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Capture, care, and captive breeding of 13-lined ground squirrels, *Spermophilus tridecemlineatus*

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Researchers use the 13-lined ground squirrel for studies of hibernation biochemistry and physiology, as well as for modeling a variety of potential biomedical applications of hibernation physiology. It is currently necessary to capture research specimens from the wild; this presents a host of unknown variables, not least of which is the stress of captivity. Moreover, many investigators are unfamiliar with the husbandry of this species. The authors describe practical methods for their capture, year-round care (including hibernation), captive mating, and rearing of the young. These practices will allow the researcher to better standardize his or her population of research animals, optimizing the use of this interesting model organism.

Formerly known as *Sciurus tridecemlineatus* and *Citellus tridecemlineatus*, the 13-lined ground squirrel, *Spermophilus tridecemlineatus* (Mitchell 1821; NCBI taxon id 43179), is a long-standing model species for studies of hibernation biochemistry and physiology¹⁻⁴. It is an emerging model for studies of potential biomedical applications of hibernation physiology⁵, in diverse fields that include organ transplantation, cardiology, and neurology⁶⁻⁸. In June 2005 the National Human Genome Research Institute announced plans to sequence its genome as part of a mega-analysis of mammalian genome evolution, increasing the 13-liner's usefulness for all forms of research.

Thirteen-liners are obligate hibernators^{9,10}. In Wisconsin they typically enter hibernation in October and emerge from it in April^{11,12}. Biologists believe that spring temperature is the main Zeitgeber for setting the timing of emergence¹³. It seems that males emerge first and experience a burst of testosterone, apparently to permit sufficient regeneration of their regressed gonads tsk. Long ago researchers suggested that 13-liners are reflex ovulators¹⁴, but evidence is lacking¹⁵.

Ground squirrels spend the late spring and summer months eating a varied diet of plant material, including the seeds for which they are named (*spermo*-, seed; *phi*-

lus-, lover). They also eat a surprising variety of animal tissue, including insects, birds, bird eggs, reptiles, and small mammals. Indeed, one Wisconsin study identified the 13-liner as second only to raccoons as the major predator of nestling grassland birds¹⁶. Metabolic changes induce a spurt of rapid weight gain in the fall, such that fat stores accumulate before their descent into underground chambers that branch off the main burrow and are used solely for the several months of hibernation^{12,17}.

During hibernation the animal assumes the fetal position in a nest of shredded plant material, and its body temperature falls to ambient levels, often near freezing. The heart rate declines from 300 b.p.m. to 5–10 b.p.m., with a concomitant decrease in ventilation rate and activity. During periodic interbout arousals, when shivering thermogenesis returns body temperature to normal, 13-liners do not eat even when food is provided⁹; indeed, there is a marked degeneration of the digestive tract, reflecting its long inactivity⁵. In this way, energy expenditure is at a minimum to cope with months of starvation.

During interbout arousals ground squirrels enter non-REM sleep¹⁸ for ~24 h and then cycle back into torpor. The interval between interbout arousals lengthens to about 2 weeks as the winter progresses.

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We currently do not know the purpose of these interbout arousals.

In the United States at this time it is necessary to capture all 13-liners destined for research purposes from the wild during the spring and summer months, typically from open grassy areas such as golf courses, pastures, lawns and cemeteries (*e.g.*, refs. 10, 12). Reliance on wild-caught specimens presents a host of unwanted variables for the researcher, not least of which are the stress of captivity and postcapture mortality. The alternative is thus the development of a captive breeding program.

The literature on the captive breeding of 13-liners has a history of 75 years. Animal use problems included low conception rates (*e.g.*, only six copulations during several years with hundreds of animals^{19,20}), complex artificial habitats impractical for today's research environments, and maternal cannibalism^{21–23}.

The most recent work on captive breeding¹⁵ reports that, upon removal of 13-liners from winter torpor in a cold room, researchers placed one male and two females together in a Masonite mating enclosure containing two nest boxes. After sperm were found in vaginal lavages, the investigators separated the males and females and returned them to their individual plastic cages. All females, whether signs of mating were visible or not, became pregnant and produced young. After remaining with their dams for 37–38 d the young moved into individual cages. Since that report¹⁵, to our knowledge, no one has attempted a systematic captive breeding program for research specimens.

