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Immobilization of Muskrats (*Ondatra zibethicus*) with Ketamine and Xylazine

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ABSTRACT: The effectiveness of ketamine and xylazine as an immobilizing combination for muskrats (*Ondatra zibethicus*) was evaluated. Eleven muskrats were intramuscularly injected using a high (n = 7) or low (n = 4) dosage of a 20:1 mixture of ketamine (12 or 20 mg) and xylazine (0.6 or 1.0 mg) in Carlton County, Minnesota (USA) from 1 to 4 May 1995. Mean (±SD) induction times for muskrats receiving a high dosage (6.5 ± 2.6 min) or low dosage (7.0 ± 1.6 min) was similar (P = 0.71). In contrast, muskrats receiving a low dosage recovered sooner (37.0 ± 15.1 min) than muskrats receiving a high dosage (62.2 ± 15.6 min) (P = 0.04). There was a positive linear relationship (r^2 = 0.75, P = 0.02) between the amount (mg/kg) of ketamine-xylazine injected and recovery time but not between the amount injected and induction time (r^2 = 0.49, P = 0.18). Heart rate, respiratory rate, and body temperature were similar (P = 0.20 to 0.62) between high and low dose groups. No mortality occurred nor were short-term adverse effects observed in recaptured individuals. I conclude that a 20:1 mixture of ketamine-xylazine is a safe and effective immobilization agent for muskrats when conducting non-surgical field procedures. Immobilizing muskrats with 15 mg/kg ketamine and 0.75 mg/kg xylazine should provide about 10 min of handling time before arousal and allow full recovery in <60 min.

Key words: Muskrats, *Ondatra zibethicus*, immobilization, ketamine, xylazine, field study.

Muskrats (*Ondatra zibethicus*) have been immobilized using ketamine (Gilbert, 1976) and sodium pentobarbital (MacArthur, 1978). Inhalation anesthetics, including halothane, methoxyflurane, and isoflurane also have been successfully used to anesthetize muskrats (Blanchette, 1989; Lacki et al., 1989; Belant, 1995). Seal and Kreeger (1987) suggested a combination of ketamine (20 to 40 mg/kg) and xylazine (1 mg/kg) as a suitable injectable anesthetic for muskrats.

Ketamine is a cyclohexane-based drug that creates dissociative anesthesia (Seal and Kreeger, 1987). Used alone, ketamine frequently results in rough induction and recovery which often includes convulsions. Xylazine is an alpha$_2$-adrenergic agonist that induces transitory hypertension prior to prolonged hypotension (Kreeger et al., 1986; Seal and Kreeger, 1987). Ketamine and xylazine in combination generally result in smooth induction and recovery (Harthoorn, 1976). Various combinations of ketamine and xylazine have been used to immobilize numerous mammalian species; however, their use for immobilizing muskrats has not been reported. My objective was to evaluate the effectiveness of ketamine and xylazine for immobilizing muskrats and determine a suitable dosage for standard field procedures such as radio-tagging and blood sampling.

The study was conducted from 1 to 4 May 1995 at Rice Portage Lake (48 ha), located in Carlton County, Minnesota, USA (46°40′N, 92°26′W). Ambient temperatures during this period ranged from 4 to 16 C. Muskrats were captured in live traps (Model 103, Tomahawk Live Trap Company, Tomahawk, Wisconsin, USA) baited with carrots. All muskrats were intramuscularly injected in the gluteus maximus, gluteus medius, or vastus laterallis using a 1-ml (0.01 ml graduations) hand syringe containing a 20:1 (12.0:0.6 mg or 20.0:1.0 mg) combination of ketamine (100 mg/ml, KetaVed®, Boehringer Ingelheim Animal Health, Inc., St. Joseph, Missouri, USA) and xylazine (20 mg/ml, Anased, Lloyd Laboratories, Shenandoah, Iowa, USA). Ketamine and xylazine were premixed (10.0 ml ketamine and 2.5 ml xylazine) before injecting muskrats.

