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Tools and Technology

Trapping and Handling Squirrels: Trap Modification and Handling Restraint to Minimize Injuries and Stress

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ABSTRACT Trapping and handling is stressful for wild animals and may result in injuries. Minimizing stress and injuries is important not only for the welfare of the animals, but to assure integrity of research using trapped wild animals. By recording injury rates associated with trapping and handling, it is possible to assess the welfare performance of trapping and handling methods. Although the International Organization for Standardization published a standardized scale for the type and severity of injuries caused by trapping and handling (ISO 1999), it does not provide guidelines for acceptable standards of animal welfare; that is left to the researchers themselves to determine. The purpose of this paper is to measure the level of injury to wild squirrels caused by trapping and handling using minimally disruptive methods. We report our injury rates from several studies conducted in California, USA, that used various trapping and handling methods and the refined procedures we have adopted. Our data set on multiple Sciuridae species provides values for comparison with other studies. We found that using a canvas cover for traps minimized stress and injuries in captured squirrels. We also found that using a cone handling bag minimized handling time and stress associated with handling and eliminated the need for chemical immobilants. Further, we found that covering the animals' eyes during handling appeared to reduce visible signs of stress. © 2013 The Wildlife Society.

KEY WORDS animal welfare, chemical immobilant, handling, injury, restraint, squirrel, stress, trapping, welfare.

In studies of wild mammals, animals are often trapped to gather basic information on health and physical measurements and to mark individuals for identification, usually with ear tags or fur dye. The animals then are released back into the wild. Individual identification of free-living wild animals allows researchers to estimate population size, calculate demographic variables, and discern the behavior of individuals; this aids in the development of conservation and management programs (Powell and Proulx 2003, Iossa et al. 2007). Live-traps serve to hold the animal, unharmed and with minimal stress, until the trap is checked (Iossa et al. 2007). Types of live-traps include stopped-neck snares, leg-hold snares, leg-hold traps, box or cage traps, pitfall traps, corral traps, and net traps; their use is dictated by the species being studied, the ease of use, portability, and familiarity of the researcher with the device (Schemnitz 1996, Iossa et al. 2007). Once trapped, the animal is typically handled to gather reproductive, health, and other data, and to apply individual identification. Handling devices used by researchers include squeeze boxes, metal mesh or wire handling devices, cloth net bags, and bags that permit the head of the animal to protrude (Arenz 1997). Sometimes sedatives are used to immobilize the animal while identification data are gathered (Gannon and Sikes 2007). Chemical restraint and immobilization became common practices in wildlife studies in the late 1970s because they may reduce trauma to the animal and facilitate research procedures (Fowler 2008). Ketamine hydrochloride is commonly used on a variety of small animals (for a review see Wright 1983). It has a dissociative effect on animals; it depresses physical sensation but does not inhibit visual and somatic sensation (Collins 1976).

Trapping and handling is stressful for wild animals. In fact, stress physiology is studied in many species by using a capture and handling protocol as a standardized acute stressor (Romero 2004). Stress and pain associated with capture cause significant physiological changes in animals, including changes in levels of hormones, enzymes, electrolytes, and muscle pH (Romero 2004). Many studies have shown that trapped mammals have increased levels of serum cortisol, indicating a stress response (Moe and Bakken 1997, Kenagy and Place 2000, Place and Kenagy 2000, Harper and Austad 2002, for a review see Iossa et al. 2007). While animals are in a trap, they initially exhibit increased activity as they struggle and attempt to escape (White et al. 1991). This can increase heart rate and body temperature (Kreeger et al. 1990, White et al. 1991, Moe and Bakken 1997) and cause long-term

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muscle damage (Duncan et al. 1994). Even in domesticated animals such as cattle, handling, and restraint cause physiological and behavioral changes; heart rate and plasma cortisol concentrations increase and animals become highly agitated and struggle, potentially resulting in injury (Mitchell et al. 2004). Although chemical immobilants are commonly used to restrain wild animals for routine examinations, immobilants may not be the best choice because of a risk of overdose or an adverse reaction (Friend et al. 1996).

