Mouse (*Mus*) burrows: Effects of age, strain, and domestication

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Burrows dug by house mice in laboratory burrow boxes were examined in two inbred strains (C57BL/6J and BALB/cJ) across five age groups and compared with burrows of wild trapped mice. Burrows of feral domestic mice were examined in an outdoor enclosure as well as in the laboratory. Results demonstrated that burrows differ between strains; highly active C57 mice tended to burrow more than did Balbs at all age ranges. Moreover, burrows became more complex with age in both strains. Differences among domestic, feral, and wild mice were minimal. Results are discussed in terms of possible genetic differences in activity and as evidence against the notions of degeneracy accompanying domestication.

Why is it that domestication, the process that changes wild animals into convenient laboratory subjects, has been generally ignored in *Mus*? One reason is that the other favorite laboratory rodent, *Rattus*, has been the focus of suspicions about dire effects of domestication. Rats, more than mice, have been criticized as the degenerate products of a domestication process that necessarily produces a decrease in the adaptivity of many behaviors (e.g., Lockard, 1968). So it is that recent work on the behavioral effects of domestication has dealt almost exclusively with rats. The thrust of that research contradicts traditional notions of degeneracy; when differences between wild and domestic rats can be shown, they have been matters of degree and not kind (Boice, 1980). There are clear indications, for example, that domestication has produced no deficits in laboratory learning abilities (Boice, 1973), in social behaviors (Boice, 1972; Price, 1980), or in the skills to resume life outdoors, including burrowing (Boice, 1977; Flannelly & Lore, 1977). For domestic rats, at least, degeneracy concerns have been quieted by replacing speculation with investigation.

The same approach can be used to encourage the more global study of domestication in mice. Claims for degeneracy in domestic mice, although not as well publicized as those for rats, have been made by prominent investigators. Kavanau (1966), for instance, described the effects of artificial selection in *Mus* as leading to "the reduction or elimination of

many wild traits, with the consequent production of a relatively 'vegetative' strain" (p. 864). The basis for Kavanau's conclusion typifies many claims of degeneracy: Although he did compare running wheel behaviors of wild and domestic *Mus*, the comparison used to label the former as "vegetative" was made between domestic *Mus* and wild *Peromyscus*! What is known of actual behavioral differences between wild and domestic *Mus* does little more than reinforce the view that wild mice are strikingly different in terms of timidity and savageness (e.g., Coburn, 1923; Smith, 1972). From that perspective, domestication effects may appear to be so well documented as to obviate further research.

One goal of the present study was to emphasize possible similarities between wild and domestic *Mus*. Instead of basing the comparison on laboratory procedures that encourage the emotional reactivity of wild mice, we chose burrowing. Burrowing, a behavior that is clearly adaptive in nature, has already been assumed to be an inevitable victim of the degeneracy accompanying domestication (Skinner, 1966) and is representatively studied in laboratory apparatus (Boice, 1977; Thiessen & Maxwell, 1979).

EXPERIMENT 1

We began with the question of whether domestic mice burrowed at all or whether this highly patterned form of behavior disappeared over the generations that laboratory mice lived in cages. Two inbred strains (C57BL/6J and BALB/cJ) were chosen because of their known differences in activity levels (Messeri, Oliverio, & Bovet, 1972; Thompson, 1953). Digging activity is clearly increased by most manipulations of general activity level in rodents, so we expected the C57 mice, if they dug burrows at all, to burrow in superior fashion to the BALB mice. Because burrowing

(as distinguished from mere digging) may be age-specific in rodents (Boice, 1977), comparisons were made across five age groups. To further maximize the likelihood of burrowing, we ran female mice only; the casual observation of rodents burrowing in natural surrounds is that females assume more of the responsibility for burrow construction than do males.

Method

Subjects. Sixty female mice (*Mus musculus*) were used, 30 of them from the BALB/cJ strain and 30 from the C57BL/6J strain. All were obtained from the Jackson laboratory.

Apparatus. Mice were tested individually for burrowing in Plexiglas boxes filled with a mixture of dirt. Each chamber (20 × 60 × 45 cm) was covered with a lid made of ¼-in. wire mesh; a cylindrical depression contained the water bottle, which was adjusted as dirt levels changed. The dirt comprised a mixture of sandy soil with peat added so that burrows would not collapse. Dirt was supplied, in firmly packed fashion, to a level of two-thirds the height of the chamber.

