Copulatory Behavior and Fertility of Male House Musk Shrews (Suncus murinus) Paired with One, Two and Four Females Each

Haruo HASHIMOTO¹, ², Naoki MORITANI¹, and Toru R. SAITO¹

¹Behavioral Neuroscience Laboratory, Department of Laboratory Animal Sciences, Nippon Veterinary and Animal Science University, Musashino, Tokyo 180-8602, and ²Animal Resource Center, Central Institute for Experimental Animals, Kawasaki, Kanagawa 216-0001, Japan

Abstract: In order to improve the productivity of house musk shrews, we investigated whether a male could impregnate more than one female within 24 h. Eighteen males and 40 females aged one year were used in this experiment. The mating systems were as follows: one male was paired with one female, one male was paired with two females, and one male was paired with four females. In the fertility rate, six out of 6, 4 of 12 and 4 of 20 females became pregnant and gave birth under three systems, respectively. In the copulatory behavior, numbers of intromissions and ejaculations were more in the 1:1 mating group as compared with the 1:2 and 1:4 groups. We conclude that it is possible for a male to impregnate about one female within 24 h.

Key words: copulation, fertility, house musk shrews, mating system

House musk shrews have many unique characteristics as an experimental animal. For example, they are sensitive to motion sickness [6], the structure of their canalis alimentarius is more similar to that of human beings than rats or mice [7], and they are more resistant to X-rays than C3Hf/He mice as measured by disorder of bone-marrow [10]. House musk shrews have several important uses as disease models of motion sickness and gastric cancer, and it is anticipated that they will become a model in the field of hematopoietic studies. It is also anticipated that they will become a model for hormone-dependent tumors because they exhibit spontaneous androgen-dependent pilosebaceous tumors [4, 5]. Therefore, improved husbandry of house musk shrews is needed to support research into this animal. In past studies, the reproduction rate of rats was successfully improved using polygamous mating [12], but that of Syrian hamsters was not [13]. There has been no report about the improvement of reproduction in house musk shrews.

We postulated that it would be possible to promote the reproductive efficiency of house musk shrews using a polygamous mating system because females are reflex ovulators and ready to mate with males at any time [1, 3]. In this study, we investigated whether one male house musk shrew could impregnate many fe-
males in a night.

**Animals**: In this study we used 17 sexually experienced male house musk shrews (*Suncus murinus*) of the Jic: SUN strain supplied from Central Institute for Experimental Animals (Kanagawa, Japan). The animals were housed in polycarbonate cages (220D × 380W × 200H mm) kept in an animal room with controlled temperature (24 ± 2°C) and humidity (55 ± 10%). A 12:12-h light:dark cycle, with lights on at 07:00, prevailed. Food (CIEA-305, CLEA Japan, Inc., Tokyo, Japan) and tap water were always available. Both males and females were 1-year-old at the start of tests. All experiments were performed under the Guidelines for Animal Experimentation of the Japanese Association for Laboratory Animal Science.

**Mating systems**: Each of 6 males was paired with a single female (the 1:1 mating group). Six other males were each paired with 2 females (the 1:2 mating group). Each of the remaining 5 males was paired with 4 females (the 1:4 mating group). All females were maintained with the males for 24 h.

**Copulatory behavior test**: Copulation was observed under a 6W red light during the dark period and was recorded by video recorder. First, a male house musk shrew was placed in a cage (220D × 380W × 200H mm).

Five minutes later, 1, 2 or 4 female house musk shrews were introduced into the same cage. The following indices of copulation were measured, according to the method reported elsewhere [9].

1) **Mount frequency (MF)**: Number of mounts without intromission during 24 h.
2) **Intromission frequency (IF)**: Number of mounts with intromission during 24 h.
3) **Ejaculation frequency (EF)**: Number of ejaculations during 24 h.
4) **Mount latency (ML)**: Elapsed time between introduction of the female and the first display of mounting.
5) **Intromission latency (IL)**: Elapsed time between introduction of the female and the first display of intromission.
6) **Ejaculation latency (EL)**: Elapsed time from first intromission of the female to time of ejaculation.

**Statistical analysis**: Differences of copulation among mating groups were compared with the Mann-Whitney U test [8]. Differences among rates of deliveries and fertilities in 1:1, 1:2, and 1:4 mating systems were analyzed by Fisher’s exact probability test [2].

---

### Table 1. Comparison of behavioral frequencies for male house musk shrews among mating groups

<table>
<thead>
<tr>
<th>Mating group</th>
<th>n</th>
<th>No. of Mount/24 h</th>
<th>%a)</th>
<th>No. of Intromission/24 h</th>
<th>%</th>
<th>No. of Ejaculation/24 h</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: 1</td>
<td>6</td>
<td>32.5 (23–210)b)</td>
<td>100</td>
<td>21 (3–41)*</td>
<td>100</td>
<td>4 (3–6)*</td>
<td>100</td>
</tr>
<tr>
<td>1: 2</td>
<td>6</td>
<td>18 (0–43)</td>
<td>83.3</td>
<td>4.5 (0–11)**</td>
<td>66.6</td>
<td>2 (0–4)**</td>
<td>66.6</td>
</tr>
<tr>
<td>1: 4</td>
<td>5</td>
<td>23 (0–141)</td>
<td>80</td>
<td>4 (0–21)**</td>
<td>60</td>
<td>2 (0–4)**</td>
<td>60</td>
</tr>
</tbody>
</table>

P valuec) ns d) ns P<0.05 e) ns P<0.05 ns

a) Percent of animals responding.  b) Median (Range).  c) Determined by Mann-Whitney U test.  d) Not significant.  e) Significant difference between * and **.

