Environmental Influences on Flank Marking and Urine Marking by Female and Male Rats *(Rattus norvegicus)*

Blaine F. Peden and William Timberlake
Indiana University

Sprague-Dawley rats *(Rattus norvegicus)* were observed in a familiar environment. In Experiment 1 a leader entered a clean chamber, and an opposite-sex follower entered the chamber next. Both sexes began to flank mark after several sessions. Males flank marked more, but both sexes urine marked and investigated objects equally often. Leaders and followers did not differ on any measure. In Experiment 2 we measured floor marks more precisely and manipulated the number of objects and the presence of scent marks. Flank marking was more frequent in the presence of conspecific urine but did not vary with the number of objects or the sex of the rats. More objects elicted more investigating and urine marking and produced fewer floor marks but increased the number of marks in the central area in relation to the periphery. The results indicate that rats' flank marking is behaviorally distinct from urine marking and differentially affected by environmental variables.

Field observations of mammals have revealed numerous types of scent marking: urinating, defecating, and rubbing secretions of the flank or anogenital region on objects and the substrate (Rails, 1971; Thiessen & Rice, 1976). These observations also reveal complex behavioral adaptations that use scent marking to delineate feeding, sleeping, or reproductive territories (Ewer, 1968) or to advertise reproductive state (Johnston, 1983).

Compared with many spectacular examples of mammalian marking, scent marking by laboratory rats has seemed pallid at best. Rats lack specialized scent glands and any obvious tendencies to mark individual food or mating territories. Even though Calhoun (1963) reported that rats in a natural environment urinated on clods of dirt, rocks, and at the intersection of paths, the possibility of scent marking in the laboratory rarely was mentioned until Brown (1973) provided rats with a low object that elicited considerable urine marking.

Once marking by rats was established as a reliable phenomenon, most investigators used males to study how endogenous variables such as gonadal conditions controlled urine marking (e.g., Brown, 1975; Price, 1975; Scouten, Burrell, Palmer, & Cegavske, 1980). More recently, attention has been directed to scent marking by females (Birke, 1978, 1984) and to the importance of stimulus circumstances (Birke & Sadler, 1984; Brown, 1978; Hopp & Timberlake, 1983).

Our experiments further the study of scent marking by increasing the potential ecological relevance of the laboratory testing conditions to rats' selection environment. In particular, we were interested in providing rats with stimulus conditions that might control flank marking. Calhoun (1963) reported that male rats rolled and flank rubbed at the entrance to burrows in the presence of estrous females. Grant and Mackintosh (1963) and Adams (1976) have also noted flank marking of the wall in familiar home cages. To promote flank marking we used a familiar environment in which rats could move between a small, dark burrow and a large illuminated test chamber that contained a number of low objects. The availability of the burrow reduced the contribution of fear-motivated locomotion to our results (Montgomery, 1954, 1955). To assess the effects of environmental variables on flank and urine marking by males and females, we manipulated the number and the odor condition of markable objects in the environment. Odor condition was manipulated by observing animals in both clean and previously scented environments. We also repeated test trials with conditions held constant to ensure that the rats were familiar with the environment and to assess long-term patterns of marking.

**Experiment 1**

In the first experiment we observed the extent to which flank and urine marking were controlled by the presence or absence of scent marks from the opposite sex in a familiar environment with objects, walls, and an entryway. The sexual dimorphism hypothesis (Thiessen & Rice, 1976) led us to expect sex differences in flank marking because flank marking...
by females had not previously been reported. We also ex-
pected variations in flank marking by males because of Cal-
houn's (1963) report that estrous females elicited flank mar-
kering by males. Finally, to the extent that scent marking is a
simple social response, we expected more frequent flank and
urine marking by the first rats (leaders) that entered an
unmarked chamber (the odor-absent condition) than by their
opposite-sex followers that entered an environment marked
by a leader (the odor-present condition).

Method

Subjects. Six male and 6 female sexually inexperienced Sprague-
Dawley rats (Rattus norvegicus) were about 200 days old at the
beginning of the experiment.

