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Source: Journal of Wildlife Diseases, 41(3) : 659-663

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-41.3.659

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Journal of Wildlife Diseases, 41(3), 2005, pp. 659–663
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Tiletamine–Zolazepam–Xylazine Immobilization of American Marten (*Martes americana*)

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ABSTRACT: The effectiveness of tiletamine–zolazepam (Telazol) and xylazine as an immobilizing combination for American martens (*Martes americana*) was evaluated. Fifteen martens were intramuscularly injected on 19 occasions using a 3:2 mixture of tiletamine–zolazepam (3.2±0.6 mg/kg [mean ± SD]) and xylazine (2.1±0.4 mg/kg) at Pictured Rocks National Lakeshore, Michigan (USA) during May to October 2002–2003. Mean induction time was 2.5±1.8 min; mean recovery time was 70.8±31.9 min. There was no relation between the amount (mg/kg) of tiletamine–zolazepam–xylazine injected and induction (r^2=0.08, P=0.26). However, there was an inverse relation (r^2=0.28, P<0.01) between dosage and time to first effect of immobilants. Time to recovery increased (r^2=0.21, P=0.05) with increased dosage. Mean heart rate, respiratory rate, and body temperature declined through 10 min postinduction (P<0.05). No mortality occurred and no short-term adverse effects were observed in recaptured individuals. In conclusion, a 3:2 mixture of tiletamine–zolazepam/xylazine is a safe and effective immobilizing agent for martens when conducting nonsurgical field procedures. Immobilizing martens with 4.2 mg/kg tiletamine–zolazepam and 2.8 mg/kg xylazine should provide ≤30 min of handling time and allow full recovery in about 70 min.

Key words: American marten, chemical immobilization, field study, *Martes americana*, telazol, tiletamine, xylazine, zolazepam.

Field immobilization of American marten (*Martes americana*) has been conducted with halothane (Herman et al., 1982) and injectable anesthetics including ketamine (Wright, 1983) and ketamine–xylazine (Belant, 1992). Kreeger (1999) recommended using 10 mg/kg ketamine and 0.2 mg/kg medetomidine, with an alternative combination of 60 mg/kg ketamine and 12 mg/kg xylazine.

Telazol (100 mg/ml, Fort Dodge Animal Health, Fort Dodge, Iowa, USA) containing a 1:1 combination of tiletamine and zolazepam has been used effectively on numerous wildlife species (e.g., Mitcheltree et al., 1999; Golden et al., 2002). Advantages of tiletamine–zolazepam include a high therapeutic index, minimal respiratory effects, and good cardiovascular support (Kreeger, 1999). Xylazine (Xyla-ject®, 100 mg/ml, Phoenix Pharmaceutical Inc., St. Joseph, Missouri, USA) is an α_2-adrenergic tranquilizer also used to immobilize wildlife, typically in combination with other anesthetics (Kreeger, 1999). Tiletamine–zolazepam–xylazine has been used successfully on grizzly bears (*Ursus arctos*; Cattet et al., 2001) and raccoons (*Procyon lotor*, Belant, 2004); use of tiletamine–zolazepam–xylazine for immobilizing American martens has not been reported. The objective of this study was to assess effectiveness of tiletamine–zolazepam/xylazine for field immobilization of American martens.

The study was conducted from May to October 2002–2003 at Pictured Rocks National Lakeshore, central Upper Peninsula of Michigan (46°27′N, 86°33′W). Ambient temperatures during the study ranged from about 4–30 C. Martens were captured in live traps (model 108, Tomahawk Live Trap Company, Tomahawk, Wisconsin, USA) baited with sardines or chicken and commercial trapping lures. After visually estimating body weight, all martens were intramuscularly injected in the gluteus maximus, gluteus medius, or vastus laterallis using a 1-ml (0.01-ml graduations) hand syringe containing a 3:2 combination of tiletamine–zolazepam and xylazine. Each 500-mg vial of Telazol was reconstituted with 5 ml of sterile water to create the 100 mg/ml tiletamine–zolazepam solution. Xylazine (333 mg; 3.33 ml) was then added to the tiletamine–zolazepam

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TABLE 1. Initial doses, weight, and physiologic responses of 19 marten immobilizations with a 3:2 combination of tiletamine–zolazepam and xylazine, May to October 2002–2003, Pictured Rocks National Lakeshore, Michigan, USA.

