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Authors: Walter, W. David, Leslie, David M., Herner-Thogmartin, Jennifer H., Smith, Kimberly G., and Cartwright, Michael E.

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EFFICACY OF IMMOBILIZING FREE-RANGING ELK WITH TELAZOL® AND XYLAZINE HYDROCHLORIDE USING TRANSMITTER-EQUIPPED DARTS

W. David Walter,[1,5] David M. Leslie, Jr.,[2] Jennifer H. Herner-Thogmartin,[3] Kimberly G. Smith,[3] and Michael E. Cartwright[4]

[1] Oklahoma Cooperative Fish and Wildlife Research Unit, 404 Life Sciences West, Oklahoma State University, Stillwater, Oklahoma 74078, USA
[2] United States Geological Survey, Oklahoma Cooperative Fish and Wildlife Research Unit, 404 Life Sciences West, Oklahoma State University, Stillwater, Oklahoma 74078, USA
[3] Department of Biological Sciences, University of Arkansas, Fayetteville, Arkansas 72701, USA
[4] Arkansas Game and Fish Commission, PO Box 729, Hwy 56 East, Calico Rock, Arkansas 72519, USA
[6] Corresponding author (email: wdwalte@okstate.edu)

ABSTRACT: From January 1999 to April 2002, 14 free-ranging elk were darted with a mixture of Telazol® reconstituted with xylazine hydrochloride (HCl) in a forested habitat in southwestern Oklahoma and north-central Arkansas. Elk were darted from ground blinds, tree stands, or a vehicle at distances of 14–46 m and were recovered 37–274 m from the dart site. Elk were located using radiotelemetry with 3-cc disposable Pneu-dart® transmitter darts. Mean±SD dose of Telazol® and xylazine HCl was 590±192 mg/ml and 276±153 mg/ml, respectively, and mean time to standing after injection of reversal agent was 27 min (range: 1–65 min). The combination of Telazol® and xylazine HCl successfully immobilized free-ranging elk, and transmitter-equipped darts permitted successful location of sedated elk by two people in areas of dense forest cover. The dose required to sedate elk appeared to vary depending on physiology and behavior, but no drug-induced mortality occurred despite the wide variance in the doses administered. We recommend 500 mg Telazol® reconstituted with 300 mg xylazine HCl as an initial dose for a ≥200 kg elk. If needed to achieve full sedation, up to 3 additional ml of the mixture may be administered without adverse effects.

Key words: *Cervus elaphus nelsoni,* elk, immobilization, Telazol®, transmitter-equipped darts, xylazine hydrochloride.

INTRODUCTION

Traditionally, free-ranging elk (*Cervus elaphus*) have been captured with collapsible clover traps (Thompson et al., 1989), propelled nets (Hawkins et al., 1968), or potent opioid analgesic compounds such as carfentanil (Wildlife Pharmaceuticals Inc., Fort Collins, Colorado, USA) (Meuleman et al., 1984; Bailey et al., 1985) and A-3080 (Wildlife Pharmaceuticals Inc., Fort Collins, Colorado, USA) (Stanley et al., 1988). Clover traps and nets can result in ungulate mortality caused by capture myopathy of physically restrained animals (Thompson et al., 1989; Beringer et al., 1996; Haulton et al., 2001). Small doses of potent opioids can effectively subdue large ungulates and can be antagonized for rapid recovery (Meuleman et al., 1984), but opioids, if handled improperly, can be hazardous to humans, limiting their use in the field (Parker and Haigh, 1982; Kreeger, 1996).

Ketamine hydrochloride (HCl), a dissociative anesthetic, has been effective for immobilizing elk, moose (*Alces alces*) and white-tailed deer (*Odocoileus virginianus*) with no mortality when combined with xylazine HCl, a nonnarcotic sedative (Golightly and Hofstra, 1989; Garner and Addison, 1994; Kilpatrick and Spohr, 1999). Use of ketamine HCl and xylazine HCl for immobilization of larger ungulates (≥200 kg) has been limited because the volume of the required dose may limit the ability to remotely dart, achieve adequate sedation, and recover the immobilized animal. Telazol® (1:1 tiletamine hydrochloride and zolazepam hydrochloride; Fort Dodge Laboratories, Inc., Fort Dodge, Iowa, USA) is a cyclohexamine anesthetic similar to ketamine HCl but more potent (Short et al., 1989). Although ketamine HCl/Tel-

