METHODS & DESIGNS

Outdoor enclosures for feralizing rats and mice

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Rationales for the naturalistic study of *rattus* and *mus* in outdoor enclosures are well known but rarely transformed into practice. This paper describes the materials, construction details, and operational procedures for rat and mouse pens that are easily and inexpensively built and maintained. The suggestion here is that outdoor enclosures offer meaningful views of rodent behavior not accessible in traditional laboratory situations.

Why is it that the universally accepted calls for the more naturalistic study of laboratory rodents (Lockard, 1971) have produced so few changes in practice? Part of the problem is a matter of clear precedents. Methods for setting up colonies of rats (*Rattus norvegicus*) or mice (*Mus musculus*) outside the laboratory are not immediately obvious. This paper demonstrates the ease, practicality, and benefits of establishing outdoor enclosures.

The reference literature on establishing feral colonies is scant. Early attempts at feralizing rodents were apparently unsuccessful (e.g., Donaldson, 1924), and the resulting impression was that laboratory rodents could not survive the rigors of outdoor living. Recent studies, however, indicate that laboratory varieties of rats and mice placed outdoors dig burrows and tolerate wide extremes of climate in good health (Adams & Boice, in press; Boice, 1977).

The best known study of wild rodents in a large enclosure is Calhoun's (1962) monograph on the social behavior of Norway rats. Lesser known but richly descriptive articles by Steiniger (1950) and Telle (1966) are also important in preparing researchers for the wealth of behaviors to be seen in noncaptive rodents. Most of the remaining literature is simply demographic. Davis (1953) and his colleagues (e.g., Davis, Emlen, & Stokes, 1948) provide information on the home range, reproduction rates, and the effects of manipulating amounts of haborage for Norway rats. Much the same is true for most naturalistic reports of *Mus*. There is evidence, however, that wild house mice, on occasion, aggregate into high densities (Rowe, Taylor, & Chudley, 1964), and thus the laboratory results of increased

aggression and decreased reproduction (e.g., Southwick, 1955) may be observed. It may be that the social organization of *Mus* varies somewhat with habitat conditions. Although such indications for *R. norvegicus* are mostly anecdotal or post hoc, there are signs of a renewed interest in the naturalistic study of wild Norway rats (Robitaille & Bovet, 1976).

While there has been little naturalistic work with domestic rodents, laboratory research on burrowing (Boice, 1977; Flannelly & Lore, 1977) and on scent marking (Thiessen, 1973; Thiessen & Maxwell, 1979) has provided some impetus. One unexpected result of allowing laboratory rodents to conceal themselves in burrows or artificial tunnels is a reversion to wild-like manifestations of emotional reactivity and neophobia (Boice, in press-a; Clark & Galef, 1977, 1979; Daly, 1973).

Overall, these sketchy beginnings for the naturalistic study of laboratory rodents suggest several good reasons for their acceptance. There is, in the first place, more meaningful richness in the behavior of laboratory animals placed in natural surrounds (Hess, Petrovich, & Goodwin, 1976; Miller, 1977). This sort of argument for naturalistic study is much the same as that popularized by Lockard (1971) and others (Boice, in press-b). The problem, as we have already seen, is that it has done little to change research methodology. So it is that the reasons cited in this paper, most of them hitherto underemphasized, become an important part of the rationale.

The second advantage in establishing outdoor colonies concerns economy, health, and government regulations. Paradoxical as it may seem, the move outside the laboratory is helpful on all three accounts. The construction of a pen large enough to house a typical population of rats or mice is measured in mere hundreds of dollars. Once built, an outdoor pen requires little maintenance. It needs no cleaning personnel. Feeding and watering take only a few minutes per week. Perhaps because they are not bored captives, rats and mice consume less food in an outdoor enclosure than

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they do in laboratory cages (Boice, 1977). The last but not the least of these practical considerations concerns regulatory agencies; they ignore rodents housed in outdoor pens.

Other incentives to study rodents in naturalistic settings relate to some of the most fundamental of considerations in behavioral research with rats and mice. Outdoor enclosures encourage the study of the effects of captivity, the careful training of researchers in observational skills, and the collection of demographic data relevant to our laboratory studies. In a naturalistic perspective, the need to assess the effects of decreasing confinement for the rodents or the effects of increased experience in watching the rodents is quickly apparent. So, too, there is importance in establishing facts as basic as the typical family constellation of rats and mice living naturally, contrasted to the arrangements typical in laboratories.