Recording injury rates associated with trapping and handling allows researchers to assess the relative safety of different trapping and handling methods. Minimizing stress and injuries is important not only for the welfare of the animals, but to assure the integrity of research using trapped wild animals. Researchers seek to minimize the influence of their trapping and handling methods on the subject animals' behavior or physiology and thus lessen effects on research results (Powell and Proulx 2003). Many researchers have developed scales to rate injuries, each scale with its own injury classes and scoring methods (reviewed in Iossa et al. 2007). However, these differing scales complicate efforts to measure repeatability and compare trapping and handling methods across studies. The International Organization for Standardization published a standardized method for assessing welfare performance of restraining traps in 1999 (ISO 1999), but few studies have utilized it (Iossa et al. 2007). Although the International Organization for Standardization provides a standardized scale for the type and severity of injuries caused by trapping and handling, the guidelines for acceptable standards of animal welfare is left to the researchers themselves to determine.

The purpose of this paper is to measure the level of injury to wild squirrels caused by trapping and handling using minimally-disruptive methods. During a pilot study, we used unmodified traps and chemical sedation to trap and handle California ground squirrels (*Otospermophilus beecheyi*). We found the resulting injury levels unacceptable for our study goals. Therefore, in later studies on California ground squirrels, eastern fox squirrels (*Sciurus niger*), western gray squirrels (*S. griseus*), and eastern gray squirrels (*S. carolinensis*) we used trap modifications and a handling bag instead of chemical sedation. We report our injury rates from several studies using various trapping and handling methods. Our data set on multiple species provides values for comparison with other studies and can be used to compare and choose appropriate methods and thereby improve the welfare of animals captured for research.

STUDY AREAS

We conducted research at 4 different study sites with 4 species of squirrels. A pilot study for work with California ground squirrels was conducted in June 2009, at Lake Solano Park campground in Winters, California, USA. The campground bordered Lake Solano, which was created in 1957 by completion of the Putah Diversion Dam and was surrounded by foothills and orchards. Vegetation at this location included blue, valley, and interior oaks (*Quercus* sp.) with stands of cottonwood (*Populus fremontii*), black walnut (*Juglans nigra*), willow (*Salix* sp.), alder (*Alnus* sp.), and aquatic plants along the lake and stream banks (Gates & Associates 2006). Human traffic was frequent at this site.

Study 1, involving California ground squirrels, was conducted during the summer (Jun–Aug) of 2010 and 2011 at Lake Solano Park campground and at the Blue Oak Ranch Reserve biological field station and ecological reserve in San Jose, California. The Reserve comprised 3,260 acres (1,319 ha) operated jointly by the University of California Berkeley Natural History Museum and the University of California Natural Reserve System, created and maintained to provide undisturbed environments for conducting field-based research (BORR 2008). Vegetation at this location was composed of blue and valley oaks and native perennial grassland. Human traffic was infrequent at this site.

Study 2, involving eastern fox squirrels, was conducted between November 2008 and December 2010 at the University of California Davis campus, Davis, California. Specifically, the study was conducted around Mrak Hall on the central campus, and in Orchard Park, a graduate-student family housing location. Both areas consisted of manicured lawn interspersed with a variety of large trees dominated by oaks. Human traffic was frequent at both sites.

Study 3, involving western gray squirrels and eastern gray squirrels, was conducted between August and October 2006 in a lightly travelled area of Big Basin Redwoods State Park in the Santa Cruz Mountains, California. The habitat of the study area mainly consisted of old-growth redwood (*Sequoia sempervirens*) forest with a tan oak (*Lithocarpus densiflorus*) understory. Other common tree species included Douglas fir (*Pseudotsuga menziesii*), madrone (*Arbutus menziesii*), and live oak (*Q. agrifolia*).

