# Immobilization of Clover-trapped White-tailed Deer, *Odocoileus virginianus*, with Medetomidine and Ketamine, and Antagonism with Atipamezole

JOSHUA J. MILLSPAUGH[1], BRIAN E. WASHBURN[1], TAMARA M. MEYER[2], JEFF BERINGER[2], and LONNIE P. HANSEN[2]

[1]Department of Fisheries and Wildlife Sciences, University of Missouri, 302 Anheuser-Busch Natural Resources Building, Columbia, Missouri 65211 USA

[2]Missouri Department of Conservation, Conservation Research Center, 1110 South College Avenue, Columbia, Missouri 65201 USA

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We evaluated the effectiveness of immobilizing Clover-trapped White-tailed Deer (*Odocoileus virginanus*) with medetomidine hydrochloride (HCl) and ketamine HCl during winter and summer by monitoring immobilization intervals and vital signs. In winter, we captured deer in Clover traps in 1 4-ha research enclosure for relocation to another on-site enclosure ($n = 5$). In summer, we captured free-ranging deer in Clover traps to attach radio-collars ($n = 4$). We administered an estimated 0.055 mg/kg medetomidine HCl and 2.5 mg/kg ketamine HCl to adult (> 1.5 years of age) deer and 0.06 mg/kg medetomidine HCl and 2.5 mg/kg ketamine HCl to subadult (< 1.5 years of age) deer. We used an intramuscular injection of atipamezole HCl as the antagonist at a rate of 0.275 mg/kg for adults and 0.3 mg/kg for subadults > 30 minutes post-induction. Mean induction time in winter was 11.2 minutes (SE = 2.5, range = 5.4 – 24.2) and 6.5 minutes (SE = 0.8, range = 6.2 – 7.5) in summer. After atipamezole HCl injection, the mean time to walking was 17.1 minutes (SE = 3.5, range = 7.5 – 41.5 minutes) in winter and 11.3 minutes (SE = 3.8, range = 4.7 – 13.5) in summer. Rectal temperature was relatively constant throughout immobilization; however rectal temperatures of 5 deer ($n = 3$ in winter; $n = 2$ in summer) exceeded 40°C, a sign of hyperthermia. Respiration rate and pulse rate peaked at about 20 minutes post-medetomidine HCl and ketamine HCl injection, then generally declined thereafter. No mortalities were observed in our study. Medetomidine HCl and ketamine HCl doses for Clover-trapped White-tailed Deer provided satisfactory induction times, sufficient level of anesthesia for short-distance relocation or radio-collar attachment, and were effectively reversed with an IM injection of atipamezole HCl.

Key words: White-tailed Deer, *Odocoileus virginianus*, atipamezole, capture, chemical restraint, Clover trap, deer, ketamine, immobilization, medetomidine, Missouri.

White-tailed Deer (*Odocoileus virginianus*) have been chemically immobilized with Telazol® (1:1 tiletamine hydrochloride (HCl) and zolazepam HCl) and xylazine HCl (Schultz et al. 1992; Kilpatrick and Spohr 1999), ketamine HCl and xylazine HCl (Mech et al. 1985; Farley et al. 1986; Kreeger et al. 1986; Ballard et al. 1998; Kilpatrick and Spohr 1999), etorphine and xylazine HCl (Presnell et al. 1973; Presidente et al. 1973; Nielsen 1982), xylazine HCl alone (Gibson et al. 1982), phencyclidine HCl (Dean et al. 1973), and succinylcholine chloride (Wesson et al. 1974; Jacobsen et al. 1976). Kreeger (1996) recommended 4.4 mg/kg Telazol® and 2.2 mg/kg xylazine HCl to immobilize White-tailed Deer; 0.125 mg/kg yohimbine HCl was the recommended antagonist. Recently, Kilpatrick and Spohr (1999) used a 4.8:3.9 mg/kg dose of Telazol®: xylazine HCl to dart free-ranging White-tailed Deer. Alternative drugs recommended by Kreeger (1996) include ketamine HCl and xylazine HCl, etorphine, xylazine alone (for calm deer only), and a combination of medetomidine HCl and ketamine HCl.