Procedure. Each subject was kept in a burrowing box for 7 consecutive days in a laboratory that was lighted for 12 h of each 24-h period. Water was sprinkled on the soil as needed to prevent the soil from drying to the point at which burrowing was inhibited. Daily sketches were made of the burrows as seen from the top and sides of chambers; at the end of 7 days, burrow systems were excavated and measured. Measures included dimensions, number of surface holes, number of distinct tunnel segments, length of tunnel segments, latency in days to begin a burrow, and a measure of burrow complexity (number of nest chambers, presence of a circular tunnel system, and presence of more than one level of tunnels).

Mice of both strains were divided randomly into five groups so that their testing commenced at 24, 39, 53, 67, or 90 days of age.

Results

Domestic mice do, indeed, burrow. Figure 1 shows representative burrow diagrams of young and old mice of both strains. Overall, 88% of the mice dug a burrow at least as long as their body length.

Strain differences appeared; in almost every measure, there is a clear indication of more sophisticated burrowing in the more active C57 mice. The C57 mice were more likely to burrow than were BALBs (28/30 vs. 25/30 burrowing), and, at every age level, a shorter latency to burrow was shown (2.00 vs. 2.56 days). The latter difference, shown in Figure 2, approaches statistical significance [$F(1,43) = 3.74$, $p < .06$]. Consistent with that difference, C57 mice tended to dig more surface holes than did BALBs (mean = 3.5 vs. 2.6 holes) and significantly more tunnels [6.0 vs. 3.5 tunnels; $F(1,43) = 14.23$, $p < .01$]. Similarly, mean tunnel lengths were greater for C57 than for BALB mice [15.6 vs. 12.6 cm; $F(1,43) = 3.90$, $p < .06$].

A more qualitative measure of burrowing is complexity. This is an index that discriminates remarkably well between immature and mature mice as burrowers. Figure 3 shows that difference in terms of the components used to judge complexity. The relative simplicity of burrows dug by young mice (which also may be seen in Figure 1) produced a complexity score far below those of mature mice. Of the fully mature
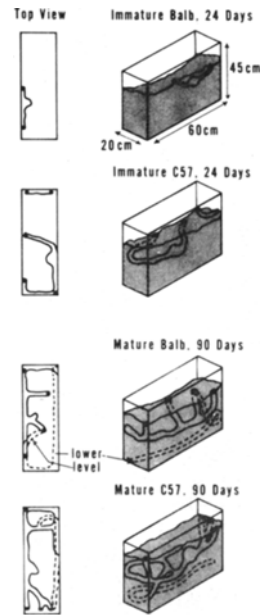

Figure 1. Drawings of representative burrow systems. The burrows of the immature mice are relatively simple; the two strains differ in number of tunnels. The burrows of the mature mice show more sophistication; a two-level system can be seen in the BALB burrow system, and the C57 system has both a circle and two levels. All burrows shown have nest chambers.
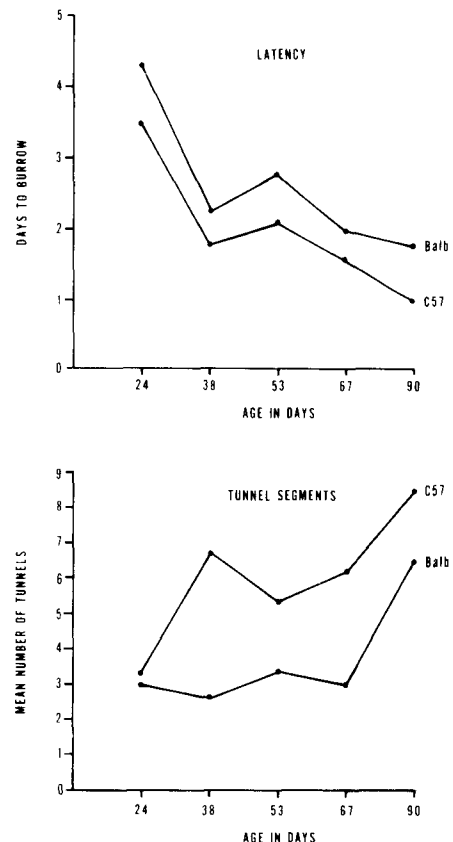