Most important is simplicity. Outdoor pens are not difficult to use or to build. Effective studies of laboratory rodents in an outdoor pen can be completed, if desired, within a few months. Moreover, construction of a durable and problem-free enclosure takes no more time than that required for most laboratory projects.

PEN CONSTRUCTION

Some details of outdoor pens have been published elsewhere (e.g., Boice, 1977), but without attention to construction procedures. The best of these, Calhoun's (1962) monograph, might discourage some novices. Calhoun's enclosure encompassed some 10,000 ft² (cf. the 800-ft² size recommended here). It was built by the Army Corps of Engineers, and it required a sizable crew of observers to collect the data. More than a decade had passed before the results of his 27-month study were published.

Bureaucracies

While it is true that regulatory agencies are disinterested in rodents housed in already established pens, some sort of administrative committee may resist their construction. In our case, delays came from administrators who feared that we would damage the ecology by placing our pens in the woods (away from most student traffic). Even when it was established that an endangered species of butterfly did not occupy the proposed site, administrators continued to delay construction. Given the practicalities of building the pen and establishing the colony during warm weather, it is imperative to plan for this step well in advance.

Site

Several factors in site selection seem to help ensure the ease of construction and the successful use of a pen. Location under trees provides a windbreak and shade. Large trees (and their root systems) may, however, be problematic: A trench at least 2 ft wide and 2 ft deep

must be dug at the location of the walls. Moreover, mature root systems left within the pen make the excavation of burrow systems extremely difficult.

Another consideration is topography and soil composition. Ideally, the terrain should have a moderate slope to encourage both drainage and burrowing (rats and mice generally prefer to initiate burrows into the sides of embankments). The soil should ideally be a spongy, sand-loam mixture to facilitate drainage and burrowing. Dirt that is too sandy will not support tunnel construction, and dirt that has a high clay content will not drain well. Most locations can probably be made usable with help from the university's landscaping/gardening department, which can supply soil mixtures and grading equipment.

Plans and Materials

We recommend a pen size of 20 x 40 ft for rats. This size will hold a stable population of about 50-100 rats without crowding, a typical aggregation of rats in natural settings with one somewhat limited food source (Boice, 1977). These dimensions are also nicely suited to accurate recordings by two observers.

An effective size for a mouse pen is 8 x 12 ft.

The basic materials to construct an outdoor rodent pen are listed as follows (estimates for the mouse pen appear in parentheses): 80 (40) medium-grade 2 in. x 4 in. x 8 ft studs to frame the structure; 120 (40) bd ft of 1 x 3 in. lumber to support the electric fence; 120 (40) ft of 2 ft x .5 (.25) in. mesh hardware cloth to be placed on the floor of the trench in which the walls are based; 120 (40) ft. of 4 ft x .5 (.25) in. mesh hardware cloth to form the bottom part of the fencing; 120 ft of chicken wire (1-in. mesh) to complete the upper part of the fencing in the rat pen; one standard cattle fence electrifier/shocker; one 10- (5-) gal container of creosote, if cheaper, untreated wood is used; a staple gun with .25-in staples for attaching the fencing to the framing; outdoor bulb sockets, electric cord, and 25-W red bulbs for night observations; and three (one) poultry waterers (3 gal) to supply drinking water.

More expensive hardware cloth may be substituted for the chicken wire if desired; the instance of building a mouse pen requires the use of .25-in. mesh for the walls and even across the top. A top for the rat pen is probably unnecessary, unless aerial predators prove to be a problem. In that event, a crisscrossing of fine wires across the top should be sufficient.

The fence electrifier keeps the rats or mice from climbing up the walls. The shocker is attached to bare wire, run in double strands around the wall of the pen, and attached to plastic insulators. Both of these items, the wire and the insulators, can be supplied by the farm equipment store at which the electric fence generator is obtained.

The waterers may be wrapped with thermal heating tape for use in subfreezing conditions. The tape should be covered with an epoxy shield and its lead-in wire

Figure 1. Cross-sectional view of trench, showing steps in construction procedure. Hardware cloth (.5-in. mesh) baffle is stapled to the base rail (2 x 4 in.); then the rail is laid in the trench with the rail fitting into the bottom outside corner of the trench (1). Next, upright supports (2 in. x 4 in. x 8 ft) are nailed to the base rail at 4-ft intervals (2); use of a square or plumb line will ensure that the uprights are straight when the top rail is attached (3). These rails are nailed onto the top of the upright such that every other upright will share the ends of two top rail sections. Once the wood frame is up, the 4-ft-wide strip of bottom fencing (.5 in.) may be stapled to the bottom rails and uprights (4). Next, the dirt is slowly put back into the trench, with care being taken not to bend the bottom fencing (5). With the trench completely filled, the upper fencing (chicken wire) may be stapled to the uprights and top rail to complete the fence (6). Next, a thin rail (1 x 3 in.) is nailed to the uprights around the entire pen at a height of 2 ft. The bottom edge of the chicken wire and the top edge of the hardware cloth may be stapled onto this rail so that there will be no holes due to folds in the fence (7). The plastic insulators are then nailed at 2-ft intervals to the (1 x 3 in.) perimeter rail (8). Shocker cable is strung around the pen twice, using the insulators as mounts (9).

should be hung from overhead to avoid their being chewed by the rodents.