Medetomidine HCl depresses the central nervous system and acts similarly to xylazine HCl (Jalanka and Roeken 1990), but with greater affinity to alpha$_2$-adrenoreceptors (Klein and Klide 1989; Jalanka and Roeken 1990; Kreeger 1996). Ketamine HCl, an anesthetic, is often combined with a tranquilizer or sedative to improve induction and recovery (Haigh 1982; Kreeger 1996). Medetomidine HCl and ketamine HCl alone or in combination with other drugs have been successfully used to immobilize a diversity of large ungulates including Reindeer (*Rangifer tarandus tarandus*) (Ryeng et al. 2001, 2002), Mule Deer (*Odocoileus hemionus*) (Caulkett et al. 2000), Mule Deer/White-tailed Deer hybrids (Caulkett et al. 2000), Sika Deer (*Cervus nippon*) (Tsuruga et al. 1999), gemsbok (*Oryx gazella*) (Grobler et al. 2001), Roan Antelope (*Hippotragus equinus*) (Citino et al. 2001), Blue Duiker (*Cephalophus monticola*) (Bailey et al. 1995), Moose (*Alces alces*) (Arnemo 1995), Tigers (*Panthera tigris*) (Miller et al. 2003), Impala (*Aepyceros melampus*) (Bush et al. 2004), European Mink (*Mustela lutreola*) Fournier-Chambrillon et al. 2003) and Red Deer (*Cervus elaphus*) (Arnemo et al. 1994).

Notable among the advantages listed in these and other studies is the ability to reverse medetomidine HCl

with an intramuscular (IM) injection of atipamezole HCl (Tsuruga et al. 1999; Haulena et al. 2000). Atipamezole HCl is an extremely efficient alpha$_2$-adrenergic antagonist compared with yohimbine HCl and tolazoline HCl (Kreeger 1996) and effectively reverses medetomidine HCl in many wildlife species (Tsuruga et al. 1999; Haulena et al. 2000; Grobler et al. 2001). If medetomidine HCl and ketamine HCl were as efficient and safe as other immobilizing agents (e.g., Telazol® and xylazine HCl) and if an IM injection of atipamezole HCl was a safe and effective antagonist, this combination could prove efficacious in field studies. Our objective was to determine the effectiveness and safety of immobilizing Clover-trapped White-tailed Deer with medetomidine HCl and ketamine HCl, and the feasibility of reversing this combination with an IM injection of atipamezole HCl, during winter and summer by monitoring immobilization intervals and vital signs. To our knowledge, an evaluation using medetomidine HCl and ketamine HCl to immobilize free-ranging White-tailed Deer and antagonism by atipamezole HCl has not been previously published.

## Methods

Our review of the medetomidine HCl and ketamine HCl combination took place in winter and summer 2001. In summer and winter, we trapped White-tailed Deer in Clover traps (McCullough 1975). During winter we trapped deer at the Charles W. Green Conservation Area, located near Ashland, Missouri. Traps were baited with corn, set each evening, and checked at sunrise. All winter-trapped and immobilized deer ($n$ = 5) were captured within a 4-ha research enclosure for relocation to another on-site 4-ha enclosure. These deer were not habituated to humans.

In summer, we trapped White-tailed Deer at the Thomas S. Baskett Wildlife Research and Education Area, located near Ashland, Missouri. Traps, baited with salt, alfalfa, and corn, were set each evening and checked at sunrise. We captured and immobilized summer-trapped deer ($n$ = 4) for purposes of radio-collar attachment. These deer were free-ranging animals and not habituated to humans.

