METHODS & DESIGNS

A glass rodent enclosure: Gerbil City

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A glass housing unit for the study of rodent burrowing behavior is described. The results of 18 months of burrowing for a family of *Meriones unguiculatus* are depicted. The system can be used to investigate relationships among the animals' behaviors, communication processes, and ecology.

The most widely studied rodents in the behavioral laboratory, the rat (*Rattus norvegicus*), mouse (*Mus musculus*), gerbil (*Meriones unguiculatus*), and hamster (*Mesocricetus auratus*) are investigated almost entirely in isolation from their normal habitat. Paradoxically, they are then required to demonstrate behaviors we believe to be part of their species-typical repertoire (Lockard, 1968). While we can gain considerable information in this fashion, and certainly control the relevant stimuli, in the end we lack certainty as to the ecological importance of the behaviors we so assiduously measure. The message is not to abandon the typical laboratory approach, of course, but to pay more attention to the normal ecology of our fossorial and semifossorial species.

To this end we have devised a large glass-enclosed, dirt-filled living area for the study of rodent behavior. The living area is described here, along with the burrow system constructed by a family of Mongolian gerbils, *Meriones unguiculatus*. The advantages of studying behavior in this context are discussed. Other seminatural observation areas have been described for the Norway rat (Boice, 1977; Flannelly & Lore, 1977) and the Mongolian gerbil (Agren, 1976; Roper & Polioudakis, 1977).

LIVING AREA: GERBIL CITY

The living enclosure is constructed from double-pane window glass in the shape of a square-cornered horseshoe. It rests on a sheet-metal floor and is open at the top. The glass panes are rigidly joined with aluminum struts. The exact dimensions are seen in Figure 1. Its size requires a room approximately 3.7 x 5.5 m, allowing the investigator to view the burrows from all sides and from within the central opening of the horseshoe. Sandy loam fills the area to the depth of 60 cm.

This work was sponsored by NIMH Grant MH 14076-13, awarded to Del D. Thiessen. Our thanks to Capital Glass Company of Austin for a particularly fine job of construction. Our thanks, too, to the gerbils who provided us with so much information and hours of entertainment.

BURROW SYSTEM

The nature of the gerbil burrow system was observed following the introduction of four pairs of adults. All were socially naive and had been living for several weeks in isolated cages. Ad-lib water was provided in a pie plate at one corner of the area, and fist-sized rocks and small logs were placed over the surface. Purina Lab Chow pellets were tossed into the area several times a week.

Within 1 week of the introduction of the gerbils, a dominant male and female pair emerged. The dominant pair dug tunnels, hoarded food, and prevented the remaining gerbils from establishing burrows. Within 3 weeks, the subordinate animals were killed by attacks or starved to death. The dominant pair eventually gave birth to two litters of four pups each. A description of the behaviors is found in Thiessen and Yahr (1977).

After 18 months, six remaining gerbils, including the original pair, were removed. The tunnels were filled with plaster of paris. The liquidity of the plaster of paris necessary to fill the tunnels and still harden was determined empirically. The approximate ratio of water to plaster by weight was .65. After the filler had hardened for a minimum of 72 h, the burrow system was excavated with garden trowels. The tunnels and underground rooms were videotaped and subsequently mapped on coordinate paper. From this, a 1/10 scale model was constructed from pipe cleaners, clay, and Plexiglas. It, in turn, was photographed from several angles.

NATURE OF THE BURROWS

Photographs of the resultant model are seen in Figure 2. The complexity of the system is striking. In general, there are two major levels of tunnels: one near the surface and one running along the floor. Approximately 20 burrow entrances or exits were found, each at the base of a rock or a log or against the glass side. The major tunnels could be seen through the glass. With the exception of a partially collapsed and abandoned tunnel, all tunnels were interconnected. The average tunnel

Figure 1. Dimensions of glass panes for Gerbil City.

Figure 2. One-tenth scale model of Gerbil City, showing burrow system from three angles.

length was 40 cm, and the longest was 130 cm. In general, the physical structure of the tunnels resembles that reported for the Mongolian gerbil in its natural environment (see Gulatta, 1971, for a review). No portion of the burrow system was further than 150 cm from an entrance, and approximately 80% of the tunnels were within 150 cm of a nest area.

Two nest areas were found, one at an intermediate level and the other at the floor of the apparatus. A food storage area was found between the two nests at the bottom of the enclosure. Two latrines, one in each arm of the U, were at the floor. Two other large den areas were found, but since they contained neither nest material nor feces, their function remains a mystery. Carcasses of three gerbils were found, two in latrines and one walled off with boli.

DISCUSSION

Burrowing is critical for survival in many rodent species (Baudinette, 1974; Chapman & Bennett, 1975;

Daly & Daly, 1975; Kenagy, 1976; Lore & Flannelly, 1978; B. Schmidt-Nielsen & K. Schmidt-Nielsen, 1950; K. Schmidt-Nielsen, 1964; Solberg, 1975; Vogel, 1978; Von Frisch, 1974). Burrows are used as an adjunct to homeostatic mechanisms to stabilize temperature, humidity, and oxygen levels. They are also used for food storage, protection against predators, nesting sites, and possibly mating. In other words, burrows provide the architectural supports for individual survival and reproduction.