Construction Details

Erection of the pen is probably best managed in the steps indicated in Figure 1.

If the pen is constructed on an uneven terrain, the most difficult part of construction is aligning the trench level and the wall studs so that the top plates will align; this is most easily accomplished by establishing a reference-stake system beforehand, something that any surveyor can quickly describe.

Once the wall is constructed, the trench is refilled slowly to avoid bending the fencing. It is best, then, when having the trench dug by backhoe or by hand, to place that dirt to the interior of the pen. Construction of this sort of L-shaped, buried fence (as per Calhoun, 1962) is more than sufficient to keep rats or mice from burrowing out of the pen. Both *Rattus* and *Mus* dig shallow burrows and do not persist in constructing the sort of tunnels required to escape this configuration.

METHODS OF STUDY

We began with a small group of young adult pilot animals. Baited live traps (see Boice, 1971) were placed outside the pen to determine if the pen was escape-proof and if the soil was suitable for burrowing. The effectiveness of the electric fence was also checked at this time. In the 1st day or 2, most inmates get shocked and stunned at least once, rarely more than three times. After that, the inhabitants rarely climb up to the shock wires.

We provide laboratory food pellets in a wire-open live trap (with a cover when it rains) to facilitate trapping for census purposes. Nesting material (e.g., paper shreadings) is supplied daily.

Marking for Visual Identification

Because Calhoun's (1962) monograph has long been out of print, a modified version of his numbering system is presented in Figure 2. Calhoun used this code with wild rats whose dorsal pelage was dark, and so he marked the spots with a commercial depilatory. When using light-colored rodents, especially albinos, the spots are more easily seen if a black hair dye is used. Either sort of marking, depilatory or dye, usually needs renewing every 6 weeks.

Figure 2. Marking scheme for identifying individual rats. Dyeing no more than two spots (excluding the female head spot) yields 43 possible numbers for each sex (adapted from Calhoun, 1962).

Suggestions for Observation Procedures

We find it most efficient to concentrate our observations in the 1.5 h preceding darkness. This is a time when *rattus* and *mus* are especially active. Social behavior is easily and reliably recorded in 2-min time samples taken every 15 min. An example of the sort of data sheet we use in studying *Rattus* social behaviors is presented in Figure 3.

We also suggest an occasional excavation of burrow systems for researchers interested in social organization. Figure 4 illustrates the kind of map of burrows that may be expected with a small group of rats. In warm weather, these systems can change dramatically within days. Excavation of one section of a burrow at a time will not seriously disorganize the rodents. Caution is advised, however, in instances in which an obviously pregnant rodent is seen constructing a separate burrow system.

Sample Results

The outcome of manipulations to increase the numbers of rats who are active above ground helps illustrate devices that can aid in observation. In this instance, eight Sprague-Dawley rats, four males and four

TIME SAMPLES-CHECK LIST										NAME NA.		DATE 3/20					
RATS																	
TIME	1	3	6	7	8	5.6	2	4	5	9							
5:45	X	FR	N		OP	SI	SI		D								
6:00		FR	AB	X	FR	OP	SI	OP		SI							
PERSISTENT FR. 3, 8.....										KEY:							
BURROWING 6.....										SI SOCIAL							
NEST GATHERING 6.....										INTERACTION							
										X EXPLORE							
										FR FOODRETRIEVE							
										N NEST GATHER							
										OP ON PATH							
										AB AT BURROW							
SOCIAL SNIFFING										RELIABILITY							
9 → 8										TOTAL OBSERVED ITEMS							
2 → 56										ERRORS							
5 → 9										RELIABILITY%							
NOTES.....																	
DOMINANCE ENCOUNTERS														NAME NA.		DATE 3/20	
TIME	PARTICIPANTS	WIN	LOSE	TIE	BEHAVIOR	KEY:											
5:48	9 5	9	5		S, CS	S SIDEPOST.											
6:00	9 2	2	9		CS, BI	CS CHASE											
6:09	8 7 *	8	7		J, BI	P PIN											
						BI BITE											
						B BOX											
						W WRESTLE											
						J POUNCE											
* FEMALES																	
SEXUAL ENCOUNTERS														NAME NA.		DATE 3/20	
♂	♀	UNSUCC. MOUNTS	SUCC. MOUNTS	EJAC.	TOTAL												
2	6				7, 17, 2												
5	6				19, 9, 1												