In winter and summer, we immobilized adult deer (> 1.5 years of age) ($n$ = 2 in winter; $n$ = 3 in summer) using an estimated 0.055 mg/kg medetomidine HCl and 2.5 mg/kg ketamine HCl; 0.06 mg/kg medetomidine HCl and 2.5 mg/kg ketamine HCl was administered to subadult deer (< 1.5 years of age) ($n$ = 3 in winter; $n$ = 1 in summer). Adult deer, estimated to be 60 kg, were given 3.3 mg of 1 mg/ml Domitor® (medetomidine HCl; Orion Corporation, Orion–Farmos, Espoo, Finland) and 150 mg of 100 mg/ml Ketaset® (ketamine HCl; Fort Dodge Laboratories, Inc., Fort Dodge, Iowa, USA). Subadult deer, estimated to be 30 kg, were given 1.8 mg of 1 mg/ml medetomidine HCl and 75 mg of 100 mg/ml ketamine HCl. We injected drugs IM into the biceps femoris with a hand syringe. Sex and age (adult or subadult) were recorded and during winter each deer was marked with a plastic cattle ear tag in one ear for later identification. In summer, deer were fitted with radio-transmitters.

Following sedation in winter and summer, we applied an ophthalmic ointment and blindfolded the deer. In winter, we relocated deer to a different on-site 4-ha enclosure. Two or three field assistants placed the sedated deer into the rear of a vehicle (range from 100 to 300 m away), which was driven to the release enclosure (< 1 km driving distance). Each deer was carried into the enclosure (< 30 m away), and placed in a sternal recumbent position.

We reversed the medetomidine HCl and ketamine HCl combination with an IM injection of Antisedan® (atipamezole HCl; Orion Corporation, Orion–Farmos, Espoo, Finland) into the biceps femoris with a hand syringe at a rate of 0.275 mg/kg (16.5 mg of 5 mg/ml atipamezole HCl) for adults and 0.3 mg/kg (9 mg of 5 mg/ml atipamezole HCl) for subadults. We visually monitored all deer until they departed the area.

During winter and summer, we attempted to monitor immobilization intervals and vital signs at 5-minute intervals. For all deer, we recorded time of medetomidine HCl and ketamine HCl injection, induction (time from injection to time animal was handled), atipamezole HCl administration, "head up" (time when the animal first lifted its head), "standing" (time when the animal first stood up), and "walking" (time when the animal successfully departed the area). We also recorded respiration rate (breaths/minute), rectal temperature (°C), and pulse rate (beats/minute) at 5-minute intervals beginning at the time of medetomidine HCl and ketamine HCl injection for respiration rate and beginning 10 minutes post-medetomidine HCl and ketamine HCl injection for temperature and heart rate.

## Results

Nine deer ($n$ = 5 in winter, including 2 female subadults, 1 male subadult, 1 female adult, and 1 male adult; $n$ = 4 in summer, including 3 adult females and 1 female subadult) were immobilized using the drug combination described above and either relocated or equipped with a radio-collar. No mortality has been observed 10 months post-winter immobilization and 5 months post-summer immobilization.

Mean induction time was 11.2 minutes (SE = 2.5, range = 5.4 – 24.3) in winter and 6.5 minutes (SE = 0.8, range = 6.2 – 7.5) in summer. Time to atipamezole HCl injection averaged 54.4 minutes (SE = 3.7, range = 37.7 – 79.2) in winter and 33.4 (SE = 1.3, range = 30.4 – 33.8) in summer. After atipamezole HCl injection, the mean time to head up was 11.4 minutes (SE = 2.9, range = 4 – 27.5) in winter and 9.3 minutes (SE = 0.7, range = 8.4 – 9.9) in summer. Mean time to standing was 15.9 minutes (SE = 3.6, range = 4.4 – 41) in winter and 10.5 minutes (SE = 3.2, range = 4.7 – 12.3) in summer. The mean time to walking was 17.1 minutes

(SE = 3.5, range = 7.5 – 41.5 minutes) in winter and 11.3 minutes (SE = 3.8, range = 4.7 – 13.5) in summer.