To provide animals for our vision research program, we sought to establish a population of purpose-bred 13-liners that are accustomed to captivity and that have a known age, relatedness, nutritional history, and health status. To that end we began efforts to establish a breeding colony in 2003, using simple equipment typically found in a modern laboratory animal facility adapted from the methods of Landau and Holmes¹⁵. Our first 2 years of experimentation with husbandry practices had mixed results, hampered by low conception rates and maternal cannibalism. Here we detail the simple procedures that, in spring 2005, yielded a high conception rate and no maternal cannibalism. It also documents the practices we use to care for this species during the entire year of its life history.

CAPTURE, PARASITE LOAD, AND MORTALITY

Before capture, we obtained a Scientific Collector's permit from our state Department of Natural Resources and approval from the Institutional Animal Care and Use Committee; moreover, all personnel had animal care certification. Thirteen-liners have a range that covers most of central North America, where they prefer short-grass habitats. We captured our specimens, with permission, from several cemeteries in the vicinity of Oshkosh, Wisconsin (latitude 44°, altitude 229 m) in the

summers of 2002, 2004 and 2005. We predicated capture on observable surface activity, which in Wisconsin is reportedly maximized when the ambient temperature is between 30° C (86 ° F) and 40° C (104 ° F) (ref. 24) [**AU: ref. 24 here. okay?**] when it is sunny¹².

Capture equipment included nets, heavy leather gloves, empty plastic bin cages with wire tops (no bedding), medium-sized plastic garbage cans (for toting tap water) and a dolly or cart (for carrying the cans of water). The type of net is important for the capture of this species. We have obtained years of satisfactory service in the field and in the animal facility from a 12-inch-diameter, soft fabric entomology net with a 32-inch wooden handle (Entoproducts, Kewaunee, WI).

Spotters stationed themselves in the cemetery habitat. When a 13-liner was observed, the spotter walked slowly toward it until it disappeared down a burrow. Then the spotter placed the net over the burrow entrance and poured tap water steadily into the burrow until the animal exited, running directly into the net. Occasionally the burrow capacity exceeded the volume of water applied, and no animal was forthcoming. Rarely the animal exited a different burrow a short distance away.

Capture excursions during mid- to late May yielded mostly pregnant females along with a few adult males, whereas excursions in June yielded only lactating females that were immediately released. Excursions in mid-July and thereafter yielded weanling young of the year, with an occasional adult female. Weanlings are reportedly less vigilant than adults as a result of their greater nutritional needs²⁵ and thus probably became visible to the spotters more often.

It is possible to explain this capture pattern by hibernation emergence patterns in the wild, whereby the first animals to enter torpor are adult males, followed by adult females who did not wean a litter, then adult females who did wean a litter, and finally weanlings¹². The explanation for this emergence schedule lies in the relative reproductive and growth costs that must be met before sufficient fat is stored to support hibernation. Because of time constraints we never trapped beyond the end of August, but a commercial trapper (TLS Research, Bartlett, IL) provides animals in August and September. We always quarantined newly caught wild animals for at least 1 week before moving them into the main colony.

Upon arrival in the facility, technicians examined 13 randomly selected captive-born and 5 wild-caught squirrels for ecto- and endoparasites by combing and close observation. [**AU: edit okay in previous sentence?**] Technicians then made Giemsa-stained smears from peripheral blood obtained by toenail clip for detection of hemoparasites. They also qualitatively studied fecal samples by microscopic examination of direct preparations in phosphate-buffered saline (PBS, pH 7.2) and by trichrome staining (ENG Scientific, Clifton, NJ). When

TABLE 1. Record of 2003–2005 captive breeding efforts

Calendar year	No. wild caught	Post-capture mortality	Breeding pairs	No. litter/pups born	% fecundity ^a	% weaned
2002	27	4	0	N/A	N/A	N/A
2003	0	N/A	9	1/7	11	100
2004	12	1	9	3/19	33	0
2005 ^b	14	1	4	3/21	75	100

^aBreeding success reflects pairs producing an observed litter (cannibalized litters may have been missed).

^bOnly six animals were overwintered during 2004–2005, so there were only four breeding pairs in 2005, yet three of the four pairs produced pups, all of which were weaned. 2005 was the first year that breeding pairs were fed a cat food–based diet. All successful captive-breeding parents thus far have been captures in the wild as young of the year and overwintered once or twice in captivity before reproducing.

coccidia were detected in direct preparations, technicians incubated feces in 2.5% K₂Cr₂O₇ to induce sporulation and then re-examined the material by light microscopy for genus determination. Dissection of intestines of freshly euthanized wild-caught animals permitted direct examination; technicians also examined mucosal scrapes made after incubation of the material at room temperature in PBS overnight.