Apparatus. The top panel of Figure 1 depicts the test chamber
(90 cm wide x 71 cm high x 90 cm deep) used in this experiment.
Galvanized-metal sides covered the bottom 36 cm of three walls; the
front wall was a double-paned glass window. The walls, ceiling, and
removable sheet-metal floor were painted flat black. A 2.54-cm lip
along the front edge of the floor could be straddled by a rat as it
walked along the glass window. White automotive striping divided
the floor into a 5 x 5 grid of 18-cm squares. One of six brass cylinders
(3.49 cm diameter and 3.18 cm high) was placed on end in every
other square in columns 2 and 4 and secured to the floor with rubber
cement. One of six ring magnets (4.13 cm diameter with a 2.22 cm
diameter center hole and 1.27 cm high) was located in every other
square in rows 2 and 4. The burrow was a small, plastic mouse cage
(27.9 x 12.7 x 17.8 cm) with an entryway (7.5 cm wide and 9.0 cm
high) that opened onto the second row of squares. An exhaust fan in
the ceiling vented heat from four red 25-W incandescent bulbs and
provided ambient noise.

Procedure. Two weeks before the rats entered the chamber for
the first time, they were housed 2 per cage and placed on a reverse
12:12-hr light/dark cycle. All the cages of males were located inside
one cabinet, and all the cages of females were located inside a separate
cabinet; both light-tight cabinets were situated in the same colony
room.

All sessions occurred under red light during the first 3 hr of the
dark cycle. During the 5-day familiarization period, cagemates were
placed together in the chamber for about 10 min each day. Subse-
quently, the rats were grouped at random into opposite-sex leader-
follower pairs for testing. Each rat in a pair served as both leader and
follower. During a 5-min test session, a leader entered a clean cham-
ber, whereas a follower entered the chamber that had been scent
marked by the leader. This intense odor field was removed after each
pair by cleaning the chamber and objects with Roccal-D (Sterling
Animal Health Products, New York, NY), a detergent solution mixed
10 cm3/3.8 L (after Hopp & Timberlake, 1983). The order of testing
the male-leader versus the female-leader pairs was alternated from
session to session. The order of testing the three male-female or
female-male leader-follower pairs was counterbalanced within each
block of six sessions.

Before the start of each test session, a rat was placed in the burrow.
To begin a test session, the experimenter started a 5-min timer and
opened the door to the chamber.

A single observer (Blaine F. Peden) recorded flank marking, two
forms of urine marking, object investigating, and locomoting. Flank
marking refers to a rat's leaning against and rubbing the flank against
the entryway or the glass window. The two forms of urine marking,
object and entryway floor marking, entailed lowering the hindquarters
and depositing urine on an object or the floor, respectively. Object
investigating refers to moving the nose within 1 cm of any object
accompanied by obvious whisker movements. Locomoting was meas-
ured by the number of squares entered. We also videotaped selected
sessions at the end of each odor condition.

Testing occurred on consecutive days except for a 9-day break
between Sessions 15 and 16. After 30 sessions, the order in which
each member of a leader--follower pair entered the chamber was
reversed for 6 additional sessions (31–36). For each animal we com-
puted the median for Sessions 26–30 and 34–36 to minimize the
effect of occasional deviant scores. These scores were analyzed with
a 2 x 2 mixed factorial analysis of variance in which sex (male vs.
female) was a between-subjects variable and test order (leader vs.
follower) was a within-subjects variable.

Results

Table 1 presents the group means for males and females in
the two odor conditions and summarizes the univariate anal-
yses of variance. There were three significant main effects of sex, no significant main effects of odor condition, and no significant interactions between sex and odor condition.

Flank marking. Rats flank marked the entryway more frequently than the window. In both cases the rats typically turned around and sniffed the site after rubbing against the vertical surface. Figure 2 illustrates a typical example in which a male flank marked the entryway by leaning sideways and pushing its side against the edge of the entryway while pulling itself into the burrow. Panels 1-4 in Figure 3 exemplify flank marking by 1 of the 3 males that rubbed against the glass observation window during almost every session. This behavior occurred while a rat walked along the window and straddled the lip of the floor with the hind legs.

Flank marking varied with both long-term and immediate experience. A long-term effect was demonstrated because flank marking began to occur only after 5-10 sessions in the chamber. Thereafter, 5 males and 2 females flank marked consistently from session to session. An immediate effect of experience was demonstrated because flank marking within a session began to occur only after several circuits around the perimeter of the chamber. Males flank marked more frequently than females, $F(1, 10) = 6.5$, $p < .05$; however, there was no significant effect of odor condition.