With the exception of rectal temperatures, other vital signs were considered normal (Table 1). Rectal temperatures were stable from 10 – 30 minutes post-medetomidine HCl and ketamine HCl injection in summer and winter (Table 1). Temperatures of 1 subadult female captured in winter were 37.4°C and 36.2°C at 70 and 110 minutes post-induction, respectively; thus, she was within 1.2°C of becoming hypothermic (defined as < 35°C; Kreeger 1996; DelGuidice et al. 2001). No attempt was made to increase body temperature of this individual prior to antagonism with atipamezole HCl. After atipamezole HCl administration, it took that individual 41.5 minutes to depart, the maximum time observed in our study. Rectal temperatures of 5 deer ($n$ = 3 in winter, $n$ = 2 in summer) exceeded 40°C, a sign of hyperthermia. No attempt was made to decrease body temperature of these animals prior to antagonism. Respiration rates showed little variability in summer and winter and were generally in the upper 20's to low 30's (breaths/minute) (Table 1) peaking at about 20 minutes post-medetomidine HCl and ketamine HCl injection. Pulse rates peaked about 20 minutes post-medetomidine HCl and ketamine HCl injection at 95 beats/minute (SE = 3.6) in winter and 103 beats/minute (SE = 1.4) in summer and declined thereafter to 74 beats/minute (SE = 5.6) in winter and 88 beats/minute (SE = 3.1) in summer at 30 minutes post-medetomidine HCl and ketamine HCl injection (Table 1). No other adverse side effects were noted.

During summer captures, response to IM injection of atipamezole HCl was predictable, as previously described by Jalanka and Roeken (1990). Within 3 – 6 minutes of atipamezole HCl injection, "ear-twitching" occurred, followed by leg extensions after an additional 3 – 6 minutes, and "head up" 2 minutes thereafter. Standing followed within another 2 minutes and the animal departed almost immediately with good muscle coordination.

## Discussion

Medetomidine HCl and ketamine HCl doses for Clover-trapped deer provided satisfactory induction times, produced a sufficient level of anesthesia for short-distance relocation or radio-collar attachment, and were effectively reversed with an IM injection of atipamezole HCl. Small dosage volume, ease of preparation and predictable responses to sedation and to the antagonist make this combination a useful alternative to drug combinations that may require prolonged recovery.

Medetomidine HCl and ketamine HCl provided induction times similar to those reported in other studies and with other drugs. For 13 captive White-tailed Deer in Minnesota, it took 2 to 35 minutes (median = 8, SE = 1.2) from the time of xylazine HCl and ketamine HCl administration before deer lost the ability to stand (Mech et al. 1985). Our mean induction time in winter ($\bar{x}$ = 11.2 minutes, SE = 2.5, range = 5.4 – 24.3, $n$ = 5) was about double the median time of 6.2 minutes (range = 0.5 – 17.3) reported by Jalanka and Roeken (1990) for 28 captive White-tailed Deer housed at the Helsinki Zoo, but similar to our summer mean time of 6.5 minutes (SE = 0.8, range = 6.2 – 7.5). In the Helsinki Zoo study, deer were given an average of 61 ug/kg (SD = 14, median = 58, range = 37 – 98) medetomidine HCl and a mean ketamine HCl dose of 1.6 mg/kg (SE = 0.3, median = 1.5, range = 1 – 2.3).