There was no evidence of fleas or ticks in the wild-caught (or captive) animals examined, although ground squirrels can act as hosts for many different ectoparasites²⁶. Of the wild-caught squirrels examined upon capture, one presented with intestinal amebas (*Entamoeba* spp.)²⁷ and trichomonad (order Trichomonadida) and retortamonad (*Chilomastix mesnili*) flagellates, one with an adult tapeworm (family Hymenolepididae) and coccidia (*Eimeria* spp.²⁶), one with *C. mesnili* and an unidentified larval nematode, one solely with trichomonads and the last apparently devoid of intestinal parasites.

Infection by tapeworms in the wild-caught squirrel was most likely the result of ingestion of fleas during grooming or of predation on other arthropod hosts. We observed no nematode, trematode or cestode ova in the feces of laboratory-raised ground squirrels (*i.e.* the offspring of wild-caught parents never treated for parasites), suggesting that regular bedding changes curtail transmission of many intestinal parasites from mother to young. Oocysts of *Eimeria* spp. were evident in the feces of one laboratory-raised squirrel.

It seems that the use of good management practices minimizes parasite transmission between animals housed in group caging situations. If desired, a single treatment for most internal and external parasites is oral ivermectin such as Ivomec 1% Injection (Merial Ltd., Duluth, GA). One mixes this preparation as 1 part to 199 parts vegetable oil, to a final concentration of 0.05 mg/ml. One can administer the final oral dose of 0.02 mg/kg body mass using a needle-less 1-ml plastic syringe or micropipettor. For example, a 100-g ground squirrel would receive 0.04 ml (40 μ L) of the 0.05-mg/ml ivermectin-oil mixture.

Additionally, metronidazole can treat intestinal flagellates and amebas (Flagyl, Searle; 20 mg/kg once daily

by mouth) [[Author: edit to dosage instructions okay?](#)]; praziquantel treats cestodes (Droncit, Bayer; 25 mg/kg orally or subcutaneously, repeat in 10 d) [[Author: edit to dosage instructions okay?](#)], and coccidiostats such as amprolium prevent coccidia transmission (Corid, Merial, 0.012–0.025% in drinking water). Preparations suitable for cats are necessary, because ground squirrels also lick themselves to remain clean. Note that these measures, in combination with the low exercise levels produced from caging, may result in higher body weights for laboratory-reared animals than for wild type.

From 2002 to 2005 we have had ~11% mortality in newly caught wild animals (**Table 1**). Shortly after capture one animal exhibited bleeding from the mouth and underwent euthanasia; necropsy revealed only gastric bleeding, suggesting the animal had ingested rodenticide before its capture and would have died in any case. One animal sustained a leg injury (apparently self-inflicted because it was housed alone) and thus underwent euthanasia. One failed to thrive and died before it entered hibernation. Two manifested symptoms of a vestibular disorder (running in tight circles with the head held to the side) and underwent euthanasia. Because the two affected animals were each the sole case of the disorder in two different capture years, this disorder must not be very contagious.

In only two circumstances have we experienced mortality of the animals during hibernation. Two wild animals captured as weanlings, fed the rodent chow diet (as recommended in the literature) and housed alone during hibernation, died during hibernation. Three captive-born weanling animals housed before and during hibernation with same-sex littermates sustained injuries from the littermate during hibernation. We do not know if these were the cause of death or occurred after death. Since we adopted a higher protein diet (see below) and now house hibernating animals strictly alone, we have not lost any animals during hibernation.

CAGING AND HYGIENE

Experts consider *S. tridecemlineatus* to be an asocial species²⁸. Females defend a home burrow through



FIGURE 1 | Illustration of ground squirrel handling with heavy leather gloves. Animals may bite or give alarm calls when handled in this fashion.

intrasexual aggression that increases with population density²⁹; nonetheless investigators have not considered this practice as a high degree of aggression among sciurids^{30,31}.

Except during the breeding season (April through June or July), we maintained adult 13-liners individually in standard, clear plastic rat bins, 43 × 21 × 20 cm, with wire tops. We have also found it possible to house weaned littermates in pairs in the same size cages during their summer and fall. We used wood shavings as bedding and provided a ~8-inch length of plastic rain gutter tubing (per animal) as a burrow. The rain gutter is easy to sanitize and has proven invaluable for transporting animals between cages; they readily enter it with little encouragement and have never tried to bite when bare hands are placed over each end for carrying. Chewing of the rain gutter burrows has not been a problem.