Object investigating and marking. Both females and males investigated and urine marked the brass cylinders three times for every two times that they investigated and marked the ring magnets. Panels 5 and 6 of Figure 3 show an example of a rat approaching and investigating a brass cylinder. Typically, the rats investigated an object in two different ways. For example, short sniffs occurred as the rat rapidly passed over an object; long sniffs, lasting 2 or more s, occurred while the rat hunched over and grasped an object (see Panel 6 in Figure 3). In the latter case the rats sometimes appeared to lick deposits on the cylinder and to rub the sides of their face on it, another possible form of scent marking or, alternatively, scent rubbing (Rieger, 1979).

Object marking typically entailed a sequence of behavior in which sniffing was followed by urine marking. Panels 7 and 8 of Figure 3 portray the subsequent urine marking of an object. Neither sex nor odor condition systematically influenced either investigating or marking the objects.

Locomoting and entryway floor marking. All rats repeatedly entered the chamber, locomoted around the chamber, and exited the chamber through the entryway. Females traversed significantly more squares than males during the test period, $F(1, 10) = 8.9$, $p < .05$; however, the odor condition did not affect locomoting systematically.

After locomoting the perimeter, all the rats marked the entryway while entering the burrow and then immediately returned to the chamber. Entryway floor marking occurred significantly more frequently for females than males, $F(1, 10) = 6.0$, $p < .05$, and typically was followed by sniffing at the site of the mark by both sexes. This behavior was not significantly affected by the odor condition.

Additional findings. We plotted and examined the data for individual pairs of males and females. The patterns of results were qualitatively similar, and there were no apparent effects of a presumed estrous cycle for any measures. In addition, there was no evidence that marking, investigating, or locomoting habituated with repeated trials (cf. Bronson, 1976; Maruniak, Owen, Bronson, & Desjardins, 1974).

Discussion

First and foremost, both male and female rats flank marked the smooth glass window and the entryway under controlled laboratory conditions. The finding that males flank marked more frequently than females provides support for the sexual dimorphism hypothesis (Thiessen & Rice, 1976); however, this conclusion must be qualified because the frequencies of flank marking by actively marking males and females overlapped. In addition, there were no apparent sex differences in flank marking related to an estrous cycle. Our findings appear to confirm Calhoun's (1963) observations about features of the environment such as entryways that influence flank marking. Perhaps, rolling in front of the burrow did not occur because there was no receptive female therein.

The rats frequently investigated and urine marked objects. Our results also replicated the finding that certain types and sizes of objects were marked preferentially (Birke, 1978); however, there were no sex differences in object investigating and marking related to an estrous cycle (cf., Hopp & Timberlake, 1983).

Our finding that male and female rats urine marked objects equally often is inconsistent with the sexual dimorphism hypothesis (Thiessen & Rice, 1976), but our result is not

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Male Leader</th>
<th>Male Follower</th>
<th>Female Leader</th>
<th>Female Follower</th>
<th>Sex</th>
<th>Order</th>
<th>Sex × Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flank marking</td>
<td>3.0</td>
<td>2.3</td>
<td>0.7</td>
<td>0.2</td>
<td>6.45*</td>
<td>1.64</td>
<td>0.03</td>
</tr>
<tr>
<td>Object marking</td>
<td>11.7</td>
<td>14.8</td>
<td>11.3</td>
<td>9.3</td>
<td>2.24</td>
<td>0.60</td>
<td>0.84</td>
</tr>
<tr>
<td>Entry marking</td>
<td>0.3</td>
<td>0.2</td>
<td>0.8</td>
<td>0.7</td>
<td>6.00*</td>
<td>0.91</td>
<td>0.00</td>
</tr>
<tr>
<td>Investigating</td>
<td>19.8</td>
<td>22.3</td>
<td>21.3</td>
<td>24.0</td>
<td>0.70</td>
<td>3.14</td>
<td>0.00</td>
</tr>
<tr>
<td>Locomoting</td>
<td>62.8</td>
<td>57.8</td>
<td>88.8</td>
<td>77.1</td>
<td>8.89*</td>
<td>1.09</td>
<td>0.17</td>
</tr>
</tbody>
</table>

* $p < .05$.

