THE INFLUENCE OF MATURE MALES ON SEXUAL MATURATION IN FEMALE COLLARED LEMMINGS
(DICROSTONYX GROENLANDICUS)

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The rate of sexual maturation in females has been shown to be related to population density in a number of species of small wild rodents (Microtus californicus: Greenwald, 1957; Mus musculus: Southwick, 1958; Rowe, Taylor & Chudley, 1964; Microtus ochrogaster and M. pennsylvanicus: Keller & Krebs, 1970; Lemmus trimucronatus and Dicrostonyx groenlandicus: Krebs, 1964). It has been shown in the laboratory that the presence of an adult male accelerates the rate of sexual maturation in young female mice (Vandenbergh, 1967; Castro, 1967; Fullerton & Crowley, 1971), prairie voles (Hasler & Nalbandov, 1974) and cuis, Galea musteloides (Weir, 1973).

In this study, the influence of adult male collared lemmings (Dicrostonyx groenlandicus) on the rate of sexual maturation after weaning of juvenile females was investigated. The animals were laboratory-born descendants of lemmings captured near Fort Churchill, Manitoba, in 1967. They were maintained in an environmentally controlled room at 12 ± 3°C, on a light regimen of 18 hr light/6 hr dark. Commercial rabbit chow (Purina) and water were freely available. The females were weaned at 19 days of age.

In Exp. 1, twenty-five pairs of female siblings were allocated at weaning to one of two groups; one sibling from each pair was housed alone in a plastic cage measuring 28 × 17 × 12 cm, and the other was paired with an adult male (5 to 8 months of age) in the same type of cage. Both groups were housed in the same room. All females were checked once daily for vaginal perforation and daily vaginal smears were taken by the lavage method from all perforate females. The females were weighed to the nearest 0.1 g at the beginning of the experiment and again 21 days later when they were 40 days of age.

Animals in the two groups did not differ significantly in body weight either at the time of weaning or at 40 days (Table 1). There was, however, a significant difference (P < 0.001, Student’s t test) in the age at which first vaginal perforation occurred. Females paired with males became perforate an average of 14 days earlier than isolated females. Although the time to perforation varied considerably within each group, comparisons showed that sixteen of the nineteen surviving paired females exhibited vaginal perforation before their isolated siblings. In both groups, all the females became perforate by 40 days of age.

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except one isolated female which became perforate at 47 days of age. After perforation, most females became imperforate again within a few days. Females which remained perforate did not exhibit any regular vaginal smear patterns. Most vaginal smears were composed of a predominance of leucocytes with an occasional predominance of cornified cells, but in approximately 25% of the females in both groups, the vaginal smear on the day of perforation was composed mainly of cornified cells. Copulation plugs were found in six of the paired females and two of these females subsequently carried litters to term. The youngest female to give birth was impregnated at 38 days of age (based on a 20-day gestation period: Hasler, 1974).

Table 1. Mean body weight and the mean age at vaginal perforation in female collared lemmings kept in isolation or paired with a mature male after weaning

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<tr>
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<th>Females kept alone</th>
<th>Females with a male</th>
<th>P*</th>
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<tbody>
<tr>
<td>Initial body weight (g)</td>
<td>21.1 ± 1.1</td>
<td>21.0 ± 1.1</td>
<td>N.S.</td>
</tr>
<tr>
<td>Body weight at 40 days of age (g)</td>
<td>37.6 ± 1.4</td>
<td>38.7 ± 1.6</td>
<td>N.S.</td>
</tr>
<tr>
<td>Age at vaginal perforation (days)</td>
<td>41.7 ± 1.0</td>
<td>27.6 ± 0.9</td>
<td>&lt;0.001</td>
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<td>Range</td>
<td>4 to 47</td>
<td>3 to 15</td>
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Values are expressed as Mean ± S.E. for nineteen females in each group.

* Student’s t test for paired samples. N.S., not significant.

Experiment 2 was designed to determine if there were any changes in the weights of certain organs when vaginal perforation was accelerated by the presence of a male. At weaning ten pairs of female siblings were allocated to two groups and housed as described earlier. They were checked daily for vaginal perforation. On the day that vaginal perforation occurred in either female of a sibling pair, a vaginal smear was taken and both females were then killed by cervical dislocation and weighed. The carcasses were fixed in acetic-formol-alcohol for 48 hr and stored in 70% ethanol. Later, the ovaries, uteri, preputial glands and adrenals were dissected, cleaned of fat, blotted on paper and weighed to the nearest 0.1 mg.

