Postimplantation pregnancy disruption in
Microtus ochrogaster, M. pennsylvanicus and
Peromyscus maniculatus

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The Bruce effect, the inhibition of pregnancy by a 'strange' male before implantation (Bruce, 1959), has been demonstrated in house mice, Mus musculus (Bruce, 1959; Chipman & Fox, 1966), prairie deer mice, Peromyscus maniculatus bairdii (Eleftheriou, Bronson & Zarrow, 1962), field voles, Microtus agrestis (Clulow & Clarke, 1968), prairie voles, M. ochrogaster (Stehn & Richmond, 1975), and meadow voles, M. pennsylvanicus (Clulow & Langford, 1971). In their study of prairie voles, Stehn & Richmond (1975) described a postimplantation disruption of pregnancy by a non-stud male as late as Day 17 of the 21–23-day pregnancy, and they ascribed this prolonged susceptibility to factors associated with the occurrence of reflex ovulation in these voles. We therefore examined the effect of a 'strange' male on pregnancy in prairie and meadow voles, species in which ovulation is induced by copulation, and in prairie deer mice which are spontaneous ovulators.

Methods

The animals of all three species (M. ochrogaster, M. pennsylvanicus and P. maniculatus) were maintained in temperature-controlled rooms on a reversed 16 h light:8 h dark cycle with red light on at all times. Vaginal smears, examinations for pregnancy and counts of young were conducted in the second half of the light phase. Purina lab chow and water were freely available, and the voles received occasional supplements of lettuce and oats. Cages were cleaned once every 2 weeks.

Laboratory-born, parous females of each species were paired with fertile, non-litter mate, conspecific males and daily vaginal smears were taken with a wire loop. A female was tentatively considered pregnant if (1) an oestrous vaginal smear (50% cornified cells) was followed by marked invasion of leucocytes lasting 13 days (Richmond & Conaway, 1969; Clulow & Mallory, 1970, 1974; Maddock, 1972), (2) spermatozoa were present in the vaginal smear, or (3) a copulatory plug was found in the vagina. In most cases, at least 2 of these criteria were met, and the day of sperm or plug presence or the last day of oestrus was called Day 1 of gestation. On Day 14 of gestation all females were examined manually to verify that they were pregnant, and any non-pregnant females were not further considered. The Day 14 pregnant females were assigned to one of 2 groups: in the control group, the females were returned to the cage of the stud male, and in the experimental group, the females were placed in the home cage of another fertile male. Daily vaginal smears were continued, and males with females of either group were removed the day before the projected parturition date for a litter sired by the first male. Litters were weaned on Day 21 except for some M. pennsylvanicus litters which were killed on Day 5. After a week of complete isolation, each female was again mated to the original male, but at Day 14 was allocated to the other group.

Results and discussion

M. ochrogaster. All 13 females adjudged pregnant on Day 14 and replaced with the stud male gave birth, with a mean of 4·5 ± 0·6 (S.E.M.) young, at the expected time, 22·8 ± 0·2 days after mating. Most (77%) of the females met the criteria for having mated on the 1st or 2nd day after pairing. When exposed to a 'strange' male, 4 of 13 females showed vaginal oestrus 2–3 days later. Spermatozoa were found in the vaginal smears of 3 females which subsequently gave birth to 3·3 ± 0·9 young 24·3 ± 0·9 days later. No spermatozoa were found in the smears of the fourth female, and no litter was born.
M. pennsylvanicus. All 12 females which were pregnant on Day 14 and returned to the stud male littered (3·7 ± 0·6 young). Mating occurred on the day of or after pairing in 92% of the females and the gestation length was 21·0 ± 0·2 days. One of 12 females had an oestrous smear (with spermatozoa) 4 days after placing with the second male, and a litter of 3 young was born 21 days later. Five females were placed with a second male 7 days after mating with the first, but pregnancy continued in all.

P. maniculatus bairdii. The 11 females pregnant on Day 14 all gave birth when replaced with the stud male. The gestation length was 23·3 ± 0·2 days after mating on the 1st or 2nd day (73%) of pairing, and the litter size was 4·7 ± 0·4 young. Exposure to a second male resulted in 2 of 11 females becoming oestrous. Spermatozoa were found in the smears 3–4 days after pairing, but no litters were produced.

Some females in all 3 species exhibited male-induced termination of pregnancy after implantation. The incidence in M. ochrogaster was higher than in the other 2 species, but was lower than that (70%) reported by Stehn & Richmond (1975). Several procedural differences could account for this reduction in the number of disruptions. In the earlier study the strange males were left with the females until birth of the litter, but were removed after 5 or 6 days in this study. Secondly, and importantly, the females used by Stehn & Richmond were nulliparous, and the females in the present study were multiparous and had recently finished lactating. As prolactin can protect mice from a male-induced preimplantation pregnancy block (Bruce & Parkes, 1960; Dominic, 1966), it is possible that the females in this study experienced slight protection from their recent lactation. Finally, Stehn & Richmond determined the start of pregnancy from the day of pairing rather than from the day of sperm detection. If some M. ochrogaster females mated the day following pairing as they did in this study, the 16–17-day pregnant group (with 36% pregnancy disruption) of Stehn & Richmond (1975) would correspond to our Day 14 animals (31% block).

Duration of pregnancy and litter size did not differ significantly among conditions and were within the normal ranges reported for these species (Asdell, 1964; Richmond & Conaway, 1969; Maddock, 1972). There was a slight tendency toward delayed mating in the blocked females, probably reflecting the time requirements for abortion and/or resorption of the previous litter.

There were no obvious differences in the nature or incidence of pregnancy disruption in induced and spontaneous ovulators, but the incidence was very low when compared with the effect of a strange male during the preimplantation period (up to 76%; Bruce, 1959). The present data do not therefore support the hypothesis that increased susceptibility to male-induced pregnancy termination is a natural concomitant of endocrine events associated with oestrus in reflex ovulators. It is not known whether pre- or post-implantation disruption occurs in natural populations. If it does, ecological and demographic implications would be important.

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References


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