Note. The chamber was odor-absent in the leader condition and was odor-present in the follower condition.
SCENT MARKING BY RATS

Figure 2. A male rat approaches and flank marks the entryway as it exits the chamber.

contradicts a finding by Birke and Sadler (1984) that rats marked more frequently in a novel environment scent marked by a conspecific (i.e., our follower condition) than in an unscented one (i.e., our leader condition). This discrepancy may be related to the number of objects in the chamber, the strength of the odor field within the chamber, or the degree of exposure to the chamber. In our study, the rats encountered more objects, the odors from the conspecifics were stronger and more varied, and the environment was familiar rather than novel to the rats. In Experiment 2, we explicitly manipulated the number of objects and the strength of the odor field to test two of these possibilities.

Experiment 2

In the second experiment, we investigated scent marking under conditions of greater environmental control and more precise measurement of the frequency and location of urine marks on the floor. We manipulated the number of stimulus objects (2 vs. 12) and the number of objects that were scented with a drop of urine from an opposite-sex conspecific (none vs. one half) to gauge more carefully the conditions important in eliciting flank and urine marking. In addition to observing scent marking directly as in Experiment 1, we also measured urine marks on the floor by examining residues on an absorbent paper floor (see Johnson, 1973).

Method

Subjects. Five of the 6 males (1 had become ill) and the 6 females from Experiment 1 were used as subjects.

Apparatus. There were four changes in the chamber used in Experiment 1. First, the bottom panel of Figure 1 shows that both entryways on the right wall were covered with squares of sheet metal painted black, and an entryway, 15 cm wide x 15 cm high, centered on the left wall was uncovered. An opaque guillotine door separated the entryway from the open end of the mouse cage. This modification eliminated having an object in the square abutting the entryway and permitted us to create a symmetrical pattern of objects relative to the entryway. Second, the stimulus objects were 12 brass cylinders, 3.49 cm in diameter and 3.18 cm high, in which a hole was bored and then filled with a speaker magnet. This modification facilitated cleaning and also ensured that the object remained stationary. Third, the floor was covered with unprinted newspaper stock on which the 5 x 5 grid was drawn in pencil. Fourth, four red 60-W bulbs replaced the 25-W bulbs. The white paper floor and brighter lights improved the ease of observation, particularly in the case of floor marking.

Procedure. The panels of Figure 1 depict the placement of the brass cylinders in the 12- and 2-object conditions. In the odor-absent condition, all the objects were clean, whereas in the odor-present condition, a drop of urine from an opposite-sex conspecific was deposited on one half of the objects just before the start of each 5-min test session. Unlike Experiment 1, the donors were not subjects in this experiment, although their cages were located in the same colony room as the cabinets in which the subjects were housed. Urine was collected in plastic boxes covered with mesh screen and located beneath the donor's home cage. After passing the urine through a coffee filter, a syringe was used to place a drop of about 0.03 cm$^3$ on the appropriate cylinders.

anomalous. Although Brown (1978) reported more urine marking by males than females, the first experiment by Birke and Sadler (1984) demonstrated that males and females marked both objects and the floor at comparably low rates in a clean chamber and comparably high rates in a chamber scented by a conspecific. Two other experiments have obtained results directly contrary to the sexual dimorphism hypothesis. In Birke and Sadler's second experiment, estrous females marked at least two times more frequently than males. In addition, Lee, Mitchell, and Adams (1984) observed more frequent urine marking by females than males.

Although casual observations suggested that the rate of investigating and marking objects was slower, at least initially, in the presence of odors, the frequency of neither behavior varied as a function of the odor condition. Our finding of comparable rates of object marking by leaders and followers
Relative to the observer the location of the scented object was balanced. The experimenter placed a drop of urine on the cylinder in the rear (2-object condition) and on the cylinders 3 to a row (12-object condition) for one half of the males and females. Similarly, the experimenter placed a drop of urine on the cylinder in the front (2-object condition) and on the cylinders 3 to a column (12-object condition) for the remaining rats.

