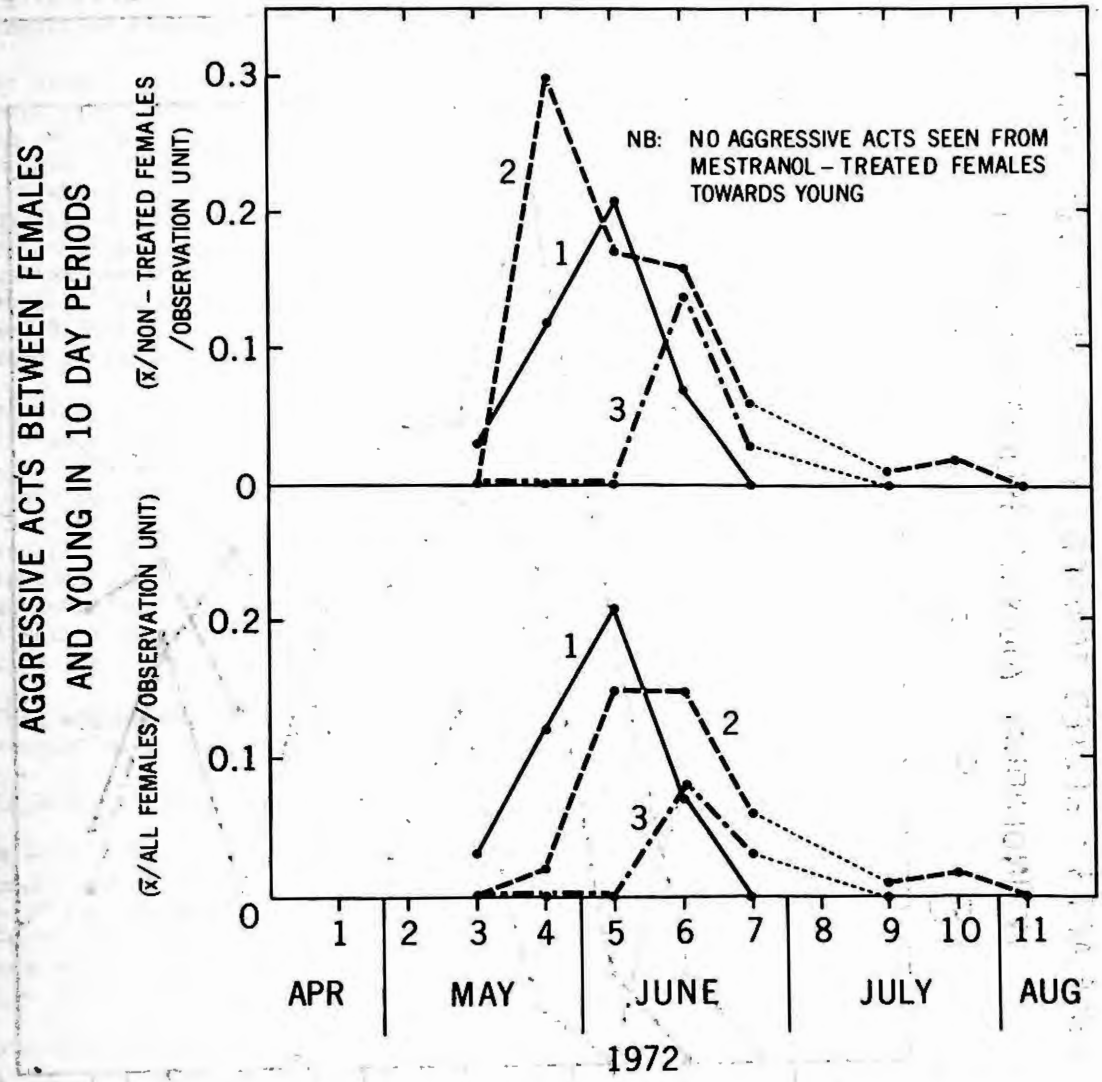

Figure 2. Seasonal changes in level of aggression of adult females directed towards young on the three plots.

The lower levels of aggression observed in the treated plots are also due to the fact that in these plots not only females but also young (Table 2) are not as aggressive towards other young as compared to the squirrels from plot 1 (Figure 3). Thus by reducing the number of young in the treated plots, the treatment also reduced the average amount of aggression between young.

Table 2. Average number of aggressive interactions per squirrel per 45 minute period (observation unit) for juveniles (Y), treated (M), and untreated (A) females in 1972 and 1973.