Parameter	*n*	Mean	SD	Range
Tiletamine–zolazepam (mg/kg)	19	3.3	1.1	1.8–6.0
Xylazine (mg/kg)	19	2.2	0.7	1.2–4.0
Weight (g)	19	980	190	620–1,250
First effect (min)	17	0.96	0.31	0.50–1.27
Induction time (min)	19	2.5	1.8	0.8–6.1
Recovery time (min)	19	70.8	31.9	30.3–122.0
Heart rate at 0 min (beats/min)	19	163	34	66–226
Heart rate at 10 min (beats/min)	17	94	24	100–184
Heart rate at 20 min (beats/min)	3	123	—	108–142
Respiratory rate at 0 min (breaths/min)	18	67	30	18–124
Respiratory rate at 10 min (breaths/min)	17	48	30	27–150
Respiratory rate at 20 min (breaths/min)	3	39	—	22–58
Rectal temperature at 0 min (C)	19	39.3	1.0	37.7–40.6
Rectal temperature at 10 min (C)	17	37.0	2.2	34.1–41.8
Rectal temperature at 20 min (C)	3	37.2	—	35.0–38.5

solution, creating a 3:2 tiletamine–zolazepam/xylazine mixture.

Procedures used to document marten response to immobilization followed Belant (1991). Induction time was defined as the interval between injection and lack of responsiveness to tactile stimuli. Recovery time was the interval between immobilization and the animal's ability to maintain an upright posture and respond to external stimulation, including moving the live trap to different positions. We also measured time to first effect, which was defined as the interval between injection and when the animal exhibited initial signs of immobilization (e.g., head bobbing, inability to keep eyelids open). Rectal temperature, respiratory rate, and resting heart rate were recorded as soon as practical after immobilization (≤3 min) and at 10 and 20 min postinduction. Rectal temperature was recorded using a digital thermometer. Respiratory rate was determined by counting complete thoracic cycles (inhalation and exhalation) for 30 or 60 sec. Resting heart rate was determined by placing fingertips against the marten's chest and counting beats for 30 or 60 sec. Each marten was weighed, a tag placed in each ear (model 1005-1, National Band and Tag Company, Newport, Kentucky, USA), and a radio transmitter attached using a collar (Advanced Telemetry Systems, Inc., Isanti, Minnesota, USA). Martens were placed in their respective live traps after handling procedures were completed. All animals were released at the capture site upon full recovery. Linear regression (Zar, 1984) was used to determine the relations between dose and time to first effect, induction time, and recovery time. Paired *t*-tests (Zar, 1984) were used to compare heart rate, respiratory rate, and rectal temperature at 0 and 10 min postinduction. Means are reported with ±1 SD; statistical significance was established as $P \leq 0.05$.

Fifteen martens (13 males, 2 females) were captured and immobilized on 19 occasions; weights ranged from 640–1,250 g. Mean initial doses of tiletamine–zolazepam and xylazine injected were 3.3±1.1 and 2.2±0.7 mg/kg, respectively. A second injection of 0.9–2.7 mg tiletamine–zolazepam and 0.6–1.8 mg of xylazine was required on 10 occasions to sustain sedation during handling procedures.

Mean time to first effect of immobilization was 1.0±0.3 min; mean induction time was 2.5±1.8 min (Table 1). Full recovery from immobilization occurred in 70.8±31.9 min. There was a linear relation between dose and time to first effect ($y = 1.43$–

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0.08x, y = time to first effect in minutes and x = dose in mg/kg, $r^2 < 0.28$, $P < 0.01$). No relation between dose and induction time ($y = 3.98 - 0.26x$, y = induction time in minutes and x = dose in mg/kg, $r^2 = 0.08$, $P = 0.26$) was found. There was no relation between total dose and recovery time for martens receiving a single injection ($y = 22.41 + 6.71x$, y = recovery time in minutes and x = dose in mg/kg, $r^2 = 0.41$, $P = 0.06$) or two injections ($y = 18.44 + 11.20x$, y = recovery time in minutes and x = dose in mg/kg, $r^2 = 0.05$, $P = 0.53$). The slopes of these regression lines were similar ($t = 0.42$, 15 df, $P > 0.50$). However, pooled data for all martens demonstrated a direct relation ($y = 21.23 + 6.73x$, y = recovery time in minutes and x = dose in mg/kg, $r^2 = 0.21$, $P = 0.05$) between dose and recovery time. There were reductions in mean heart rate ($t = 1.18$; 16 df; $P = 0.01$), respiratory rate ($t = 3.16$; 15 df; $P = 0.01$), and body temperature ($t = 4.91$; 16 df; $P < 0.01$) from 0–10 min postinduction (Table 1). Physiologic parameters of three martens recorded at 20 min postinduction indicated that heart rate and respiratory rate declined but body temperature remained stable after 10 min.