The time to walking after the IM injection of atipamezole HCl was similar to that for deer in other studies reversed with yohimbine HCl, but was less

TABLE 1. Mean ± SE (N) vital signs of White-tailed Deer immobilized with medetomidine hydrochloride (HCl) and ketamine HCl, and antagonized with atipamezole HCl during winter and summer 2001 in mid-Missouri for purposes of relocation (winter) and radio-collar attachment (summer). Adults were immobilized with 0.055 mg/kg medetomidine HCl and 2.5 mg/kg ketamine HCl and subadults were immobilized with 0.06 mg/kg medetomidine HCl and 2.5 mg/kg ketamine HCl. Adults were antagonized with 0.275 mg/kg of atipamezole HCl and subadults were antagonized with 0.03 mg/kg of atipamezole HCl. We have not reported data where information was collected on < 2 deer. Time 0 is the time of medetomidine HCl and ketamine HCl injection.

| | Winter | | | Summer | | |
|---|---|---|---|---|---|---|
| Time (minutes) | Respiration Rate (breaths/minute) | Pulse Rate (beats/minute) | Temperature (°C) | Respiration Rate (breaths/minute) | Pulse Rate (beats/minute) | Temperature (°C) |
| 0 | 27.2 ± 2.1 (5) | – | – | 23 ± 1.4 (4) | – | – |
| 5 | 27.2 ± 2.3 (5) | – | – | 23 ± 2.2 (4) | – | – |
| 10 | 28.8 ± 2.9 (5) | 87 ± 3.6 (4) | 41.1 ± 0.5 (2) | 31 ± 2.4 (4) | 98 ± 2.0 (4) | 39.9 ± 1.2 (4) |
| 15 | 29.6 ± 3.2 (5) | 88 ± 4.3 (4) | 40.9 ± 0.8 (4) | 31 ± 2.2 (4) | 101 ± 1.9 (4) | 39.8 ± 1.4 (4) |
| 20 | 31 ± 3.2 (4) | 94.7 ± 3.6 (3) | 40.6 ± 1.2 (3) | 30 ± 2.6 (4) | 103 ± 1.9 (4) | 39.8 ± 1.4 (4) |
| 25 | 28 ± 3.1 (5) | 86 ± 3.5 (4) | 40.4 ± 1.2 (4) | 30 ± 3.1 (4) | 101 ± 2.4 (4) | 39.6 ± 1.3 (4) |
| 30 | 29.3 ± 3.6 (4) | 74 ± 5.6 (2) | 39.3 ± 1.9 (2) | 32 ± 2.9 (4) | 88 ± 3.1 (4) | 39.3 ± 1.2 (4) |
| 35 | 24 ± 2.4 (2) | 75 ± 1.2 (2) | – | 24 ± 0.0 (2) | – | – |
| 40 | – | – | – | 24 ± 0.0 (2) | – | – |
| 45 | 32 ± 3.3 (3) | – | – | – | – | – |
| 50 | 28 ± 3.3 (3) | – | 40.1 ± 1.2 (2) | – | – | – |

variable. An intravenous injection of yohimbine HCl following xylazine HCl and ketamine HCl immobilization resulted in an adult male walking in 1.5 minutes (SE = 0.5, $n$ = 2 immobilizations) to 26.5 minutes (SE = 11.5, $n$ = 4 immobilizations) for an adult female (Mech et al. 1985). For 22 White-tailed Deer (18 free-ranging captured using drop nets and 4 captive) immobilized with xylazine HCl and ketamine HCl, an IM injection of yohimbine HCl produced a mean recovery time of 11.6 minutes (SE = 2.3) (Wallingford et al. 1996). Hsu and Shulaw (1984) used an IV injection of yohimbine HCl and reported a mean recovery time of 4.4 minutes (SD = 5.4 minutes) for xylazine HCl-immobilized deer.