METHODS

Trapping

All studies used Tomahawk® (Hazelhurst, WI) live-traps, model 103. The traps measured 19 inches × 6 inches × 6 inches (48 cm × 15 cm × 15 cm) with a wire mesh of 1 inch × 1 inch (2.54 cm × 2.54 cm) and 14-gauge wire. The number and severity of injuries for each squirrel was assessed by the authors.

Pilot study—California ground squirrel.—Nine squirrels were captured using traps without covers. Traps were placed at the entrances of burrows and baited with black oil sunflower seeds. Traps were checked every hour for squirrel captures.

Study 1—California ground squirrel.—One hundred twenty-one squirrels were trapped using a canvas cover attached to each trap. The canvas covered the top and 2 sides of the trap, leaving the door and back of the trap uncovered. Four metal grommets were placed in the top side of the cover (one in each corner) for attachment to the trap and to protect the fabric from unraveling. The covers were attached to the traps using plastic zip ties at the 2 grommets nearest the cage door. Rear attachment points were only used during windy conditions when the trap cover was likely to be blown out

of position. Traps were placed at the entrances of burrows and baited with black oil sunflower seeds. Traps were checked every hour for squirrel captures.

Study 2—eastern fox squirrel.—Trapping methods were similar to Study 1. Three-hundred four squirrels were trapped with canvas covers, similar to those used in Study 1, but also covering the back of the trap; these were attached as above to each trap. Rear attachment points were used at all times. In addition, wooden peg board was attached to the inside of the trap door in a manner that did not interfere with the door mechanism but, when closed, provided additional privacy for caged squirrels. Traps were placed in the shade at the base of trees and baited with in-shell walnuts. Traps were checked at least every 90 minutes for squirrel captures.

Study 3—western gray squirrel and eastern gray squirrel.—Five western gray squirrels and 14 eastern gray squirrels were trapped without using trap covers. Traps were placed in the shade at the base of trees and baited with in-shell walnuts. Traps were checked twice daily for squirrel captures.

Handling

Studies 1–3 used a cone handling bag constructed with lightweight canvas (Koprowski 2002). The cone had a small opening at one end through which the snout of the animal protruded; the small opening could be decreased according to the size of the animal using a Velcro® fastener (Velcro USA, Inc., Manchester, NH); a large opening at the other end fit over the cage door. The bag had a Velcro® closure along the length of the bag to allow access to any portion of the animal's body.

Pilot study—California ground squirrel.—When squirrels were captured, they were carried in the trap to a central location for administration of the chemical immobilant ketamine, injected intramuscularly (40 mg/kg). A large rectangular bag was placed over the opening of the trap and squirrels were encouraged to enter the bag by assistants making quick movements with their hands or feet at the other end of the trap, or by blowing on the squirrel. Once in the bag, squirrels were maneuvered to a corner of the bag and pinned to the ground with a gloved hand. The bag was then peeled back to expose the squirrel's thigh for injection. Once the injection took effect, squirrels were removed from the bag and handled with gloved hands. Squirrels were marked with ear tags and fur dye. Eyes were not covered. Squirrels were allowed to recover $\geq$2 hours or until they returned to normal activity levels before they were released.

Study 1—California ground squirrel.—When a squirrel was captured, the trap was carried to a nearby location for anti-predator behavior trials. The cover was removed and the squirrel remained in the trap during these trials. After trials were completed, the cover was placed back over the trap. Sex, age (juv or ad), and reproductive status (lactating or non-lactating F) were assessed by picking up the trap and examining the squirrel's ventral side. The squirrel was then removed from the trap by placing the cone handling bag over the entrance of the trap. The trap door was raised and the trap cover was pulled back toward the bag; the squirrel retreated with the cover and entered the handling bag. The squirrel was then weighed using a spring scale attached to the handling bag. First-capture squirrels were flushed into the tapered end of the cone. The longitudinal fastener immediately posterior to the head was opened and one ear was exposed for application of an ear tag. While the head was exposed, a gloved hand was cupped over the squirrel's eyes. After the ear tag was applied, the trap was placed in front of the squirrel with the door open. The bag was then pulled open from the tapered end and the squirrel was released into the trap. After the anti-predator trial, the squirrel was transported to the burrow entrance where it had been captured and was released. Recaptured squirrels were released after weighing. If squirrels were captured more than once per day they were released immediately from the cage without handling (thus, they are not reflected in Table 1 results).