Animals of all age received water by a standard bottle with a metal sipper tube. Adults received chow in a depression built into the wire cage top, while juveniles received it in a shallow hard plastic dish. We placed supplementary foods (greens and seeds) in the bedding to simulate natural foraging.

Because 13-liners generally eliminated in one corner of the cage, spot cleaning was feasible when changing to a completely clean cage was impractical. More frequent cleaning was necessary when two or more animals were caged together or whenever a water bottle discharged its contents. As a precaution against stress, we suspended cage cleaning for the first week that a female had a litter did spot cleaning during the second week and resumed regular cleaning by the third week, during which we

lifted intact the entire nest of infants and transferred them to the clean bin.

DIET

According to most of the literature, commercial rat chow is the base diet for 13-liners. However, in our experience, 13-liners do not readily eat rat chow. Moreover, the natural 13-liner diet contains significant animal prey (e.g., ref. 32). Thus after our first year of keeping them we fed our 13-liners a base diet of commercial dog chow (IAMS Chunks) or cat chow (Purina Indoor Formula), containing 26% or 30% protein, respectively. This compares with only 23% protein in commercial rat chow. Perhaps significantly, we noticed improved growth and ceased to observe both maternal cannibalism in the breeding colony and death during hibernation after we switched to higher protein chow. Sunflower seeds and greens (carrots and celery) supplemented the chow diet.

Thirteen-liners cache food for a day or two during summer arousal, both in the artificial laboratory situation³³ and in the wild³⁴, but do not cache food for consumption during hibernation¹². It was important for our research purposes to approximate the wild condition during hibernation. Therefore, during the months of hibernation we withheld water and food, as has long been standard procedure in laboratories where wild-caught animals are overwintered for research purposes.

PHOTOPERIOD

We maintained aroused squirrels in rooms equipped with standard overhead fluorescent lighting controlled by a programmable timer. Adjustment of the photoperiod every 2 weeks simulated the actual sunrise and sunset in the county of capture. The hibernaculum remained dark except for brief periods of routine animal inspection.

RESTRAINT

We could pick up torpid animals curled in the characteristic fetal position without gloves. Cold to the touch, their extremities were bright pink showing normal oxygenation.

Aroused animals are more difficult to handle. “Scruffing” this agile animal is not easy to do, meaning that picking them up involves grasping them around their bodies (Fig. 1). Once weaned, they usually respond to handling by biting hard, necessitating that handlers wear heavy leather gloves. Because 13-liners are capable of tail autotomy, handlers must always be careful not to accidentally grasp an animal by its tail. By far the easiest way to pick up a 13-liner is in its plastic rain gutter burrow.

FALL AND WINTER CARE

Joy³⁵ has reported that wild-caught 13-liners from two different latitudes (Texas vs. Michigan) retain the circannual cycle of their capture site (i.e., the southern animals enter hibernation later, and emerge earlier, than



FIGURE 2 | Mating enclosure conveniently constructed from a child's plastic sandbox. Water bottle sipper tubes project through wire mesh that replaces some of the original plastic lid. Wooden nest box is barely visible resting on top of the bedding.

their northern conspecifics). She concluded that some sort of “program” influences regional wild populations. We do not yet know if the circannual cycles of captive-bred animals will be subject to their Wisconsin origins but will examine this in future years.

In captivity, by mid-October and sometimes as early as mid-August, most of our 13-liners had already begun to cycle in and out of torpor, with body temperatures dropping to match ambient ($\sim 70^\circ\text{F}$). It was not unusual to observe a 13-liner staggering about as if ill, only to find that it was cool to the touch and thus either entering or exiting a bout of torpor. Probably because of the *ad libitum* food supply during the preceding months of arousal, we saw little difference in the immergence timing of the various sexes and ages among captive 13-liners.

In mid-September we added brown paper towels to the bedding, which the animals shredded to make large hibernation nests. During cage cleaning technicians did not discard these nests but transferred them en masse to the clean cage. We also noted a marked reduction in consumption of food and production of feces and urine, evidence that significant periods of torpor had begun.

When animals had passed through observed torpor at least twice, technicians moved them into in a $38 \pm 3^\circ\text{F}$ hibernaculum and, by late October, all animals were there. Even aroused 13-liners that had not previously exhibited torpor promptly immersed into hibernation. The hibernaculum remained dark except during brief daily periods of inspection. If any newly installed 13-liner emerged from hibernation and remained aroused for more than 48 h, we returned it to the warm room and reinstated food and water for another week or two before another attempt at immergence; however, this rarely occurred. Most animals remained in hibernation until early April, but in

2003 one male emerged in late January and remained aroused until the following October.