The housing and testing conditions duplicated those of Experiment 1 except for cleaning the chamber and objects before testing the next animal. All rats were tested on the odor-absent condition for 16 sessions before they were tested in the odor-present condition for 16 sessions; in both cases, the 8 sessions on the 2- and 12-object conditions were counterbalanced. Thus, there were 8 consecutive sessions for each odor-object-number condition, a total of 32 sessions altogether. The daily order of testing males and females alternated from session to session. The order of testing the males and females was counterbalanced across sessions.

During the session the observer (Peden) recorded flank marking, urine marking of objects and the floor, investigating objects in the form of short and long sniffs, and locomoting. After the session, residue on the paper floors was examined to determine the number of urine marks to the objects and the number and spatial location of urine marks on the floor. We counted the number of marks in the square adjacent to the entryway separately from those floor marks elsewhere in the chamber. We also distinguished the number of floor marks in the outer 16 squares from those in the inner 9 squares (after Johnson, 1973). For each animal we again computed the median for the last five sessions under each of the four odor-object-number conditions. These scores were analyzed with a univariate $2 \times 2 \times 2$ mixed factorial analysis of variance in which sex (male vs. female) was a between-subjects variable and both the number of objects (2 vs. 12) and the odor condition (odor absent vs. odor present) were within-subjects variables.

**Results**

Table 2 presents the group means for males and females in the four odor-object-number conditions and summarizes the univariate analyses of variance. Qualitatively, the pattern of results tended to replicate those for Experiment 1; however, the scores were lower for Experiment 2, and there were no significant main effects of sex. There were significant effects of odor on flank and floor marking. In addition, there were significant effects of number of objects on object and floor marking and object investigating.

**Flank marking.** As in the previous experiment, flank marking the window or entryway occurred after several circuits while returning to the burrow. Males tended to flank mark more frequently than females as in Experiment 1, but the differences were not significant. Rats in the odor-present
condition flank marked more frequently than those in the odor-absent condition, \( F(1, 9) = 6.1, p < .05 \). This outcome occurred because 2 males and 3 females that did not flank mark in the initial odor-absent condition flank marked in the subsequent odor-present condition. The number of objects in the open area did not systematically affect flank marking.

Object investigating and marking. On entering the chamber the rats typically proceeded directly to a nearby brass cylinder, investigated, and then marked it. Because distinguishing between short and long sniffs was meaningful for neither number of objects, odor condition, nor sex, we combined the short and long sniffs into a single measure for analysis. There were no systematic effects of either sex or odor condition on object investigating; however, object investigating occurred about three times more frequently in the 12-object than in the 2-object condition, \( F(1, 9) = 93.8, p < .001 \).

The rats frequently crawled over and marked the cylinders with small amounts of urine. Although there were no marks on the paper floor, these small amounts were detectable during the cleaning process because the objects felt moist or sticky. For this reason the observed number of object marks always exceeded the number recorded from residue on the paper floors. For example, the ratio of marks to the object that were observed as opposed to recorded from residue was less than one. For example, the ratios for males (about 1 to 2) and for females (about 3 to 4) indicated that the rats actually marked the floor more often than detected by the experimenter. This outcome occurred because the rats moved about the chamber in a relatively crouched position and placement of a drop of urine on the floor required slighter and much less obvious movements than those entailed in marking the relatively tall and wide brass cylinders (see also Maruniak, Desjardins, & Bronson, 1975). In addition, the amount of urine released typically was less when marking the floor than when marking objects.

There were no significant sex differences in floor marking; however, floor marking was observed more frequently in the odor-present condition than the odor-absent condition, \( F(1, 9) = 6.0, p < .05 \). In addition, there was a significant interaction between sex and odor condition, \( F(1, 9) = 8.6, p < .05 \), such that males increased the observed number of floor marks from the odor-absent condition to the odor-present condition, whereas females did not.

Floor marking was observed more frequently in the 2-object than in the 12-object condition, \( F(1, 9) = 7.4, p < .05 \). Floor marks easily were distinguished from marks off the object because floor marks were elliptical whereas off object marks were round and adjacent to an object.