It seems obvious that if we are to understand the most crucial and subtle features of behaviors in fossorial and semifossorial species, the animals must be studied under natural conditions. While this is not always possible, it can be approached under the conditions described here. The glass enclosure allows a glimpse of a wide array of species-typical behaviors and still provides for considerable experimental manipulation. We have extended our control by restructuring the enclosure in a temperature-, humidity-, and light-regulated room. We can now simulate circadian and circannual variations in meteorological

conditions. Among the problems to be studied are (1) the rapidity with which burrows are formed, as well as their depth, under different temperature conditions, (2) burrow defense and kinship cooperation, and (3) the nature of subterranean communication.

Some particular features of the gerbils' burrow system are notable. Their underground environment is functionally compartmentalized, suggesting differential activities and perhaps cooperation. Certainly, cooperation is apparent in the defense activities of the dominant pair, and digging often requires moving the dirt in tandem. The rapidity with which animals move through the complex burrow system suggests a comparably complex cognitive neural map. Parenthetically, the tunnels were found to have heavily graveled bottoms, as if there had been concerted effort to pave the tunnels. Of course, gravity could cause this assortment during the movement of dirt. Nevertheless, the paving effect could aid in traction, maximize water drainage, and even act as a substrate for scent-gland marking or the reflection of ultrasounds. Tunnel marking certainly does occur, as evidenced by the oil smears seen on the glass walls of the burrows. Of great interest to us is the relative uniformity of tunnel length between intersections. Perhaps optimal communication distances for olfaction or ultrasounds correspond to these distances. These and other questions can be addressed in this highly visual display of architectural communication.

Finally, it should be noted that the behavioral repertoire seen in Gerbil City is identical in form to that seen under restricted laboratory conditions and in a large, outdoor seminatural environment (Randall & Thiessen, Note 1). The advantages of Gerbil City are that the full expression of all behaviors can be seen, but experimental control over the environment is still possible. Investigations of wild and domesticated *Rattus norvegicus* in artificial burrowing areas also suggest that the observed behaviors are distinctly species-typical (Boice, 1977; Flannelly & Lore, 1977).

REFERENCE NOTE

1. Thiessen, D. D., & Randall, J. A. *Seasonal activity and thermoregulation in Meriones unguiculatus: A gerbil's choice*. Manuscript in preparation, 1979.

REFERENCES

- AGREN, G. Social and territorial behaviour in the Mongolian gerbil (*Meriones unguiculatus*) under seminatural conditions. *Biology of Behaviour*, 1976, **1**, 267-285.
- BAUDINETTE, R. V. Physiological correlates of burrow gas conditions in the California ground squirrel. *Comparative Biochemistry and Physiology*, 1974, **48A**, 733-743.
- BOICE, R. Burrows of wild and albino rats: Effects of domestication, outdoor raising, age, experience, and maternal state. *Journal of Comparative and Physiological Psychology*, 1977, **91**, 649-661.
- CHAPMAN, R. C., & BENNETT, A. F. Physiological correlates of burrowing in rodents. *Comparative Biochemistry and Physiology*, 1975, **51A**, 599-603.
- DALY, M., & DALY, S. Socio-ecology of Saharan gerbils, especially *Meriones libycus*. *Mammalia*, 1975, **29**, 289-311.
- FLANNELLY, K., & LORE, R. Observations of the subterranean activity of domesticated and wild rats (*Rattus norvegicus*): A descriptive study. *Psychological Record*, 1977, **27**, 315-329.
- GULATTA, E. F. *Meriones unguiculatus*. *Mammalian Species*, 1971, **3**, 1-5.
- KENAGY, G. J. The periodicity of daily activity and its seasonal changes in free-ranging and captive kangaroo rats. *Oecologia*, 1976, **24**, 105-140.
- LOCKARD, R. B. The albino rat: A defensible choice or a bad habit? *American Psychologist*, 1968, **23**, 734-742.
- LORE, R., & FLANNELLY, K. Habitat selection and burrow construction by wild *Rattus norvegicus* in a landfill. *Journal of Comparative and Physiological Psychology*, 1978, **92**, 888-896.
- ROPER, T. J., & POLIOUDAKIS, E. The behaviour of Mongolian gerbils in a semi-natural environment, with special reference to ventral marking, dominance and sociability. *Behaviour*, 1977, **61**, 207-237.
- SCHMIDT-NIELSEN, B., & SCHMIDT-NIELSEN, K. Evaporative water loss in desert rodents in their natural habitat. *Ecology*, 1950, **31**, 75-85.
- SCHMIDT-NIELSEN, K. Terrestrial animals in dry heat: Desert rodents. In J. Field (Ed.), *Handbook of physiology*, Baltimore: Williams & Wilkins, 1964.
- SOLBERG, V. B. Tunneling, digging, and nest building behavior of the Mongolian gerbil, *Meriones unguiculatus*. *New Jersey Academy of Science*, 1975, **18**, 1-9.
- THIESSEN, D. D., & YAHR, H. *The gerbil in behavioral investigation*. Austin, Tex: University of Texas Press, 1977.
- VOGEL, S. Organisms that capture currents. Sponges and prairie dogs, among others, harness water currents and wind for their own purposes. *Scientific American*, 1978, **239**, 128-135.
- VON FRISCH, K. *Animal architecture*. New York: Harcourt Brace Jovanovich, 1974.

(Received for publication January 5, 1979;
revision accepted October 15, 1979.)