SPRING CARE AND BREEDING

Researchers have published a variety of practices with respect to the timing of vernal emergence in captive populations. In some cases, on a chosen date technicians remove all animals from the hibernaculum into the warm, lit room. *Ad libitum* feeding and watering always begins immediately for any animal removed from the hibernaculum. In other cases, whenever an animal exhibits arousal lasting more than 48 h, technicians remove all males from the hibernaculum and return them to individual cages at normal room temperature. For convenience, we have elected the latter method for captive breeding purposes. Males spend 2 weeks in the warm, lit environment before the introduction of any females, during which time their regressed testicles regenerate, enlarge, and acquire the black pigmentation indicative of breeding readiness.

Despite little sign of spring arousal, we moved females to the warm, lit environment 2 weeks after the males were moved there, and feeding and watering were reinstated. Forty-eight hours later, we placed mixed genders in each mating enclosure.

The term for the natural mating system of 13-liners is “scramble competition polygyny”³⁶. Several males may copulate with each female in the wild³⁷, but sperm competition produces a first-male advantage³⁸. Male 13-liners reportedly engage in conflicts when competing for estrous females in the spring, although they are not the most aggressive ground squirrel species in this regard³⁹ and the conflicts seem to be limited to chasing³⁷. There is little evidence for territoriality in wild female 13-liners^{30,31}.

In our hands, one male was able to impregnate as many as three females; we have not yet tried higher ratios. Wild males reportedly abandon females after a copulation time threshold of 9 min has been reached⁴⁰, and females may become unreceptive as few as 3 h after copulation³⁷. We never observed copulation first-hand, although it reportedly occurs above ground in the wild³⁷.

For mating enclosures we purchased large plastic children's sandboxes with internal dimensions of $\sim 90 \times 65 \times 35$ cm from a local discount department store. We selected this enclosure design because of the ease of handling, storage and sanitization. Holes cut in the plastic lid and sealed with wire mesh permitted suspension of the water bottles (Fig. 2). Bedding consisted of wood shavings and paper towels. Technicians changed the bedding twice per week; they did not discard any nest that had been built but carefully moved it to the clean bedding.

Our mating enclosures initially included artificial burrows constructed from plywood¹⁵. However, after one season we discontinued their use because we found



FIGURE 3 | Ventral view of nursing dam late in lactation. Note the heavy gloves. Protrusion from anus is a normal stress response that displays pale anal glands.



FIGURE 4 | Captive-bred 13-liners aged 4 d. Note the shredded material used for the cup-shaped nest.

that: (1) wood is difficult to sanitize, (2) the adults never made nests inside them, (3) they were used only for hiding, (4) pregnant females became stuck in the openings, and (5) pups were never placed in them. Instead, the 13-liners always located their litters out in the open, in cup-shaped nests fashioned from shredded paper towels. It seems, therefore, that it is necessary only to provide the adults with a hiding place (*i.e.*, more of the same plastic rain gutters described above for standard caging).

A previous paper describing captive breeding of 13-liners¹⁵ showed that a 22-d delay (after spring emergence) in placing males with females prevents conception, apparently by suppression of behavioral estrus. We have obtained healthy first litters from captive females that (based on a consensus gestation period of 28 d) were impregnated within a week of first exposure to a male, as is proposed to occur in the wild, or that were impregnated as much as 30 d later. In this case of delayed impregnation, exposure to the male had been continuous. To maximize conception, therefore, we recommend that males and females remain together in the mating enclosures all summer, until a female produces a litter or until the male's testicles have regressed out of breeding condition.

In this extended male-female exposure scenario in the mating enclosures, we routinely observed adult animals lying together in a relaxed fashion or sharing a burrow when disturbed by routine animal care. There was no evidence of fighting or injury despite group caging. When litters remained until weaning in the mating enclosure, there was no infant cannibalism by the sire, by the dam, or by any additional female in the enclosure for mating to the same sire.

In males whose entire "harem" had borne a litter earlier that spring, we observed regression of the testicles before July 1. In males whose "harem" included at least one nulliparous female we observed retention of fully

developed, pigmented testes past this date.

All successful breeders (male and female; **Table 1**) were either animals caught the previous year as young of the year or were animals born in captivity (to captive or wild dams) the previous year. In both instances the successful breeders had grown to adulthood in captivity and were thus accustomed to it. In our facility, litter size has ranged from 6 to 12, in accordance with published values from the wild.