Figure 2. Top: Mean latencies for the two inbred strains of domestic mice digging a burrow. Bottom: Mean number of discrete tunnel segments for each strain.
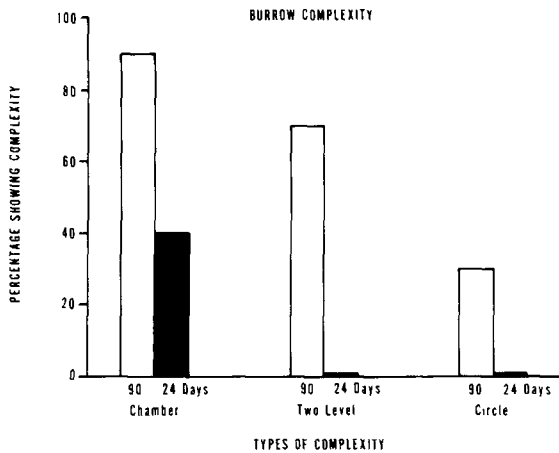
Figure 3. Percentage of mice burrows showing the following indices of complexity: nest chamber, two-level system, circular burrow system. Mice of both strains are compared at the youngest age (24 days) vs. the oldest age (90 days).

mice (age 90 days), 90% dug nest chambers, compared with 40% of the immature group (age 24 days). This difference was statistically significant [$\chi^2(1)$ = 5.4, p < .025]. Similarly, older mice dug more two-level systems [70% vs. 0%; $\chi^2(1)$ = 10.8, p < .005] and more tunnel systems in circular patterns [30% vs. 0%; $\chi^2(1)$ = 3.53, p < .07]. Combined complexity scores (one point for each chamber, for each extra level, and for each circular pattern) produced another clear indication of more sophisticated burrowing in older mice [$F(4,31)$ = 5.79, p < .01].

Measures of complexity also distinguish between strains, with the more active C57 mice exceeding the scores of BALBs on two of three dimensions (Figure 4). Despite the fact that a slightly larger percentage of BALB mice dug chambers, there was a tendency for C57s to dig more than one chamber [$\chi^2(1)$ = 3.23,
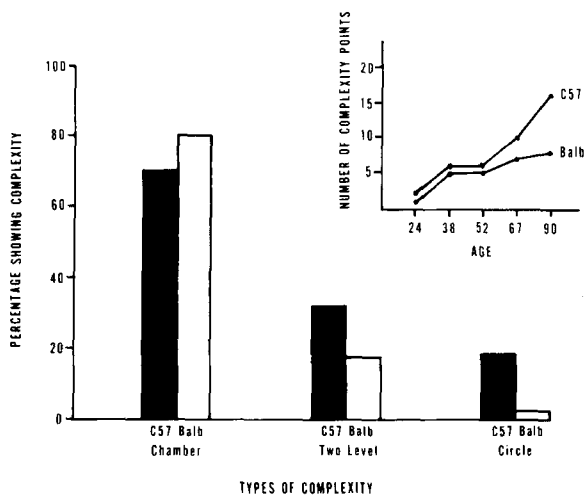

Figure 4. Percentage of burrows of differential strains showing the indices of complexity. Graph in right upper corner shows complexity scores as they changed across ages. One point was given for each chamber, for a two-level system, and for a circular tunnel system.

p < .1]. Moreover, C57 mice were more likely to dig on two levels [$\chi^2(1)$ = 3.74, p < .07] and in circular patterns [$\chi^2(1)$ = 3.49, p < .1]. Combined scores of complexity produced a significant difference between strains [mean = 1.95 for C57, mean = 1.35 for BALB; $F(1,31)$ = 4.25, p < .05]. These complexity differences may also indicate activity differences; the more dirt that was excavated, the higher the probability was of digging a complex burrow (Wolfe & Esher, 1977). There were no indications of interactions between strain and age that approached significance.