Study 2—eastern fox squirrel.—When squirrels were captured, the trap was carried to a nearby location for

Table 1. Trauma scale developed by the International Organization for Standardization Technical Committeefor the type and severity of injuries to animals, as caused by trapping and handling.

Mild trauma	Moderate trauma	Moderately severe trauma	Severe trauma
Claw loss	Severance of minor tendon or ligament	Simple fracture at or below the carpus or tarsus	Amputation of three or more digits
Edematous swelling or hemorrhage	Amputation of 1 digit	Compression fracture	Any fracture or joint luxation on limb above the carpus or tarsus
Minor cutaneous laceration	Permanent tooth fracture exposing pulp cavity	Comminuted rib fracture	Any amputation above the digits
Minor subcutaneous soft tissue maceration or erosion	Major subcutaneous soft tissue laceration or erosion	Amputation of two digits	Spinal cord injury
Major cutaneous laceration, except on footpads or tongue	Major laceration on footpads or tongue	Major skeletal degeneration	Severe internal organ damage (internal bleeding)
Minor periosteal abrasion	Severe joint hemorrhage	Limb ischaemia	Compound or comminuted fracture at or below the carpus or tarsus
	Joint luxation at or below the carpus or tarsus		Severance of a major tendon or ligament
	Major periosteal abrasion		Compound or rib fractures
	Simple rib fracture		Ocular injury resulting in blindness of an eye
	Eye laceration		Myocardial degeneration
	Minor skeletal degeneration		Death

handling. To remove the squirrel from the trap, the handling cone was placed over the door and the door was opened, allowing the squirrel to move into the handling cone. If the squirrel did not immediately move into the handling cone, the trap was either tilted onto its side or the front of the trap cover was removed; both actions usually resulted in the squirrel moving into the handling cone. Squirrels were sexed, weighed, and tagged as above. There was no formal procedure for covering the eyes. With a longitudinal opening in the bag and the squirrel's head firmly in the tapered end of the bag, the middle section of the bag was opened up, keeping the tapered end closed, in order to complete handling needs. Using this method while a gloved handler also firmly held the squirrel, blood samples were drawn from the saphenous vein and fur dye was applied to the thigh and mid-body of each animal without using any chemical restraint. Squirrels were then released near their capture site.

Study 3—western gray squirrel and eastern gray squirrel.—Captured squirrels were processed in place where they were captured. This was in a remote area with few people or other disturbances. Squirrels were transferred into the handling cone as described in Study 2. Squirrels were sexed, weighed, and ear-tagged; and parasites were identified by visual inspection. There was no formal procedure for covering the eyes. Using the bag to restrain the limbs, the head, and neck were allowed to protrude from one end of the bag. Radiocollars were affixed and squirrels were released.

RESULTS

We recorded the number and severity of injuries for each study, based on Table 1, the International Organization for Standardization trauma scale (ISO 1999), and report them in Table 2 and Figure 1. During the Pilot Study, squirrels were captured and handled 9 times (all first captures). All squirrels had mild trauma caused by struggling in the traps (cutaneous lacerations on the face). There was one instance of moderate trauma in which a squirrel had a deep subcutaneous laceration on the face, and one instance of severe trauma in which a squirrel went into a heat-induced coma and was euthanized. We determined that this number and level of injuries were unacceptable and research was halted until more humane methods of capture and handling were found (i.e., trap covers and handling bag).

During Study 1, squirrels were captured and handled 149 times (121 first captures and 28 recaptures). Squirrels were in the traps for an average duration of 19 minutes during anti-predator behavioral trials. There were 0 fatalities and 20 injuries during the field season, all of which qualified as mild trauma on the International Organization for Standardization scale (18 during first-captures and 2 during recaptures). Most of the injuries occurred prior to handling and were cutaneous lacerations on the face. There were 2 mouth injuries and 2 claw injuries.

