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INFLUENCE OF STERILE MALES ON FECUNDITY OF
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Abstract: Eighty-five percent of the males in one of two colonies of Norway rats (Rattus norvegicus) were surgically sterilized. The control and treated colonies produced 130 and 110 young, respectively. The greatest difference noted was in the number of pregnant juveniles at necropsy; nine were pregnant in the control colony but only three in the treated colony. The total number of pregnancies was 33 for the controls and 39 for the treated rats. The results suggest that an anti-fertility compound exerting an effect similar to vasectomy and affecting many, but not all, of the males in a rat colony would be ineffective in limiting population size.

Since Knipling’s (1955, 1960) classical studies demonstrated the dramatic effects of sterilization on screw-worm fly (Callitroga hominivorax) populations, the concept of vertebrate pest control by reproductive inhibitors has steadily gained supporters. For a given target species, however, it is not always known whether the male or female offers the best chance for reducing the birth rate. The recent discovery of a chemical that permanently sterilizes male Norway rats (Ericsson and Connor 1969, Ericsson 1970, Kennelly et al. 1970), focuses attention on the question: How effective will a male chemosterilant be in controlling reproduction in a free-breeding colony of Norway rats? Clearly, sterilization of a high proportion of the breeding males in a population will have no impact if the remaining fertile males impregnate the females. Several authors (Knipling 1959, Marsh and Howard 1970) have concluded that male chemosterilants would be impractical for use in vertebrate pest populations
when the males are polygamous, but no one has conducted tests that support or refute this conclusion.

**METHODS**

In an attempt to obtain an answer to this question, 85 percent of the males in one of two otherwise similar populations of Norway rats were sterilized by bilateral vasectomy and the populations compared.

Initially, each colony consisted of 20 males and 20 females, 8–19 weeks of age, that were laboratory-born progeny of wild-trapped adults. The litters were separated by sex at weaning and maintained in groups of 2–3 until shortly before the start of the study. Litters were divided as equally as possible between the two colonies. Seventeen males in the treated colony were vasectomized 12–14 days before the study began. Vasectomy was accomplished by tying two ligatures approximately 1 cm from the cauda epididymidis and severing the enclosed portion of the vas deferens. No evidence of regeneration of the cut ends was found at necropsy. The remaining three males in the treated colony and the 20 in the control colony were sham-operated the same day as the vasectomies. The three fertile males in the treated colony were 14–17 weeks of age when selected. This bias in selection was necessary to ensure that each of the three had normal testes and epididymides; a condition determined with more certainty by gross observations after the rats reach puberty.

A separate study was conducted with laboratory rats to determine whether 12–14 days was a long enough interval after vasectomy to ensure sterility. The results are shown in Table 1. None of the vasectomized rats sired litters at any of the four intervals tested. Further, motile sperm were never recovered from the portion of the vas deferens distal to the vasectomy, but motile sperm were recovered from the comparable portion in all sham-operated controls. The mean number of vaginal plugs per rat was greatest in the control group, suggesting that vasectomy had an adverse effect on libido. However, analyses of variance between the group tested 20 days after vasectomy and the control group indicated that the difference was not significant.

The two colonies were established on December 8, 1969, in insulated but unheated metal buildings, 36 feet in diameter (1,017 square feet), with concrete floors covered with about 30 inches of soil. Temperature and humidity levels were monitored continuously throughout the study by a hygrothermograph placed at ground level in the center of each building. The readings did not differ significantly between

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**Table 1.** Fertility of laboratory rats 5, 10, 15, and 20 days after vasectomy.

<table>
<thead>
<tr>
<th>Days After Vasectomy</th>
<th>Number of Animals</th>
<th>Number of Vaginal Plugs</th>
<th>Number of Males</th>
<th>Number of Females Pregnant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male Mated with Female</td>
<td>Necropsy of Males</td>
<td>Males†</td>
<td>Females Tested‡</td>
<td>With Sperm</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>5</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>12</td>
<td>5</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>17</td>
<td>5</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>22</td>
<td>4</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Control</td>
<td>22</td>
<td>7</td>
<td>28</td>
<td>35</td>
</tr>
</tbody>
</table>

† All males were proven fertile prior to the study.
‡ Two virgin females in estrus on each of two consecutive days were placed with each male on the day indicated after vasectomy. Control males were paired on days 20 and 21 after sham operations and were necropsied on day 22.
the colonies; the minimum and maximum temperatures were -10 C and 22 C. Food and water were provided ad libitum, and eight straw bales were used to provide initial harborage (Fig. 1). At 2-week intervals the lights were resynchronized with the onset and duration of natural daylight.

After 105 days the study was terminated; equal numbers of live traps were placed in each colony, and the trapped animals were examined. Approximately 75 percent of the rats recovered were collected the first 5 days of trapping, but the last animal was not captured until the 19th day.