An important consideration in examining the burrows of these domestic mice, especially in view of comparisons yet to be made with wild mice, is one of stereotypy. All burrows were stereotyped in configuration. Thus, for instance, tunnel diameters were invariably between 3.0 and 3.5 cm, and nest chambers were all close to the typical size of 8 × 10 × 6 cm high. This means that differences between strains were not a matter of basic architecture but probably one of activity. Differences in burrows as a function of age were apparently more a matter of maturation; younger mice rarely built systems on more than one level or with circular paths.

EXPERIMENT 2

Given that domestic mice do burrow, the next question is how much this behavior has changed in the course of domestication. Clearly, genotype can affect burrowing; Experiment 1 showed clear differences in the burrows dug by inbred strains differing in activity level. Our expectation was that, as in research with rats, the difference between wild and domestic mice, if any, would be subtle. The most obvious prediction is an extension from Experiment 1; because wild mice are generally more active than domestic strains (Smith, 1972), we expected that they would initiate and extend burrows more readily than did their domestic counterparts.

Method

Subjects. Six wild-trapped mice (*Mus musculus*), all adults (three males and three females), were obtained from the Troy Rodent Laboratory.

Apparatus and Procedure. Neither the apparatus nor the procedure was changed from Experiment 1. Statistical comparisons were made between these six wild mice and six domestic mice chosen from the oldest age group in Experiment 1. Three domestic subjects from each strain were chosen such that the best three burrowers (one BALB and two C57s) and the worst three burrowers (two BALBs and one C57) were exluded from the analysis.

Results

Figure 5 shows that the wild and domestic mice burrowed in almost identical fashion when conventional measurements are considered. The closest approximation to a reliable difference was in number of tunnels [$F(1,10)$ = 3.34, p < .1], a dimension that may reflect the higher activity level of wild mice.
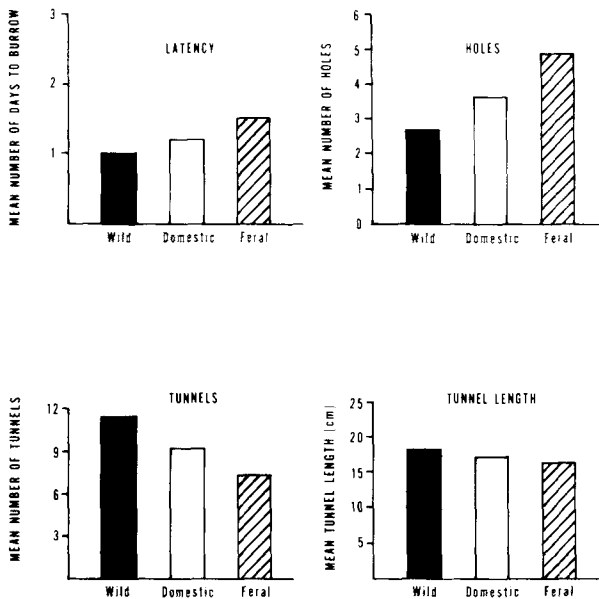
Figure 5. Comparisons among wild mice, feral mice, and a representative sample of the oldest domestic group. Each group, n = 6.

Equally important in terms of demonstrating that domestication has induced no major behavioral change was the finding that burrow dimensions and architecture were identical across groups. There were also, as expected, a few clear differences between wild and domestic mice. Wild mice dug more complex burrow systems, as measured by a complexity score [mean = 3.83 vs. 2.67; F(1,10) = 5.00, p < .05] and by circular systems [83% vs. 33%; $\chi^2(1)$ = 3.1, p < .1]. However, there was little difference in two-level burrow systems [100% vs. 83%; $\chi^2(1)$ = 1.1, p > .25].

EXPERIMENT 3

The final question addressed here concerned possible effects of laboratory artifacts in producing burrowing by domestic mice. Would domestic mice dig burrows in an outdoor enclosure, and would they do so in a fashion representative of the patterns shown in laboratory burrow boxes? In this instance, we decided to use a noninbred stock of domestic mice; our guess was that these mice would be more likely to survive the rigors of feral life than would more inbred strains.