The pattern of scores for the 402 residue marks on the paper floor was comparable with the pattern of observed floor marks; however, there were no significant main effects for either sex, odor condition, or the number of objects. Approximately 93% of the marks on the paper floors appeared in the outer squares adjacent to side walls; approximately 24% appeared in the square abutting the burrow, and 69% appeared in the remaining outer squares. This outcome confirmed the observer’s impression about the spatial distribution of marks in Experiment 1 and also supported the conclusion that scent marks abound in the borders of territories (Johnson, 1973). Of the 7% that appeared in the 9 inner squares, the number of marks was approximately five times greater in the 12-object than in the 2-object condition. Objects in the inner squares drew the animals into an area that they typically avoid.

### Table 2

**Mean Scores and Summary of the Analyses of Variance for Experiment 2**

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Male Absent</th>
<th>Male Present</th>
<th>Female Absent</th>
<th>Female Present</th>
<th>Sex (A)</th>
<th>Odor (B)</th>
<th>Number (C)</th>
<th>A × B</th>
<th>A × C</th>
<th>B × C</th>
<th>A × B × C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flank marking</td>
<td>1.0</td>
<td>1.2</td>
<td>2.0</td>
<td>2.2</td>
<td>2.24</td>
<td>6.13*</td>
<td>1.71</td>
<td>0.00</td>
<td>0.14</td>
<td>1.29</td>
<td>0.11</td>
</tr>
<tr>
<td>Object marking</td>
<td>3.0</td>
<td>4.2</td>
<td>3.0</td>
<td>3.3</td>
<td>0.24</td>
<td>0.26</td>
<td>54.46**</td>
<td>1.52</td>
<td>0.25</td>
<td>0.02</td>
<td>1.96</td>
</tr>
<tr>
<td>Object residue</td>
<td>1.8</td>
<td>2.4</td>
<td>1.2</td>
<td>1.2</td>
<td>2.45</td>
<td>0.30</td>
<td>9.02*</td>
<td>1.05</td>
<td>2.58</td>
<td>0.07</td>
<td>1.73</td>
</tr>
<tr>
<td>Floor marking</td>
<td>4.4</td>
<td>8.2</td>
<td>4.3</td>
<td>3.7</td>
<td>2.34</td>
<td>3.98*</td>
<td>7.40*</td>
<td>8.56*</td>
<td>0.02</td>
<td>0.55</td>
<td>3.24</td>
</tr>
<tr>
<td>Floor residue</td>
<td>9.2</td>
<td>14.0</td>
<td>4.5</td>
<td>5.8</td>
<td>4.28</td>
<td>3.54</td>
<td>4.96</td>
<td>2.33</td>
<td>0.25</td>
<td>5.99*</td>
<td>0.32</td>
</tr>
<tr>
<td>Investigating</td>
<td>3.6</td>
<td>16.6</td>
<td>5.5</td>
<td>6.7</td>
<td>0.79</td>
<td>1.93</td>
<td>93.75**</td>
<td>1.43</td>
<td>0.03</td>
<td>0.00</td>
<td>2.77</td>
</tr>
<tr>
<td>Locomoting</td>
<td>36.4</td>
<td>39.6</td>
<td>51.2</td>
<td>52.2</td>
<td>2.79</td>
<td>0.45</td>
<td>0.74</td>
<td>0.39</td>
<td>1.47</td>
<td>3.82</td>
<td>0.46</td>
</tr>
</tbody>
</table>

*Note.* Absent and present indicate the odor condition (i.e., the absence or presence of conspecific urine) in the chamber. The number of objects in the chamber are indicated by 2 and 12.

* \( p < .05 \)  ** \( p < .001 \)
**Additional findings.** Once again, there was no discernible evidence of temporal patterns of marking by either males or females related to a presumed estrous cycle. In addition, there was no evidence that marking, investigating, or locomoting habituated with repeated trials (cf. Bronson, 1976; Maruniak et al., 1974).

**Discussion**

The presence or absence of conspecific odors affected flank marking but not object investigating or marking. Our finding that the odor condition affects floor marking supports the results of Birke and Sadler (1984) who combined object and floor marks into a single score. Our results do not support Brown's (1973) hypothesis that females mark the floor more and mark objects less than males.

The number of objects did not influence flank marking but did affect object investigating, object marking, and the frequency and spatial distribution of floor marks. The larger number of objects elicited more investigating and urine marking and less floor marking than the smaller number of objects.