Most of the captured squirrels remained calm until the covers were lifted to verify the presence of the squirrel. Evidence that the cover created a relaxed environment for the squirrels includes indications of foraging while in the traps (squirrels would often spit out a mouthful of seeds when the cover was lifted) and squirrels' alarm calling when the cover was lifted. In addition, a high re-capture rate indicated that the squirrels were not traumatized by their experience. There were several instances of individuals being trapped multiple times in 1 day. There was one particularly "trap-happy" female who was regularly captured every day that traps were set, and she was captured a maximum of 8 times in 1 day.

During Study 2, squirrels were captured and handled 1,751 times (304 first captures and 1,447 recaptures). There were 69 total injuries that we suspected were trap-induced. Most injuries qualified as mild trauma on the International Organization for Standardization scale. The majority of the mild trauma injuries were incurred before handling and were cutaneous lacerations on the face (15 during first-captures and 43 during recaptures); there were 2 mouth injuries, 2 claw injuries, and 1 foot injury. There were 6 deaths that qualified as severe trauma on the International Organization for Standardization scale. Four deaths occurred when the squirrel was in the handling bag. Although the exact cause of death is unknown, each death occurred when the squirrel's head and neck were exposed (generally most of the head is not exposed) through the small end of the bag and we suspect that this situation caused stress to the animal resulting in heart attack or asphyxiation as the squirrel attempted to push its way out of the bag. Two deaths occurred when the squirrels were in the trap. Both deaths were a result of the nose and upper jaw being caught in the 1-inch (2.54-cm) wire mesh of the trap door between trap checks. We subsequently modified traps to reduce the trap mesh size on the cage door of the traps and subsequently we had no deaths. Effective modifications included the use of 0.25–0.50-inch (0.6–1.3-cm) wire mesh or wooden pegboard sized to avoid interference with the trigger mechanism, and affixed with bailing wire to the trap door. Wooden pegboard pieces were easier and quicker to affix in the field but required periodic replacement due to squirrel gnawing.

During Study 3, squirrels were captured and handled 65 times (19 first captures and 46 recaptures). There were 6 injuries. All injuries were incurred prior to handling and qualified as mild trauma on the International Organization for Standardization scale. The majority of the injuries were cutaneous lacerations on the face (2 during first-captures and 2 during recaptures); there were 2 mouth injuries.

During Studies 1, 2, and 3, we accomplished multiple procedures with the use of a handling bag, including identification of gender and parasites, weighing, ear tagging, and in some cases application of fur dye, blood draw, and affixation of a radiocollar.

DISCUSSION

By recording injury rates associated with trapping and handling squirrels, we can assess the welfare efficacy of our trapping and handling methods. We avoided using anesthesia and found that using trap covers and a cone handling bag, as well as covering the animals' eyes, minimized stress, and injuries incurred during trapping and handling. With the handling bag, we accomplished multiple procedures for which chemical immobilants are

Table 2. Number and severity of injuries sustained by trapped animals during each of 4 different studies involving 4 species of squirrels. The Pilot Study (June 2009) and Study 1 (Jun–Aug, 2010 and 2011) were on *Otospermophilus beecheyi*, Study 2 (Nov 2008–Dec 2010) was on *Sciurus niger*, Study 3a (Aug–Oct 2006) was on *S. griseus*, and Study 3b (Aug–Oct 2006) was on *S. carolinensis*.