CARE OF THE YOUNG

Apparently it is only the female 13-liners that care for the young³⁷. In wild populations living at high latitude and elevation, males enter hibernation so early in the summer that they may miss any opportunity to care for (or interfere with) the young. We have kept sires in the same breeding cage with lactating dams and their young, and have observed no problems.

In one instance, two females in the same mating enclosure bore their litters within the same 24-h period and combined the two litters into one group of 14 neonates in the same nest. Although all were successfully reared, we do not know if a single female was responsible for nursing them, because we decided not to cause them stress by inspecting the teats of both females. Nothing in the literature suggests this as a normal occurrence. These co-mothers had been captured as young of the year in the same cemetery the previous year and may have been sisters.

Enlargement of the teats, rather than engorged mammae, were the identifiers of nursing dams (**Fig. 3**). Nursing dams consumed nearly a bottle of drinking water each day during peak lactation. It was vital that animal caretakers monitor the availability of water during this time. Providing moist foods in the form of greens was also beneficial.



FIGURE 5 | Captive-bred 13-liners. Left, age 15 d; eyes are still closed. Right, age 26 d; eyes are open. These will be ready for weaning in a few days.

Neonates (Fig. 4) are very mobile. We commonly observed a week-old “pinkie” crawling several inches from the nest. Apparently an adult returned each wandering infant to the nest, because we experienced no infant mortality in 2005.

From the age of ~14 d on it was important to offer cat chow in a shallow dish so that juvenile 13-liners could reach it. This eases their transition to the adult diet, which is complete at the age of ~30 d. We continued this easy-access feeding practice for at least 4 weeks after weaning or until the animals were of sufficient size to reach the overhead food compartment in the wire cage top.

We observed eye opening at 20–25 d after birth (Fig. 5). Even before eye opening juvenile 13-liners were extremely vocal, sounding the characteristic whistling alarm call far more often than the adults did. Weanlings are far more skittish than adults unless they are handled daily from the age of about 14 d on, but this is a temporary phase. Females are more skittish than males, at all ages.

It is necessary to weigh the handling of pups from an early age to reduce skittish behaviors against causing stress to the dam and possibly triggering cannibalism. According to our experience maternal cannibalism occurs within the first 4 d after birth, so we recommend waiting until the pups are a week old to commence handling, during which time the dam should receive encouragement to hide in her rain gutter burrow and perhaps also have a reward of sunflower seeds. Initial handling consists of merely lifting the pups to cup them in the hand. After eye opening, handled pups readily explore a person seated on the floor. Pups that are handled daily exhibit far less alarm behavior upon weaning and thereafter, and are easier to handle than pups that are never handled. After handled pups have reached adulthood it is possible to lift them with a flat, open

palm and gently transfer them into a new cage without incident, but they will still bite if gripped tightly. A few of ours learned to climb out of one cage into another with a little encouragement.

At the age of 30 d, roughly a week after eye opening, the pups moved easily about the cage and were observed eating chow, greens, and seeds. We then separated them from their dams and placed them into standard bin caging supplied with cat chow and greens in a shallow dish. Simple inspection determined their gender at this age: the male anogenital distance is approximately twice that of the female.

During the 2005 breeding season we also captured pregnant females from the wild that subsequently gave birth in captivity. We housed these wild-caught females individually in standard bin-style laboratory caging instead of the mating enclosures. They readily accepted the cat and dog chow, plastic rain gutter burrow and water bottle. All pregnant wild females constructed the same sort of shredded paper towel nest as did the captive-born breeders and successfully bore and cared for their pups. There was no mortality or cannibalism.

CONCLUSIONS

We have here described capture methods for the wild 13-lined ground squirrel, which in our region arrives in the laboratory with a surprisingly light parasite load. Considered asocial, 13-liners nevertheless adapt well to captivity and even group housing in “territories” far smaller than those found in nature. We have described long-term husbandry methods using equipment and supplies available to any vivarium. We advocate the use of the more palatable, higher protein diet found in cat or dog chows and provision of an artificial burrow to reduce stress and facilitate transfer. We have further described the management of hibernation, mating, and successful reproduction in captivity. It may be possible

to manipulate the timing of spring emergence from hibernation to permit a second litter from each female, maximizing reproductive output. With sufficient numbers an advisable next step would be to select the most temperamentally suitable 13-liners for breeding stock, thus providing a vastly improved model species for a variety of research investigations.

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COMPETING INTERESTS STATEMENT

The authors declare no competing financial interests.

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