**General Discussion**

In two experiments we determined whether flank marking occurred under controlled conditions and whether flank and urine marking by rats were differentially influenced by the environment. In both experiments female and male rats flank marked a window and an entryway and also urine marked objects and the floor. An entryway between a protected and an open space is an important feature to elicit flank marking and to direct floor marking. A large number of low objects affects urine marking of objects and the floor. The presence of odors from a conspecific also influences flank marking but not urine marking of objects and the floor. The presence of odors from a conspecific also influences flank marking but not urine marking of objects and the floor. In addition, the intensity or distribution of the odors from conspecifics appears influential. These results indicate that flank and urine marking are differentially sensitive to environmental variables.

**Flank Marking**

Our experiments demonstrate that male and female rats flank marked an entryway more frequently than a glass window. Flank marking, a phenomenon previously reported only anecdotally (Adams, 1976; Calhoun, 1963; Grant & Mackintosh, 1963), is a relatively infrequent, but topographically distinct behavior whereby a rat presses its side against a vertical structure. Flank marking may have occurred in our experiments but not in others (e.g., Birke, 1978; Birke & Sadler, 1984; Brown, 1975, 1978) for two reasons. One reason is that our animals had access to a passageway between a small, enclosed burrow and an open area, whereas animals in other experiments typically were observed in a chamber with a single compartment. A second reason is that other researchers may not have been looking for flank marking and may have precluded its occurrence by using novel rather than familiar test environments.

Relative familiarity clearly influences species-specific behaviors such as flank marking. In the first experiment, flank marking emerged over sessions as the situation became more familiar to the rats, and in the second experiment an initially unfamiliar chamber disrupted various behaviors including flank marking for several rats (see also Adams, 1976). Our findings and Eibl-Eibesfeldt's (1970) classic demonstration that rats build nests in familiar but not novel places illustrate the general point that the testing situation must present an animal with sufficiently relevant releasing stimuli to elicit species-specific responses. Unfamiliar environments do not adequately support either flank marking or nest building.

The occurrence of flank marking suggests a behavioral function for the sebaceous glands that abound in the flank region of rats (Ebling, 1963). An informal observation that rats scratched the flank region with the hind paw, which may stimulate the sebaceous glands, and which appeared less vigorous than routine scratching, supports this conjecture.

**Object Investigating and Marking**

The presence of a large number of low objects in an open and familiar environment stimulated object investigating and urine marking by all our rats. All of them frequently marked the object in front of the entryway while entering or exiting the chamber and commonly traveled down a line or diagonal of objects investigating and marking them.

The effects of odors from conspecifics on object marking was consistent in our two experiments. In both, leaders (odor-absent condition) and followers (odor-present condition) marked objects with urine at comparable rates. The absence of an odor condition effect on object marking is inconsistent with Brown's (1978) report that rats mark scented objects more than unscented objects when both were simultaneously available. Our finding also contradicts the results of Birke and Sadler (1984) who reported that rats marked both objects and the floor at low rates in a clean chamber and at high rates in a chamber scent marked by a conspecific. One procedural difference is that we recorded and analyzed object and floor marks separately, whereas Birke and Sadler combined the two measures in their analysis. Because the results of Experiment 2 show an effect of odor condition on floor marking that is consistent with the results of Birke and Sadler, it is possible that the presence or absence of an odor more strongly affects floor marking than object marking. This speculation is consistent with Birke's (1984) argument that the two responses are different because hormone replacement affects floor but not object marking. Another possibility is that the odor condition effect may be related to the role of experience with the testing situation because a second procedural difference is that our animals were studied in a familiar environment and theirs were tested in a novel environment. Relative novelty or familiarity is the one variable of the three that distinguish our experiments from theirs that was not manipulated in our second experiment.

Compared with previous studies (e.g., Birke, 1978; Brown, 1975; Hopp & Timberlake, 1983), we used a large number of
stimulus objects, a variable that markedly influences the frequency of urine marks to objects. In the second experiment a larger number of objects elicited more object marking than a smaller number of objects, a result that replicates Mink and Adams’s (1981) finding that two petri dishes elicited more scent marks than one petri dish.