Species	Safety measures	Procedures accomplished	No. of captures	Proportion of mild trauma (*n*)	Description (mild)	Proportion of moderate trauma (*n*)	Description (moderate)	Proportion of severe trauma (*n*)	Description (severe)
Pilot study: California ground squirrel (*Otospermophilus beecheyi*)									
First capture	Chemical sedation (ketamine)	Identification of gender; weighing; ear tag; fur dye	9	1.000 (9)	9 facial scratches	0.111 (1)	Deep subcutaneous laceration on face	0.111 (1)	Death due to heat stroke
Study 1: California ground squirrel (*Otospermophilus beecheyi*)									
First capture	Trap cover; handling bag; eyes covered	Identification of gender; weighing; ear tag	121	0.149 (18)	14 facial scratches; 2 blood on mouth; 2 claw injuries	0	n/a	0	n/a
Recapture	Trap cover; handling bag; eyes covered	Identification of gender; weighing	28	0.071 (2)	2 facial scratches	0	n/a	0	n/a
Study 2: Eastern fox squirrel (*Sciurus niger*)									
First capture	Trap cover; handling bag	Identification of gender; weighing; ear tag; fur dye; blood draw	304	0.053 (16)	15 facial scratches; 1 claw injury	0	n/a	0.010 (3)	2 deaths in handling bag; 1 death from head trapped in cage door
Recapture	Trap cover; handling bag	Identification of gender; weighing; fur dye; blood draw	1,447	0.032 (47)	43 facial scratches; 2 blood on mouth; 1 claw injury; 1 foot injury	0	n/a	0.002 (3)	2 deaths in handling bag; 1 death from head trapped in cage door
Study 3a: Western gray squirrel (*Sciurus griseus*)									
First capture	Handling bag	Identification of gender; weighing; ear tag; identification of parasites; affix radiocollar	5	0	0	0	n/a	0	n/a
Recapture	Handling bag	Identification of gender; weighing; identification of parasites	12	0.083 (1)	1 blood on mouth	0	n/a	0	n/a
Study 3b: Eastern gray squirrel (*Sciurus carolinensis*)									
First capture	Handling bag	Identification of gender; weighing; ear tag; identification of parasites; affix radiocollar	14	0.214 (3)	2 facial scratches; 1 blood on mouth	0	n/a	0	n/a
Recapture	Handling bag	Identification of gender; weighing; identification of parasites	34	0.059 (2)	2 facial scratches	0	n/a	0	n/a

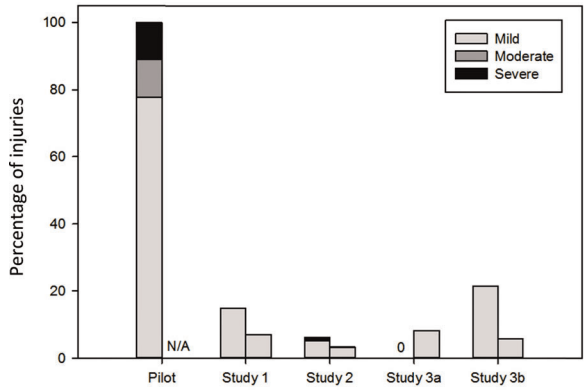

Figure 1. Percentages of mild, moderate, and severe injuries incurred during trapping and handling during each study of squirrels at four study sites in California. The Pilot Study (June 2009) and Study 1(Jun–Aug, 2010 and 2011) were on *Otospermophilus beecheyi*, Study 2 (Nov 2008–Dec 2010) was on *Sciurus niger*, Study 3a (Aug–Oct 2006) was on *S. griseus*, and Study 3b (Aug–Oct 2006) was on *S. carolinensis*. The first column for each study shows percentages of injuries for first captures and the second column shows percentages of injuries for second captures. There were no second captures during the Pilot Study and there were no first capture injuries for Study 3a.

commonly used, including fur dying, ear tagging, blood draws, and affixing radiocollars. These trapping and handling methods reduce stress and injuries. Our data set on multiple species provides values for comparison with other studies and can be used to compare and choose appropriate methods, and thereby improve the welfare of animals captured for research.