The uteri of the paired females were significantly heavier (P<0.01) than those of the isolated females (Table 2), but there were no significant differences in the other organ weights or in body weights. Of the nine surviving pairs of females, eight females housed with a male exhibited vaginal perforation before their isolated siblings (10.8 ± 1.7 (S.E.) days, range 4 to 20 days). The isolated female that became perforate before her sibling, did so on Day 12. Six of the nine females that became perforate exhibited a predominance of cornified cells in the vaginal smear on the day of perforation.

The effects of adult females on puberty in juvenile females could not be assessed because of the excessive aggression shown by the adult females.

This study has shown that young female collared lemmings housed with an adult male exhibit vaginal perforation at an earlier age than females housed individually. The lack of cyclic changes in vaginal cytology in these females
is consistent with observations on mature females of the same species (Hasler, Dziuk & Banks, 1974). The heavier uteri in females in which vaginal perforation was accelerated by the presence of a male may have been due to higher levels of oestrogen. Previous work demonstrated that both uterine weight and vaginal perforation are oestrogen sensitive in adult lemmings (Hasler, 1974). A rapid increase in plasma LH and FSH levels, in uterine development (Bronson & Stetson, 1973) and in plasma oestrogen levels (Bronson & Desjardins, 1974) occurred in immature female laboratory mice exposed to males.

<table>
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<th>Table 2. Mean body and organ weights of female collared lemmings kept in isolation or paired with a mature male after weaning</th>
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<tbody>
<tr>
<td>Females kept alone</td>
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<tr>
<td>Body weight at weaning (g)</td>
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<tr>
<td>Body weight at perforation (g)</td>
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<tr>
<td>Ovaries (mg)</td>
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<tr>
<td>Uterus (mg)</td>
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<td>Preputials (mg)</td>
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<tr>
<td>Adrenals (mg)</td>
</tr>
</tbody>
</table>

Values are expressed as Mean ± S.E. for nine females in each group. Organs were weighed after storage in 70% alcohol.

* Student’s t test for paired samples. N.S., not significant.
† Each sibling was killed and weighed on the 1st day that the vagina of either member became perforated.

It is clear that vaginal perforation in this species may not denote full sexual maturity. In perforate young females paired with males, there was a low rate of mating, as indicated by copulation plugs, and of successful pregnancies in females which mated. Similarly, Greenwald (1956) reported that a large number of wild females of Microtus californicus underwent a sterile cycle at puberty. Thus, although young females ovulated as an apparent result of mating, pregnancy did not ensue. Hasler & Nalbandov (1974) found that the number of female prairie voles (M. ochrogaster) that exhibited vaginal perforation was the same regardless of whether they were paired with sibling males or with ‘strange’ males of the same age, but that the littering rate of the sibling pairs was lower.

In this study, there were no significant differences in body weights between the two groups of females that were housed either individually or with males, and there was no correlation between body weight and the age at vaginal perforation within each group. This is in agreement with the findings of Vandenbergh (1967) and Vandenbergh, Drickamer & Colby (1972) that sexual maturation was independent of body growth in female laboratory mice. Under some conditions, however, body weight may be a factor in the timing of vaginal perforation in collared lemmings. During the past 3 years, over 500 females in our colony were weaned at 19 days of age. The mean weight at weaning of 132 randomly selected, vaginally imperforate females was 22·3±0·7 g, but twenty-two other females, found to be perforate at the time of weaning, had a significantly heavier (P<0·01) body weight of 28·5±0·4 g. From the
present evidence, it is not possible to determine whether body weight is a correlate or a causal factor in the timing of vaginal perforation.

The design of these experiments did not permit identification of the factors associated with the male that are responsible for accelerated vaginal perforation. We cannot exclude the possibility that it was due to increased activity. Mature female collared lemmings exhibited oestrus when separated from a male by a wire screen but not when separated from other females or paired with castrated males (Hasler, 1974). Vandenbergh (1969) has demonstrated that accelerated sexual maturity in female laboratory mice could be induced merely by the odour of a male. In addition, Colby & Vandenbergh (1974) have found that male urine is the source of an androgen-dependent pheromone which accelerates sexual maturity in female mice.

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REFERENCES