azol® combined with xylazine HCl has resulted in a long recovery period in ungulates after a reversal agent is given, Telazol® and xylazine HCl have been safe and effective for immobilizing trapped Rocky Mountain elk, wild pigs (*Sus scrofa*), and free-ranging white-tailed deer with no mortality (Millspaugh et al., 1995; Gabor et al., 1997; Kilpatrick and Spohr, 1999). Only one study has reported on remote ground capture of free-ranging elk using Telazol® and xylazine HCl, but details on capture protocols were limited (Read et al., 2001). Our objective was to determine the effectiveness of remotely immobilizing free-ranging elk using Telazol® and xylazine HCl using current advances in darting technology.

MATERIALS AND METHODS

Free-ranging elk were immobilized on private lands in southwestern Oklahoma, USA (34°47′N to 34°57′N, 98°25′W to 98°50′W), surrounding the Wichita Mountains Wildlife Refuge (WMWR) from January 2002 to April 2002. Elk were baited with alfalfa hay or pellets in or near wheat fields, food plots, or natural clearings. Elk were darted from permanent blinds, tree stands, and eastern redcedar (*Juniperus virginiana*) trees 18–46 m from bait. Free-ranging elk were also immobilized as part of research on private lands in north-central Arkansas, USA (36°29′ to 35°46′N, 93°52′ to 92°24′W) in Boone, Newton, and Carroll counties from August 1997 to September 1998.

Elk were initially immobilized in Oklahoma with a mixture of 500 mg/ml Telazol® reconstituted with 2 ml of 100 mg/ml xylazine HCl (Sedazine®, Fort Dodge Laboratories, Inc., Fort Dodge, Iowa, USA) as recommended by T. J. Kreeger (Wyoming Game and Fish Department, pers. comm.). The reconstitution resulted in a 2.5–2.7 ml mixture containing 500 mg Telazol® and 200 mg xylazine HCl, but some variation in administration of the recommended initial dose occurred by evaporation or transfer from dart to syringe for storage. The mixture was loaded into a 3.0-cc, double-barbed, transmitter-equipped dart to increase recovery of immobilized elk (Kilpatrick et al., 1996). Darts were fired into the hind quarter from a Pneu-dart® (Pneu-dart Inc., Williamsport, Pennsylvania, USA), Model 193, cartridge-fired rifle equipped with a 4× scope.

To reduce stress and permit satisfactory sedation for handling, elk were not approached until sedation was evident by lateral positioning. Upon capture, elk were blindfolded, and the tongue was adjusted to ensure open airways. The transmitter-equipped dart was extracted with a sterile razor blade, and triple antibiotic (Altaire Pharmaceuticals, Inc., Aquebogue, New York, USA) was administered to the wound. Respiration rate (RR; breaths/min), heart rate (HR; beats/min), and rectal temperature (RT) were recorded in 10-min intervals during capture when feasible. Effects of xylazine HCl were antagonized with the α_2-adrenergic antagonist tolazoline HCl (4 mg/kg body weight; Tolazine®, Lloyd Laboratories, Shenandoah, Iowa, USA), which was injected intravenously (IV) in the lateral saphenous vein or intramuscularly (IM) in the gluteus maximus. Each elk was monitored visually until it was able to leave the capture site and monitored daily with radiotelemetry >20 days postcapture. Animal care and experimental procedures were approved by the Oklahoma State University's Institutional Animal Care and Use Protocol GU-02-01.

In Arkansas, the first elk was initially immobilized with a mixture of 500 mg/ml Telazol® reconstituted with 3 ml of 20 mg/ml xylazine HCl (Sedazine®, Fort Dodge Laboratories, Inc., Fort Dodge, Iowa, USA) as recommended in Millspaugh (1995). Subsequent elk were initially immobilized with 500 mg/ml Telazol® reconstituted with 3 ml of 100 mg/ml xylazine HCl loaded into a 3.0-cc, double-barbed, transmitter-equipped dart (Herner-Thogmartin, 1999). Upon capture, elk were blindfolded and received an IM injection of 10 cc of penicillin G procaine (VetTek, Blue Springs, Missouri, USA) to prevent possible capture-related infections. Additional procedures for immobilized elk were reported in Herner-Thogmartin (1999). Effects of xylazine HCl were antagonized with yohimbine HCl (0.2–0.3 mg/kg body weight; Antagonil®, Lloyd Laboratories, Shenandoah, Iowa, USA) by IV injection in the jugular vein. Elk were monitored visually until the animal was able to depart from capture site. All elk in Arkansas were tranquilized and handled by employees of the Arkansas Game and Fish Commission in compliance with agency regulations.