Avoiding anesthetization and using covers on the traps in Studies 1 and 2 kept injuries to a low number and a mild level compared with the Pilot Study in which trap covers were not used (see Fig. 1). Although there were 6 instances of severe trauma (death) in Study 2, 4 of these cases were unrelated to the trap, and the other 2 deaths resulted from the mesh of the trap being too large for the animal, whereas the severe trauma (death) in the Pilot Study was a direct result of heat exposure. Trap covers were not used in the Pilot Study and squirrels were in direct sunlight for $\geq$30 minutes. Small mammals are sensitive to extreme temperatures and can dehydrate quickly because of a high metabolic rate (Iossa et al. 2007, Fowler 2008). Heat exposure could likely have been prevented by the use of a trap cover to provide shade in the Pilot Study; we had no indications of heat exposure in subsequent studies when ambient temperatures were the same as in the Pilot Study but trap covers were used. Trap covers were not used in Study 3, but the squirrels were protected from heat exposure by natural vegetation, a solution not always feasible because some field sites do not have vegetation or shade. Ground squirrel traps are most effective when placed at burrow entrances, which are not always shaded. The covers used for this field work could be used repeatedly and are not dependent on the placement of the trap.

Although heat exposure is a high risk for squirrels and other small mammals, most injuries are caused by physical exertion related to struggling while in the trap (Iossa et al. 2007). The Pilot Study and Studies 1 and 2 were conducted in public areas (a campground and a university campus), and the trap covers minimized the amount of disturbance to which the squirrels were subjected while in the traps. It was necessary to remove the traps every evening to prevent theft or disturbance. Using the canvas cover worked well for the site requirements and restrictions. The cover was lightweight and easily portable. The traps collapsed with the covers still attached. Collapsible traps have multiple metal latches that, when stacked, have a tendency to latch onto adjacent traps making them difficult to separate again; the covers kept the traps separated and reduced the setup time. Disturbance was not a concern during Study 3 because the location was remote and disturbances were uncommon.

We found that the handling bag facilitated quicker handling and release back into the wild than chemical immobilization. Using the handling bag was a simple and quick procedure that minimized the amount of time required to process individual squirrels, which reduced the amount of stress the squirrels experienced. This restraint was logistically more feasible than chemical immobilization. Chemical immobilants may not be the best choice for some animals because they are cost-prohibitive, require permitting and special storage, have the potential for overdose, and require long recovery times before the animal can be released (Koprowski 2002). Although chemical immobilants make a wild and potentially dangerous animal safe to handle, they can harm the animal because of a potential for overdose or adverse reaction to the chemical. Depending on the chemical used and the ambient temperature, animals may be at risk of becoming hyper- or hypothermic. Animals may vomit and aspirate and pregnant females may abort (Friend et al. 1996). If animals are released into the wild before they fully recover from chemical immobilization, they may be subject to increased risk of predation. Animals recovering from chemical immobilization in captivity may become stressed and injure themselves while trying to escape. For example, restraining sedated squirrels for the entire recommended 6 hours following chemical immobilization has led to squirrels breaking teeth and incurring lacerations on their rostrum from the metal bars of the trap (Arenz 1997). Our experience supports Koprowski's finding that the portability, durability, efficacy, and reasonable cost of handling bags results in a feasible and safe alternative to chemical immobilization for handling squirrels (Koprowski 2002). Our study extended the use of the bag from tree squirrels to California ground squirrels, a species that some researchers previously thought was too large and strong for physical restraint without chemical immobilization (D. H. Owings, University of California, Davis, personal communication).

In Study 1, we found covering the eyes of restrained squirrels was an effective means of reducing stress to the animal, as well as the risk of a bite to the handler. Covering the eyes reduces or eliminates an animal's visual communication with its environment and calms the animal (Young 1973, Mitchell et al. 2004). Covering the eyes of restrained animals leads to the maintenance of a normal heart rate and amelioration of other signs of stress (International Animal Care and Use Committee 1998, Koprowski 2002, Gannon and Sikes 2007), which is a high risk because restrained