**Locomoting and Floor Marking**

The entryway allowed rats to enter and exit the chamber throughout the session. The entryway also influenced floor marking, especially marks in the outer squares. Although almost all floor marks were in the peripheral squares, a disproportionate number appeared in the square abutting the entryway.

The number of objects influenced locomoting and floor marking. In the 12-object condition, the rats proceeded from object to object in the outer squares before returning to the burrow. The rats later entered the inner squares and explored and marked the objects. In the 2-object condition, the rats moved about the chamber much more tentatively and avoided the inner squares entirely unless they proceeded directly across them to reach the other object.

In the second experiment, a smaller number of objects elicited more floor marking than did a larger number of objects. In addition, the number of objects also affected the spatial distribution of scent marks. Objects in the inner squares attracted rats to an area they otherwise avoided when objects were absent.

**Sexual Dimorphism**

Despite the prediction of the sexual dimorphism hypothesis that females will mark less than males or not at all (Ralls, 1971; Thiessen & Rice, 1976), the expected pattern of results has not emerged for most forms of scent marking by rats. For example, in our study a larger proportion of males than females flank marked; however, support for the hypothesis must be qualified because the rate of flank marking was comparable for actively marking males and females. With one exception (Brown, 1978), studies have obtained object-marking results inconsistent with the hypothesis. Our results and those of Birke and Sadler’s (1984) first experiment demonstrated no sex differences in object marking, whereas two other studies reported more object marking by females than males (Birke & Sadler, 1984, Experiment 2; Lee et al., 1984). Supporting evidence for the hypothesis derives only from studies in which males mark conspecífics more than do females (Taylor, Bartko, & Farr, 1987; Taylor, Haller, & Bartko, 1984).

Despite a common belief that females marked infrequently until the approach of estrus (Johnson, 1973; Johnston, 1983; Thiessen & Rice, 1976), our results join those in which rats have been tested repeatedly in an environment that contains conspecific odors to show that intact females do not manifest a cyclic pattern of scent marking (Taylor, Haller, & Regan, 1982; Taylor, Regan, & Haller, 1983). Only in a single test in a novel environment do estrous females mark more than diestrous females (Birke, 1978) and do females with replacement hormones mark more than females without hormone injections (Birke, 1984). This difference even disappears in the presence of male odors during the first exposure to a novel environment (Birke & Sadler, 1984). We conclude that evidence for the temporal pattern of marking by females is limited to a novel situation.

**Summary and Application**

Flank marking and urine marking are behaviorally distinct and differentially affected by environmental variables. Our findings raise the possibility that flank, object, and floor marking perform separate biological functions. In addition, the alternative forms of scent marking may be differentially sensitive to endogenous and environmental variables other than the ones manipulated in our experiments (see also Birke, 1984). Future studies of scent marking will reveal much by combining a physiological approach with an environmental analysis in a more general ecological approach. For example, if the finding that scent marking and sexual behavior are related (Yahr, Jackson, Newman, Stephens, & Clancy, 1980) can be generalized to other species, an ecological approach to scent marking may help to identify variables for studies of sexual learning (e.g., Domjan & Hollis, 1988).

**References**


Montgomery, K. C. (1955). The relation between fear induced by


The Publications and Communications Board of the American Psychological Association announces the appointments of Larry E. Beutler, University of Arizona; Joel R. Levin, University of Wisconsin; Abraham Tesser, University of Georgia; and Norman Miller, University of Southern California, as editors of the *Journal of Consulting and Clinical Psychology*, the *Journal of Educational Psychology*, the *Attitudes and Social Cognition* section and the *Interpersonal Relations and Group Processes* section of the *Journal of Personality and Social Psychology*, respectively. As of January 1, 1990, manuscripts should be directed as follows:


- For *Educational* send manuscripts to Joel R. Levin, Department of Educational Psychology, University of Wisconsin, 1025 West Johnson Street, Madison, Wisconsin 53706.

- For *JPSP: Attitudes* send manuscripts to Abraham Tesser, Institute for Behavioral Research, University of Georgia, 548 Boyd Graduate Studies, D. W. Brooks Drive, Athens, Georgia 30602.

- For *JPSP: Interpersonal* send manuscripts to Norman Miller, Department of Psychology, Seeley G. Mudd Building, University of Southern California, University Park, Los Angeles, California 90089.