	Plot 1		Plot 2		Plot 3	
Aggressive Interactions	1972	1973	1972	1973	1972	1973
A.A	1.88	.82	.67	.53	.16	1.50
A.M	-	-	.35	.54	.48	-
M.M	-	-	.05	.52	.16	-
A.Y	.43	.39	.38	.13	.16	.05
M.Y	-	-	0	0	0	-
Y.Y	1.53	1.49	1.23	0	.90	0
TOTAL	3.84	2.70	2.68	1.72	1.86	1.55
Adult Male Aggression	35%	9%	29%	57%	13%	37%
Number of Observation Units	54	27	53	22	54	21

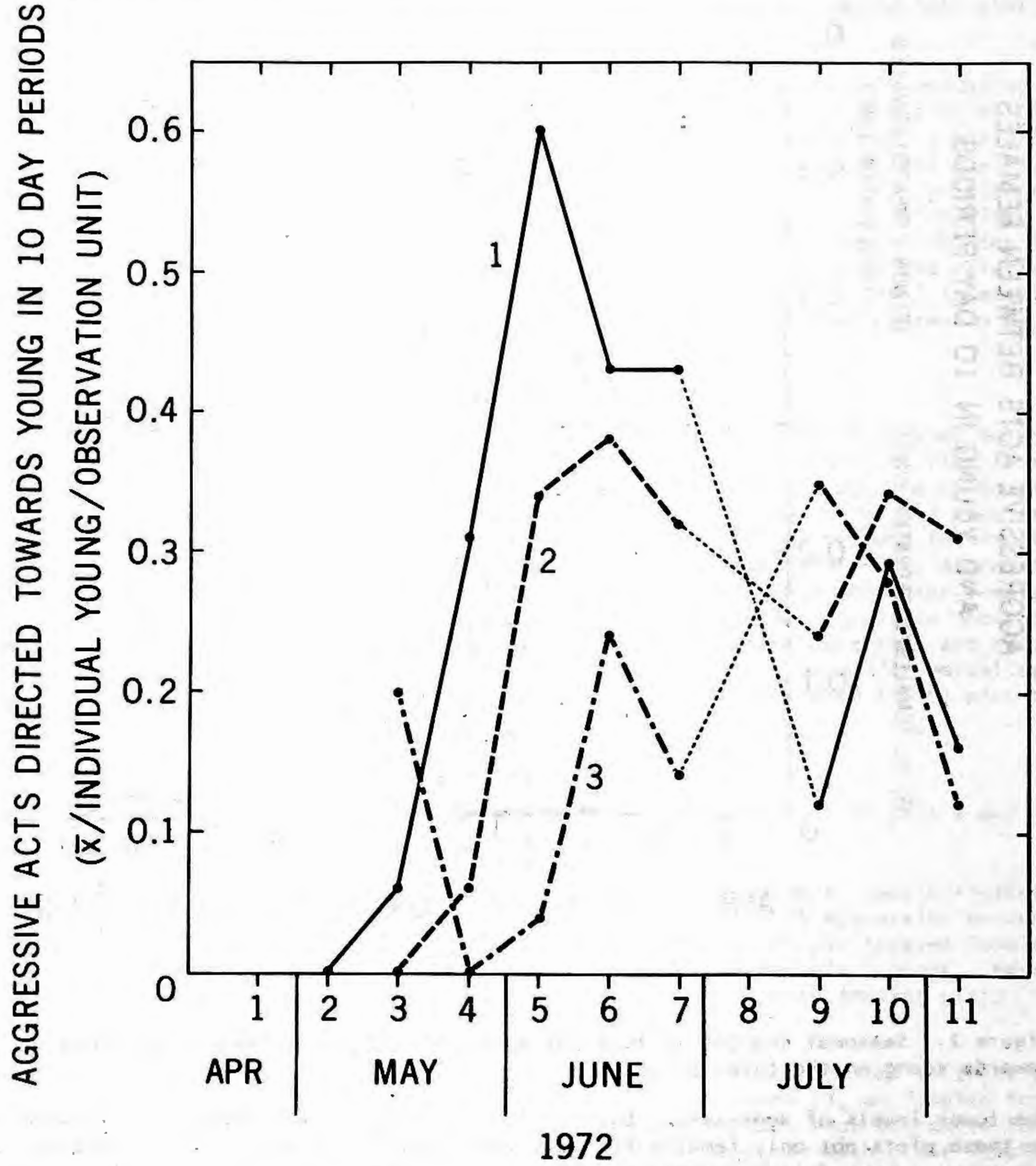

Figure 3. Seasonal changes in level of aggression directed towards young by all other squirrels on the three plots.