animals may develop shock from fear and excitement (Young 1973). Using a blindfold, hood, or a darkened environment during handling has been recommended for large mammals including cattle (Andrade et al. 2001, Mitchell et al. 2004), domestic horses (Fowler 2008), wild and farmed elk (*Cervus elaphus*; Clark and Jessup 1991, Thierman et al. 1999), antelope (species unspecified; Fowler 2008), impala (*Aepyceros melampus*; Mooring et al. 1995), deer (Clark and Jessup 1991, Haigh and Friesen 1995), and bighorn sheep (*Ovis canadensis*; Clark and Jessup 1991), as well as domesticated and wild birds including chickens and raptors (Beebe and Webster 1964, Fuller 1975, Clark and Jessup 1991, Jones and Satterlee 1997; Jones et al. 1998*a*, *b*). It is not, however, a common practice to restrict the subjects' vision when working with small mammals (Fowler 2008). Researchers have suggested confining restrained squirrels in a dark container (Clark and Jessup 1991) and the Animal Care and Use Committee of the American Society of Mammalogists suggests that covering an animal's eyes might reduce its struggle to escape (International Animal Care and Use Committee 1998). If small mammals are not immobilized using chemicals, the animals are usually handled by being placed in a plastic tube or similar device that restricts movement but does not necessarily reduce visual stimulation (Fowler 2008). Often the tubes are clear so the researcher can assess the animal. In our studies, placing a gloved hand over the squirrel's eyes while applying the ear tag calmed the squirrel and reduced its movement. We plan to examine this further by introducing a flap at the end of the cone handling bag that will allow us to more easily cover the squirrel's eyes while applying the ear tag. This simple technique could be broadly applied to small mammal handling.

We had 2 deaths occur due to a trap mesh size that allowed the animals to stick their noses through the cage door. Thus, we feel that mesh size of the trap relative to the body size of the target animal may also be an important factor in minimizing injury. We believe that squirrels were more likely to stick their noses through the trap mesh at the door because this was the only uncovered area of the trap and the doors were moveable (but not openable) by the squirrels inside. Thus mesh size was such that squirrels could stick their noses through but could not always remove them if their incisors became stuck. Modification of this mesh size eliminated further deaths or injuries. We also found that over time, the doors became loose and could be manipulated by squirrels that pushed the door to the side during an attempt to escape. This resulted in an opening larger than the 1-inch × 1-inch mesh size of the trap and was in some instances large enough for a juvenile squirrel to escape through. A trap of the same dimensions but with a <1-inch mesh size, especially on the trap door, would be preferred for squirrels similarly sized to fox squirrels (600 g–1,000 g).

We assume that all injuries reported occurred while the animal was inside the trap. Although it is possible that animals may have been injured prior to entering the trap, the stereotypical injury pattern we observed of facial and foot injury were not observed in untrapped squirrels during our study. When we approached traps we often observed squirrels digging or biting the cage, which would very likely result in the type of injuries we observed.

This paper is a summary of data collected during 3 separate studies and 1 pilot study. Although methods were substantially consistent across all studies, there were variations that could have affected the level of stress and injuries observed in each study. Those variations include squirrel species, trap-checking time intervals, timing of trapping, and abiotic conditions. Further investigation may help elucidate to what extent trapping and handling methods affect stress and injuries in animals.

MANAGEMENT IMPLICATIONS

When trapping wild mammals, both the trapping method and the handling method should minimize the impact on the individuals. This is important, not only from an animal welfare perspective, but also to ensure that the trapping and handling methods used during the study do not affect the animals' behavior or physiology in a way that could influence the results. Although the International Organization for Standardization injury scale provides standardization for assessing welfare performance of restraining traps, it does not assess handling methods, nor does it establish target levels for acceptable injuries. With researchers collecting data using this standardized International Organization for Standardization scale, this may help establish a standard of injuries from trapping and handling small mammals.

We found that using a canvas cover for traps minimized stress and injuries in captured squirrels. We also found that using a cone handling bag minimized handling time and stress associated with handling and eliminated the need for chemical immobilants. Further, we found that covering the animals' eyes during handling appeared to reduce visible signs of stress. These tools were effective and beneficial in the capture and handling of 4 species of squirrels and should be considered for studies of other small mammals.

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