Method

Subjects. Six Swiss-Webster mice (*Mus musculus*), five of them females, served as feral subjects. They were placed outdoors at age 40 days and were maintained there at the H. H. Donaldson field station, SUNY Albany, for 16 weeks in the fall and winter of 1979-1980.

Outdoor pen. The enclosure is described in detail elsewhere (Boice & Adams, Note 1). Briefly, it was an 8 × 12 × 7 ft high pen constructed of ¼-in. mesh hardware cloth over a wooden frame. Escape was prevented by extending the wall below and un-

der the dirt floor of the pen. Water was available continuously from a poultry watering can wrapped with heat tape.

Results

All the domestic mice began burrowing and living in burrows within the first day in the pen. Figure 6 is a diagram of a burrow system from a selected portion of the pen. This burrow was in use during the coldest part of winter. Even though it appears to be functional for group living (without litters) at low temperatures, the burrow nonetheless retains the same basic configurations (tunnel segment and nest chamber) as seen in more complex systems both in and out of the laboratory.

When those feralized mice were removed from the pen and placed in the same burrow-box paradigm used earlier, they showed only slight effects of their lengthy experience with burrows (Figure 5).

DISCUSSION

Taken together, these three experiments make two main points. First, domestication does not appear to have hampered the burrowing activities of *Mus*. Except for subtle differences in complexity, burrows of wild and domestic mice were identical. Second, burrowing by domestic mice is affected by genetic differences. Mice of the C57 BL/6 strain were more energetic burrowers in almost every regard than were mice of the BALB/c strain. The same strain difference held true over five age ranges and is ascribed to the established difference in activity levels between the two strains.

These results parallel findings in similar studies with *Rattus* (Boice, 1977), including a demonstration that laboratory mice can assume life in the wild (and Albany winters) without special preparation. While the message here is directed primarily at traditional claims of degeneracy, such as Kavanau's, we do not
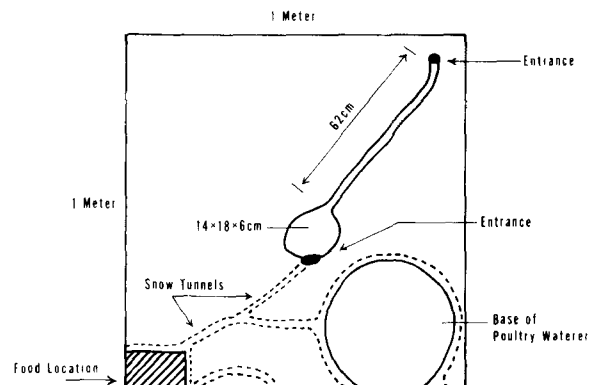

Figure 6. Sample section from outdoor mouse pen showing map of burrow system in relation to water and food location. After a snowfall of 8 in., the mice dug tunnels beneath the surface of the snow.

Figure 7. Drawings of representative burrows from the wild and feral comparison groups.

wish to imply that domestication has had no behavioral effects in *Mus*. The evidence, as with *Rattus*, is that domestication has not produced mice incapable of performing unused, but adaptive, behaviors, given the demand. Domestic mice, despite generations of laboratory ease, can resume burrowing and feral living with only minor differences apparent, relative to wild mice.

Of course, wild mice showed some subtle differences in burrowing when compared with their domestic counterparts. Domestication necessarily entails genetic changes (Ratner & Boice, 1975), including an apparent decrease in activity levels (Smith, 1972). Thus, it was not surprising that some of the differences in burrowing between the two inbred domestic strains extended to the difference between domestic and wild mice. In fact, however, wild mice excelled only in the burrowing measures of circular pathways and in a general complexity score. Moreover, there were no differences in configurational styles of burrowing between the two types of mice (Figure 7).

Why wasn't the difference between wild and domestic *Mus* greater? There is some evidence that domestication of the laboratory mouse has produced a relaxation of the expression of other activity-related behaviors (Henderson, 1978). Perhaps the most likely explanation is one that degeneracy theorists would do well to remember: Laboratory mice and rats are recent domesticants (Zeuner, 1963)—so recent, in fact, that we cannot legitimately expect great changes in most behaviors. The truth of the matter probably lies somewhere between the extremes of assuming that domestication effects are overwhelming or that they are inconsequential.

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