Thus in summary for 1972, the total aggression was lowered in the treated plots (2, 3) when compared to the aggression occurring in the control plot (1). This results from the reduced aggressiveness of both treated and untreated females towards other females or towards young. Moreover young were not as aggressive towards each other in the treated plots (2, 3) as in the control plot (1). A direct relationship was shown to exist between level of aggression and population density, while an inverse relationship existed between aggression and intensity of the mestranol treatment.

B. Year 1973

Total aggression was reduced in all plots despite the fact that the April and the resident populations were higher in plots 1 and 3. Bad weather during the 1973 season could partially explain this fact; from April to July, 1973, there were 30 days of either rain or snow, plus few days without precipitation but with snow covering the ground, while it rained only during 19 days for the same period in 1972. Consequently, not as many observations were made in 1973 (Table 2) as bad weather restricted the activity and movements of the squirrels on the plot. Two other factors changed the level of aggression in 1973; altered densities of juveniles (Figure 1) and adult males (Table 1) were responsible for changes in aggression.

In plot 1, the total aggression was lowered in 1973 despite a higher density of adult residents; this drop was due to a lowering of adult-adult (1.88 versus .82) aggression because the adult-young (.43 versus .39) and inter-juvenile (1.53 versus 1.49) aggression figures are roughly the same. When calculating proportion of adult-adult aggressive acts in which adult males are participating, it appears that males were active in 35 percent of the aggressive interactions in 1972 and only in nine percent in 1973 (Table 2). This high proportion of male aggression in 1972 was due to the presence of two non-resident males trespassing the plot territories and consequently they were chased by male and female residents. Thus each female was taking part in an average of 1.23 aggressive acts during 1972 and 0.75 (.82-.82x9 percent) in 1973. This decrease of aggression is probably due to decreased activity resulting from bad weather conditions in 1973.

In plots 2 and 3, total aggression is lowered mainly due to the absence of inter-juvenile aggression (Table 2). In plot 2, the number of males in the April population is higher in 1973 and males are involved in 57 percent of the 1973 adult-adult interactions, while they participated in only 29 percent in 1972. Thus female aggression was expressed by an average .76 aggressive acts in 1972 and .69 in 1973. Correspondingly in plot 3, 13 percent of the aggressive interactions were due to males in 1972 and 37 percent in 1973; thus females aggression was measured by an average of .69 aggressive acts per female in 1972 as compared to a figure of .95 in 1973. Female aggression was expected to increase and effectively does since no females were given mestranol that year; however, the full extent of the increase was likely curtailed by the weather conditions.

Thus aggression was reduced in all plots in 1973 due to both bad weather and differential male or juvenile aggression as compared with 1972.

OVERALL DISCUSSION AND CONCLUSIONS

Mestranol sterilizes females temporarily when given shortly before or in early pregnancy, and efficiently reduces birth rates in treated populations. However, a side-effect of the treatment is that it reduces total aggression in the treated plots; consequently it is easier for young to move in or stay on the plot as not as much aggression is directed towards them. Thus in the first season of the treatment, higher immigration and survival of young on the plot compensated for the original low birth rates.

Although the mestranol treatment did not seem to reduce the populations remaining in August 1972, it appeared that in the following year that treated populations could not sustain either repeated treatment (plot 2), low birth rate or emigration of adults (plot 3). The previously treated plots were incapable of compensating for these losses as the number of potential immigrants had been previously reduced by the treatment. Moreover the proportion of males increased in treated populations as a result of lowered densities and reduced aggression, thus the proportion of squirrels able to give birth was lowered in these populations. Consequently, the number of squirrels decreased dramatically in both treated plots and only few individuals were left in August 1973.

It seems from these results that mestranol could efficiently reduce the degree of ground squirrel damage in grazing and cultivated land. Consumption of vegetation is reduced because not only do non-born young not eat, but sterilized females increase their weight faster due to lower metabolic demands. Thus they return into hibernation sooner than normal females, consequently consuming less vegetation.

After a one year treatment of all females in one case, and a two year treatment of 50 percent of the females during each season in the other case, mestranol reduced population densities to much lower levels than original densities. It would thus appear that mestranol could be an effective way of reducing ground squirrel populations.

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