Figure 3. Portions from three data sheets used during observations. The first sheet (top half) includes boxes for listing behaviors for each individual during time samples, a checklist of behaviors (e.g., persistent food retrieval), social sniffing, including arrows indicating one-way sniffing, reciprocal sniffing, and mutual sniffing, an area for notes, and an area for tabulating reliability between observers. The second sheet (middle) shows our method for recording dominance encounters. The third sheet (bottom) shows how we tabulate sexual behavior.

Figure 4. Area of pen (11 x 11 ft) near one corner with an early burrow system. The area enclosed in bold lines shows an older portion of the system that was totally excavated. Holes coming up beneath the rock and next to the mesh barrier above ground indicated that the rats directed their burrows toward objects providing cover at the surface.

females, were placed in a pen at age 45 days. Because their outdoor stay began in November, burrowing was limited to the time before a deep frost occurred. Litters were not produced until May of the following year. In the first 6 weeks, individual rats appeared above ground during 18% to 24% (mean = 23%) of our 90-min daily observation periods. Systematic checks at other times indicated that this group was mostly subterranean in activities.

In many natural settings, food supplies are available only briefly each day. So, in order to increase surface activity, we limited food access to the 90-min observation periods for the next 6 weeks. As a result, above-ground activity increased to a mean of 37% (range = 36%-51%), a gain of 14% from the situation in which food was continuously available. The failure of a rat to appear while food was available did not mean that it went hungry. Some rats, usually females, retrieved large quantities of food to the burrows.

Observations of wild rats in natural surrounds indicate that above-ground activity increases when more cover is available. So we added six tin cans with both ends removed (attached to a piece of ballast) in which rats could sit and two barriers (L-shaped, made of a wooden frame and hardware cloth). This produced an

increase in activity (mean = 41% appearance rate) in four rats. Males increased appearance from 36% to 45% and generally spent more time exploring or grooming above ground than did females.

CLOSING COMMENTS

We have established outdoor pens in two different parts of the country, and we have described their operation to other researchers for more than 6 years. It is not difficult, therefore, to anticipate some of the remaining concerns. What of the discomforts of watching the rodents in bad weather? Because one or two observation stations are typically sufficient to make most recordings, enclosures for observers can be provided inexpensively. Appreciate, too, that most situations probably will not require more than 2 of every 15 min in actual observations; the observers can spend the interim near a space heater while they check reliabilities. There is something surprisingly pleasant about spending a 90-min period in a setting with rats that an observer has learned to recognize individually. We have had no difficulty in enlisting undergraduate volunteers to serve as observers, and they have been conscientious and enthusiastic the year round.

What of obtaining reliable observations? The rats are, first of all, easily observed and identified, even at night. (On overcast or moonless nights, the addition of four to six red lights on the top of the pen is helpful.) Even with the use of data sheets requiring the recording of more than 15 categories of social and sexual behaviors, we obtained regular reliability scores of about 88% (mean = 87.8% for 77 days) between changing pairs of undergraduate observers. Two simple devices helped ensure consistent reliability. One was the use of clear, behavioral descriptions of events like social sniffing. The other was the continuing practice of having observers compare records and agree on discrepancies after each observation period.

And, finally, what about, the suspicion that, once established, the pen will produce no interesting or meaningful results? Given our indoctrination in believing that controlled designs are requisite for worthwhile research, such apprehension is understandable (Boice, 1976). In fact, though, even casual observation of rats and mice in an outdoor pen reveals behaviors that are obviously important. Individual rats show surprising differences in personalities. Dominance hierarchies, so ephemeral in laboratory studies (e.g., Boice, 1972), are clear in these outdoor settings. To see them meaningfully, however, requires careful observation over months and even years. Dominance is displayed consistently by individuals, but its display is obvious only in stretches of days when the males (and, less occasionally, the females) are being combative. Tracing the rise and eventual fall of an individual in the dominance hierarchy

is a fascinating pursuit. Add to this the prospect of watching family constellations develop and change and the development of social classes and differences in the social skills of population members, and the outdoor pen can be seen as an exciting adjunct to our traditional laboratory procedures.

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