RESULTS AND DISCUSSION

The results of the animals recovered from each colony are summarized in Table 2. All animals, both the original and the juveniles, were apparently in good health at the close of the study. The body weight of the original animals did not differ significantly for either sex; the control and treated males averaged 347.3 and 348.4 grams, respectively; comparable figures for the females were 254.2 and 255.7 grams. The control and treated colonies had 130 and 110 juveniles, respectively, for increases of 325 and 275 percent. Animals weighing less than 25 grams were not included in these figures, because they could not be counted accurately (a nursing litter could die and go undetected if the mother was removed by trapping). The differences in body weight between control and treated juveniles were significant for the males \( (P < 0.05) \) but not for the females. The former were 141.5 and 169.2 grams in the control and treated colonies, respectively; the females were 125.2 and 132.2 grams, respectively.

We have no explanation for the observed difference among the males other than sampling variation.

The reproductive data from the original females (Table 3) showed that the two colonies had an approximately equal number of pregnancies (in each, 13 females had two pregnancies and one female had three). Litters were first observed in the control colony 31 days after the study began, and 6 days later they were first observed in the treated colony. If the sterilized males had a pronounced effect, there should have been more pseudopregnancies, and therefore fewer multiple pregnancies, in the treated colony. Apparently, the females mated with many different males during estrus, and each female had a reasonable probability of encountering a fertile male.

The mean size of the first litters in the treated colony was significantly \( (P < 0.05) \)
smaller than in the control colony (8.6 versus 10.8), but no difference was observed between the two colonies for the second litters. The reduced litter size may have been due to the presence of the vasectomized males. Adler and Zoloth (1970) showed that vaginal or cervical stimulation of female rats, especially within 15 minutes of copulation, inhibits sperm transport and results in reduced litter size. The probability was high that if a female copulated with a second male it would be a vasectomized male. The reduced litter size would account for the fewer juveniles recovered from the treated colony (Table 2).

All sham-operated males (19 control males and 3 fertile males in the treated colony), as well as 13 of the 17 vasectomized males, had testes and epididymides that appeared normal at necropsy. In the remaining four treated males* one or both testes were considerably smaller than expected, and the seminiferous tubules were either aspermatogenic or showed signs of tubular degeneration. However, the interstitial tissue appeared normal in the affected testes. In one rat, the testis was abdominal, probably as a result of adhesions after surgery. The other three rats had large bilateral spermatoceles, located either in the epididymides proper or in the proximal portions of the vasa deferentia. This may have caused a sufficient increase in intratesticular pressure to induce tubular degeneration. However, 12 of the remaining 13 vasectomized rats also had large bilateral spermatoceles but testes that appeared to be normal.

Although the number of juvenile females was greater in the control colony (61 versus 47), there were 18 sexually active juvenile females in each colony. A female was considered sexually active when graafian follicles or corpora lutea were observed in the ovaries. The greatest difference between the two colonies was in the total number of pregnancies among the sexually active juvenile females. There were 11 pregnancies among the juvenile females in the control colony (nine gravid at necropsy) but only four among an equal number of sexually active females in the treated colony (three gravid at necropsy).

The percentage of juvenile males with epididymal sperm was 56.5 in the control and 65.0 in the treated colony. Even more striking was the number of rats that weighed 200 grams or more. There were 43 in this category, of which we judged 40 (16 in the control and 24 in the treated) to be in excellent breeding condition on the basis of the abundance and motility of the sperm recovered from the cauda epididymidis. Undoubtedly, in the late stages of the study, the percentage of fertile males in the treated colony was greater than the original 15 percent.

Since it is unknown when the increase of breeding males in the treated colony began, their precise contribution to the breeding
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population cannot be assessed. Nevertheless, the results indicate that the juvenile animals in this study were capable of breeding at an early age. With a 22-day gestation period, the maximum age of the juveniles on the first day of trapping was 83 days. Two of the three parous juvenile females were captured on the 8th day of trapping, indicating that they were no older than 69 days when first bred. This is an earlier age than that reported by Calhoun (1962:152), who stated that wild Norway rats begin exhibiting sexual behavior at 80 days of age. Also, he concluded that “until the age of 115 days most females are insufficiently matured to be sexually attractive to males.”

Since only two colonies were involved in this study, the results cannot be evaluated statistically. Both the number of juveniles recovered (130 versus 110), and the number of pregnancies observed among juvenile females (11 versus 4) were less in the treated colony, implying that sterilization may have had some effect. However, the almost equal number of pregnancies among the original females suggests that, if the differences are real, they nevertheless are inadequate from a control viewpoint. We conclude, therefore, that a single application of a chemosterilant affecting the fertility of 85 percent of the males, and if we assume no effect on libido, would be ineffective in controlling a Norway rat population comparable in density to the colonies established in this study. This is not to state unequivocably that a male chemosterilant would always be ineffective. As Marsh and Howard (1970) have noted, the effect of density in chemosterilant studies is largely an unknown factor. Hence, it is possible that if less dense populations had been established for this study, a greater difference might have been observed between the two colonies.

LITERATURE CITED


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