Darting distance (DD) was measured from the darter to the darted elk. Travel distance (TD) was defined as the straight-line distance that an elk traveled from where it was darted to the induction site. Induction time (IT) was the period from remote darting to the time the elk was found using transmitter-equipped darts and under complete sedation. Procedural time (PT) was the period from the beginning of processing to injection of reversal-agent. Times to

TABLE 1. Initial dose of Telazol® and xylazine HC1 plus additional dose (mg/ml) necessary to sedate free-ranging elk on private lands in southwestern Oklahoma (ID 1–8) and north-central Arkansas (ID 9–14). TST=time (min) to standing after reversal agent was administered intravenously unless otherwise noted.

ID	Sex/Age[a]	Telazol®	Xylazine HC1	Additional Telazol®	Additional Xylazine HC1	TST
1	M/SA	426	170	0.0	0.0	7
2	F/A	500	200	0.0	0.0	49
3	F/A	463	185	0.0	0.0	11
4	F/A	500	200	+241	+96	45
5[b]	F/A	463	185	0.0	0.0	15
6	F/A	463	185	0.0	0.0	1.0[c]
7	F/A	500	200	+148	+59	25
8	F/A	500	200	+56	+22	4
9	F/A	500	60	0.0	0.0	0.0[d]
10	M/SA	500	300	0.0	0.0	1.0
11	F/A	500	300	0.0	0.0	46
12	F/A	500	300	0.0	0.0	53
13	M/SA	500	300	+500	+300	6
14	F/A	500	300	+500	+300	65

[a] A = adult (≥2 yrs), SA = subadult (<2 yrs.).
[b] Died 4 day postcapture.
[c] Tolazoline HC1 administered IM before release.
[d] No antagonist administered.

head-up (TH), sternal (TS), and standing (TST) were defined as time from reversal-agent injection to 1) raising the head, 2) sternal recumbency, and 3) departure of the elk from capture location, respectively. Only TST was recorded for elk captured in Arkansas.

RESULTS

Fourteen elk (11 adult females, two subadult females, and one subadult male) were immobilized with an initial dose of ≤500 mg/ml Telazol® and ≤300 mg/ml xylazine HCl (Table 1). Five of 14 elk required an additional 1.0–3.0 ml dose to achieve complete sedation. Two additional elk (not included in Table 1) were mistakenly darted anterior to the hind quarter causing a presumed subcutaneous injection of the drug. Those two elk were not completely sedated and could not be approached to deliver an additional dose.

A mean±SD Telazol® dose of 590±192 mg (range: 426–1,000 mg) and mean xylazine HCl dose of 276±153 mg (range: 60–600 mg) were required to successfully immobilize elk (n=14; Table 1). Mean HR was 66±32 (range: 44–104, n=3), 58±17 (range: 40–80, n=5), and 53±24 (range: 27–76, n=3) beats/min at 30, >30, and >45 min postinjection, respectively. Mean RR were 41±12 (range: 32–56, n=3), 30±14 (range: 16–48, n=5), and 23±21 (range: 11–48, n=3) breaths/min at 30, >30, and >45 postinjection, respectively. Mean RT was 101.5±0.6 (range: 100.5–101.5, n=8), 101±1.1 (range: 99.5–102.1, n=5), and 101±0.3 (range: 100.6–101.1, n=3) F at 30, >30, and >45 postinjection, respectively. To facilitate recovery, seven elk received 800 mg tolazoline HCl IV (4 mg/kg as recommended for a 200 kg elk), and one elk received 800 mg tolazoline HCl IM because arousal prevented IV injection. Five elk received 20 ml yohimbine HCl IV, and one elk was not administered a reversal agent.

Mean DD was 23.3±9.4 m (range: 13.7–45.7; n=8), and mean TD was 142.9±98.5 m (range: 37–274; n=8). Mean IT was 33.4±3.1 min (range: 27–36; n=8), and mean PT was 39.4±6.1 min (range: 27–47; n=8). Mean TH, TS, and TST when a reversal agent was administered IV was 13.3±8.6 (range: 3–25; n=7), 20.9±16.8 (range: 4–47; n=7), and 27.2±22.8 (range: 1–65; n=12) min, respectively (Table 1).