With the exception of rectal temperature, the vital signs observed in this study were within the normal range of reported values for White-tailed Deer. Mautz and Fair (1980) reported pulse rates of a 46-kg adult White-tailed Deer female in July that was lying, standing/walking, and running at 65, 74, and 106 beats per minute, respectively. Pulse rates observed in this study were similar to predicted walking pulse rates of White-tailed Deer (Moen 1978: 722), yet higher than those rates reported by Jalanka and Roeken (1990: 267). Rectal temperatures of five deer were above 40ºC, a sign of hyperthermia (Kreeger 1996). Average rectal temperatures in our study in winter (39.3ºC at 30 minutes, SE = 1.9, $n$ = 2) and summer (39.3ºC at 30 minutes, SE = 1.2, $n$ = 4) are similar to the maximum rectal temperatures reported by DelGuidice et al. (2001:1151) for White-tailed Deer captured by Clover trap and immobilized with xylazine HCl and ketamine HCl during the winter in Minnesota. Also in Minnesota, Rogers et al. (1987) reported rectal temperatures of two female free-ranging White-tailed Deer fawns in all seasons during various activities ranged between 38.2º and 40.1ºC. Rectal temperatures of 3 adult male White-tailed Deer in Mississippi, averaged 39.3ºC during late August and September and 38.6ºC in early December (Demarais et al. 1986). As suggested by DelGiudice et al. (2001), corrective actions (i.e., packing snow around the animal) should be taken when immobilized animals become hyperthermic. Consequently, rectal temperatures should be monitored and protocols should be established to determine when corrective actions should begin (DelGiudice et al. 2001).

Both medetomidine HCl and ketamine HCl have wide safety margins, produce calm inductions in several artiodactyls, are safe for humans (Jalanka and Roeken 1990), and have not caused any apparent detrimental effects in pregnant females (Jalanka 1993). Few adverse side effects were noted by Jalanka and Roeken (1990) after 1240 immobilizations with medetomidine HCl, ketamine HCl, and antagonism with atipamezole HCl. Worth noting, some ruminants became resedated between 30 and 240 minutes post-IV reversal with atipamezole HCl (Jalanka and Roeken 1990) and unremarkable ruminal tympany was common in ruminants prior to atipamezole HCl administration (Jalanka and Roeken 1990; Jalanka 1993).

A disadvantage of the medetomidine HCl, ketamine HCl, and atipamezole HCl combination is cost. In U.S. currency, cost to immobilize each adult deer was $34.72 ($32.76 for medetomidine HCl and $1.96 for ketamine HCl) and $18.85 for each subadult deer ($17.87 for medetomidine HCl and $0.98 for ketamine HCl). Atipamezole HCl cost $33.22 per adult deer and $18.14 for each subadult deer. In contrast, Kilpatrick and Spohr (1999) reported a cost of $8.44/deer for Telazol® and xylazine HCl immoblized deer and $6.34/deer for ketamine HCl and xylazine HCl without lyophilizing costs. With lyophilizing, costs were $10.05/deer for Telazol® and xylazine HCl and $16.49 for ketamine HCl and xylazine HCl (Kilpatrick and Spohr 1999). Consequently, use of medetomidine HCl, ketamine HCl, and atipamezole HCl may be cost-prohibitive in studies requiring immobilization of many animals. However, given the desirable properties discussed above, including rapid reversal that requires less manpower time, these desirable qualities may outweigh drug costs. Also, the ability to administer an antagonist IM may be advantageous in field studies (Wallingford et al. 1996). We recommend researchers investigate the utility of reversing the less costly and popular Telazol®/xylazine HCl and ketamine HCl/xylazine HCl combinations with an IM injection of atipamezole HCl.

The combination of medetomidine HCl, ketamine HCl, and atipamezole HCl reported herein provided an effective level of anesthesia for Clover-trapped White-tailed Deer. We recommend the use of 0.055 mg/kg medetomidine and 2.5 mg/kg ketamine HCl to immobilize adult Clover-trapped White-tailed Deer and 0.06 mg/kg medetomidine HCl and 2.5 mg/kg ketamine HCl for subadults. Furthermore, we recommend 0.275 mg/kg and 0.3 mg/kg of atipamezole, injected IM, to reverse this combination in adults and subadults, respectively.

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