Induction was rapid; loss of coordination occurred initially in the rear legs, followed by the front legs, neck, and head. Although depth of anesthesia was not evaluated quantitatively, martens typically did not respond to attachment of ear tags. Several martens responded to tooth extraction by attempting to move their head away from the stimulus. No salivation or defecation was observed during anesthesia. Pedal and palpebral withdrawal reflexes were observed within 10–15 min in about half of individuals, which necessitated the second injection. However, no signs of spontaneous recovery were observed. Martens frequently attempted to become upright before returning to a lateral recumbent position during recovery primarily because of a lack of coordination in the rear legs. Martens regained coordination during recovery in the reverse order of induction.

No mortality occurred because of immobilization. Three martens were recaptured up to 17 mo after initial capture. No adverse effects of immobilization were observed; behavior of recaptured individuals subjectively appeared similar to behavior of martens captured initially.

Tiletamine–zolazepam and xylazine doses used for live-trapped martens in this study provided satisfactory induction times and adequate anesthesia for minor field procedures. Cattet et al. (2001) successfully used a 3:2 combination of tiletamine–zolazepam and xylazine at 5 mg/kg to immobilize grizzly bears. Belant (2004) used this same combination and dosage to immobilize raccoons. On the basis of available literature, Kreeger (1999) recommended 10 mg/kg ketamine and 0.2 mg/kg medetomidine, or 60 mg/kg ketamine with 12 mg/kg xylazine as an alternative. That lower xylazine doses were used successfully in this study may be in part because tiletamine–zolazepam is about 2.5 times more potent than ketamine (Beck, 1972).

Martens immobilized with tiletamine–zolazepam/xylazine had decreases in heart rate, respiratory rate, and body temperature through 10 min postinduction, which, excluding body temperature, continued through 20 min postinduction in three individuals. Physiologic depression can be induced by xylazine, which is known to cause respiratory depression and disruption of thermoregulation (Kreeger, 1999). Cattet et al. (2001) reported that grizzly bears immobilized with tiletamine–zolazepam/xylazine had depressed respiration for 15 min postinduction compared with immobilization using tiletamine–zolazepam only. Physiologic depression was not observed in American martens in this study or in raccoons immobilized with tiletamine–zolazepam–xylazine (Belant, 2004). Risks of hypoxemia and hyperthermia have been reported in bears immobilized with tiletamine–zolazepam–xylazine (Cattet et al., 2003a, b); consequently, ox-

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ygenation and body temperature should be closely monitored.

Although recovery times were not unusually long, additional studies could be conducted with varying doses and combinations of tiletamine–zolazepam and xylazine. Use of an antagonist such as yohimbine could further reduce recovery times. Yohimbine reverses the sedation effects of xylazine (Hsu and Lu, 1984) and although its use has not been reported for American marten, yohimbine has been used for other medium-sized carnivores (Deresienski and Rupprecht, 1989). Cattet et al. (2001) reported that yohimbine was generally effective in reversing tiletamine–zolazepam/xylazine immobilization in bears. Finally, use of a tiletamine–zolazepam/medetomidine combination for marten immobilization should be explored. Medetomidine is more potent than xylazine and has been used successfully with tiletamine–zolazepam to immobilize polar bears (*Ursus maritimus*) (Cattet et al., 1997, 1999).

A 3:2 mixture of tiletamine–zolazepam and xylazine was effective for field restraint of American martens. Although martens in this study were immobilized with this mixture at doses ranging from 4.3 to 11.4 mg/kg, I recommend using combined 7 mg/kg (4.2 mg/kg tiletamine–zolazepam, 2.8 mg/kg xylazine) for basic field procedures (e.g., body measurements, radio-tagging). This dose will provide ≤30 min of handling time and allow full recovery in about 70 min. For more invasive field procedures (e.g., tooth extraction, blood sampling) a 10 mg/kg in combination (6 mg/kg tiletamine–zolazepam, 4 mg/kg xylazine) is recommended.

Primary funding for this study was provided by Pictured Rocks National Lakeshore with additional funding from the National Park Service Challenge Cost Share and Recreational Fee Demonstration programs. A. Hales, L. Kainulainen, L. Kruger, and J. Wolford provided field assistance. Trapping and handling procedures conformed to the American Society of Mammalogists Animal Care and Use guidelines and Pictured Rocks National Lakeshore Capture Operations Protocol.

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Received for publication 26 May 2004

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