All immobilized elk, including four darted during night hours, were located with transmitter-equipped darts. One Oklahoma elk (5; Table 1) was found dead 4 day postcapture about 2 km from the capture site. Because of the remote location of mortality, a detailed necropsy was not possible. Gross inspection revealed a partially aborted fetus and pink, gelatinous femur marrow indicative of an animal in fair to poor condition (Riney, 1955). We do not believe that this was a drug-related mortality.

DISCUSSION

Immobilization of free-ranging elk with Telazol® and xylazine HCl was successful, but 1.0–3.0 mg/kg xylazine HCl (based on a 200 kg elk) was required compared with 0.35 mg/kg used by Millspaugh et al. (1995). It has been suggested that Telazol® and xylazine HCl have wide safety margins (Kreeger et al., 1986; Millspaugh et al., 1995; Murray et al., 2000), which is substantiated by our data. Two elk receiving 1,000 mg Telazol® and 600 mg xylazine HCl were successfully immobilized with no apparent side effects. Elk given 600 mg xylazine HCl mixed with ketamine HCl were successfully sedated in California, and no mortality occurred from overdosing (Golightly and Hofstra, 1989). Xylazine HCl was increased up to three times (200–300 mg) the dose previously reported (60 mg) with successful recovery following reversal-agent injection. Heart rate and respiration of all elk monitored decreased throughout the handling process indicating that sedation was sustained. Bloat was observed on one occasion during the handling process, which can be relieved by repositioning the elk or by administering an α_2-adrenergic antagonist to permit the elk to eructate on its own (Kreeger, 1996).

Use of transmitter-equipped darts allowed elk to escape to forested cover with no human disturbance. Successful processing of elk was possible provided they were completely sedated before researchers approached. The two elk excluded from the summary were in lateral recumbence after locating them but rose to a full stance and retreated into forested cover when researchers approached within 30 m. Regardless of the distance an elk traveled after darting, transmitter darts permitted locating sedated elk in dense forested habitat.

Researchers have documented considerable differences in drug doses required to sedate relatively calm, captive ungulates compared with excited, free-ranging ungulates (Kreeger et al., 1986; Millspaugh et al., 1995; Murray et al., 2000).

The variability in TD and dose required was likely a result of the excited state of elk and dependent on previous disturbance. For example, the first four elk darted at a bait site in Oklahoma traveled a mean distance of 69±27.4 m (n=4), and subsequent elk darted at the same site traveled a mean distance of 217±84.6 m (n=4).

Dart placement apparently limited our ability to immobilize free-ranging elk with Telazol® and xylazine HCl successfully. Two elk in Oklahoma were injected subcutaneously and could not be darted with an additional dose, and two elk in Arkansas were darted with an additional dose for adequate sedation. It is possible that injection of the initial dose in nonmuscular tissue, tissue damage, or clotting associated with the impact of the dart caused incomplete absorption and, thus, incomplete sedation (Meuleman et al., 1984).

The initial dose of Telazol® (range: 426–500 mg) and xylazine HCl (range: 60–300 mg) successfully immobilized nine of 14 elk, but an additional dose was necessary to sedate the remaining five elk. Time to standing after reversal-agent injection for elk sedated with an initial dose (range: 1–53 min) was similar to those requiring an additional dose (range: 4–65 min) suggesting that successful immobilization of free-ranging ungulates would increase if a standard dose would subdue elk over a wide range of conditions. Variability in recovery times for ungulates immobilized with Tel-

azol®/ketamine HCl/xylazine HCl mixtures has been documented after an antagonist was administered, but mortality from overdosing is uncommon (DelGiudice et al., 1989; Garner and Addison, 1994; Millspaugh et al., 1995).

For remote capture of free-ranging elk, we recommend a dose that would account for varying size of elk, dart placement, and temperament. A dose of 500 mg Telazol® reconstituted with 300 mg xylazine HCl would likely immobilize free-ranging female elk over a wide range of conditions. An additional 2–3 ml of the reconstituted dose could be administered provided the initial dose does not provide full sedation for handling. Most capture rifles can project 3-ml transmitter darts with accuracy 20–40 m to locate immobilized elk successfully. The advantage of Telazol® and xylazine HCl is the wide safety margin that likely would prevent a lethal overdose and safe handling conditions for researchers at isolated study sites.

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