---

### Table 2. Comparison of behavioral latencies for male house musk shrews among mating groups

<table>
<thead>
<tr>
<th>Mating group</th>
<th>n</th>
<th>Mount latencya)</th>
<th>Intromission latency</th>
<th>Ejaculation latency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: 1</td>
<td>6</td>
<td>874 (0–25,564)b)</td>
<td>902 (0–25,683)</td>
<td>360 (120–841)</td>
</tr>
<tr>
<td>1: 2</td>
<td>6</td>
<td>4,562 (420–40,086)</td>
<td>4,085 (1,140–39,782)</td>
<td>304 (243–962)</td>
</tr>
<tr>
<td>1: 4</td>
<td>5</td>
<td>1,024 (486–8,700)</td>
<td>1,260 (785–9,244)</td>
<td>300 (182–3,606)</td>
</tr>
</tbody>
</table>

P valuec) ns d) ns ns

a) Latency in seconds.  b) Median (Range).  c) Determined by Man-Whitney U test.  d) Not significant.
value $< 0.05$ was regarded as statistically significant.

The frequencies and latencies of mount, intromission and ejaculation during 24 h in each group are shown in Tables 1 and 2. The frequencies of both intromission and ejaculation in the 1:2 and 1:4 mating groups were significantly lower than in the 1:1 mating group ($p < 0.05$). There were no differences of other items among the three groups.

In observations of the 1:2 and 1:4 mating groups, the copulatory behavior of male house musk shrews was interrupted by a specific female, the most violent of the plural females.

Delivery rates of females in 1:1, 1:2 and 1:4 mating group are shown in Fig. 1. Of the 6 females in the 1:1 mating group, 6 females (100%) delivered. Of the 12 females in the 1:2 mating group, 4 females (33.3%) delivered. In the 1:4 mating group, 4 (20%) of 20 females delivered. The delivery rates in the 1:2 and the 1:4 groups were significantly lower than those in the 1:1 mating group ($p < 0.05$ and 0.001, respectively).

Male fertility rates in 1:1, 1:2 and 1:4 mating groups are shown in Fig. 2. In the 1:1 mating group, 6 (100%) of the 6 males made female partners pregnant. In the 1:2 mating group, 4 (66.6%) of the 6 males could make one of the 2 female partners pregnant. Neither of the 2 female partners of the remaining 2 males (33.3%) became pregnant. In the 1:4 mating group, 2 (40%) of the 5 males made one of the 4 partners pregnant, 1 male (20%) could make two of the 4 partners pregnant, and the remaining 2 males (40%) had no pregnant partners.

We attempted to improve the reproductive efficiency of house musk shrew using a polygamous mating system. Delivery rates of females were 100, 33.3 and 20%, and female fertility rates were 100, 66.7 and 60% in the 1:1, 1:2 and 1:4 mating groups, respectively. It
shows that the reproductive capacity of male house musk shrews decreases as the number of female partners increases and that the delivery rates of females also decreases in polygamous mating. Further, the cause for these decreases was shown to be decreases of intromission and ejaculation frequencies caused by interruption by a specific female in polygamous mating.

It was reported that the fertility rates of male Syrian hamsters in 1:2 and 1:4 mating were lower than that of 1:1 mating [13], because of a decrease in copulatory behavior [14]. The fertility results of this study correspond to the results of the Syrian hamster [13, 14], however, the cause of the decrease in copulatory behavior was different between house musk shrews and Syrian hamsters. Yamaguchi et al. [14] reported that the copulating efforts of the male Syrian hamster in the 1:2 mating group were not concentrated on a single female but divided between two females, and in the 1:4 mating group, the presence of multiple estrous females in same cage seemed to have inhibited the copulating ability of the male. In this study, the behavioral observation of house musk shrews showed the copulatory behavior of male house musk shrews in the 1:2 and 1:4 mating groups was interrupted by a specific female. Although the reason why a specific female interrupted was unclear, we think it may be a social behavior specific to house musk shrews.

The delivery rate of the Wistar-Imamichi rat was 60% in a 1:5 mating [12] higher than 20% of the house musk shrew in a 1:4 mating. These results suggest that a male house musk shrew may be able to copulate with only one female. Wistar-Imamichi rats have been genetically controlled to have many pups [11]. Therefore, the difference of the reproductive rate in a polygamous mating system between house musk shrews and Wistar-Imamichi rats not depend on species but might depend on genetic control for high reproductive efficiency.

We conclude that the interruption of male copulatory behavior, which induced decreases in reproductive efficiency, delivery and fertility rates, by a specific female might originate from both species specific characteristics of house musk shrews and genetic control associated with breeding.

Acknowledgments

The authors thank Mr. T. Yamaguchi, Brain Science and Life Technology Research Foundation, Itabashi, Tokyo, Japan, for his helpful advice. A preliminary report of this research was presented at the 40th Annual Meeting of the Japanese Association for Laboratory Animal Science, Sendai, Japan, June, 1993.

References