Procedures used to document muskrat response to immobilization followed Be-

lant (1991). Induction time was the interval between injection and lack of responsiveness to tactile stimuli. Arousal time was recorded as the interval between immobilization and head mobility. Standing time was the interval between immobilization and upright posturing. Recovery time was the interval between immobilization and the animal's ability to maintain an upright posture and respond aggressively while moving the livetrap to different positions. Rectal temperature, respiratory rate, and resting heart rate were recorded as soon as practical after immobilization (≤2 min). Rectal temperature was recorded using a digital thermometer. Respiratory rate was determined by counting complete thoracic cycles (inhalation and exhalation) for 30 sec. Resting heart rate was determined by placing fingertips against the muskrat's chest and counting beats for 15 sec. Each muskrat was weighed and received a tag in each hindfoot (Model 1005-1, National Band and Tag Company, Newport, Kentucky, USA). One muskrat received a radio transmitter attached using a collar (Advanced Telemetry Systems, Inc. Isanti, Minnesota). Muskrats were placed in their respective live-traps after handling procedures were completed. All animals were released at the site of capture upon full recovery. Regression analysis (Zar, 1984) was used to determine the relationships between induction time and dose, and recovery time and dose. Independent t-tests (Zar, 1984) were performed to determine whether differences in physiological responses occurred between muskrats receiving a high or low dose of ketamine-xylazine.

Eleven muskrats (six males, five females) were successfully immobilized over a wide range of weights (0.76 to 1.23 kg) using ketamine-xylazine. The first seven muskrats captured were injected with 20 mg ketamine and 1 mg xylazine. Recovery time of these individuals was longer than desired. Consequently, the dose was reduced to 12 mg ketamine and 0.6 mg xylazine for subsequent immobilizations. No additional injections were required to sustain sedation at either dose level during handling procedures although two muskrats which received a low dose regained slight motor coordination of their legs subsequent to completion of handling. No mortality was observed during this study.

Mean (±SD) induction times for muskrats receiving a high dose (6.5 ± 2.6 min) or low dose (7.0 ± 1.6 min) were similar ($P = 0.71$) (Table 1). In contrast, muskrats receiving a low dose recovered sooner (37.0 ± 15.1 min) than muskrats receiving a high dose (62.2 ± 15.6 min) ($P = 0.04$). There was a positive linear relationship ($y = 3.28x - 4.67$; y = recovery time in min and x = dose in mg/kg, $r^2 = 0.75$, $P = 0.02$) between dose and recovery time but not between dose and induction time ($y = 10.77 - 0.23x$, y = induction time in min and $\bar{x}$ = dose in mg/kg, $r^2 = 0.49$, $P = 0.18$). Heart rate, respiratory rate, and body temperature was similar ($P = 0.20$ to 0.62) between high and low dosage groups.

Individuals began to lose leg and neck coordination within 1 to 2 min of injection and were positioned sternal or lateral within 3 to 4 min. Attaching tags to the hind feet often caused momentary reflexive leg movements and occasional arching of the back. Most muskrats occasionally bit the trap between standing time and recovery time; three individuals moved violently in an uncoordinated fashion for several 5- to 15-sec intervals during this period. The only injuries apparently caused by capture and immobilization were minor abrasions or cuts on the hind feet and slight bleeding at the nose from contacting the trap. No convulsions, mucous secretions, or vomiting were observed. Three muskrats were recaptured 1 or 2 days after immobilization. No short-term adverse effects of sedation were observed; behavior of recaptured individuals appeared similar to behavior of muskrats captured initially.

Ketamine and xylazine doses used for live-trapped muskrats in this study provided satisfactory induction times and ade-

TABLE 1. Dosages, weight, and physiological responses of muskrats immobilized with ketamine and xylazine using high (20 mg ketamine : 1 mg xylazine; $n = 7$) and low (12 mg ketamine : 0.6 mg xylazine; $n = 4$) dosages, 1 to 4 May 1995, Carlton County, Minnesota, USA.

	High dosage			Low dosage		
	Mean	SD	Range	Mean	SD	Range
Ketamine (mg/kg)	18.8	3.8	16.3–26.3	13.2	2.2	11.0–15.8
Xylazine (mg/kg)	0.9	0.2	0.8–1.3	0.7	0.1	0.6–0.8
Weight (kg)	1.09[a]	0.18	0.76–1.23	0.93[a]	0.16	0.76–1.09
Induction time (min)	6.5[a]	2.6	3.3–11.0	7.0[a]	1.6	5.1–8.8
Arousal time (min)	17.7[b]	4.4	14.8–23.0	7.8[b]	2.5	4.6–9.8
Standing time (min)	30.1[b]	13.8	13.0–52.0	14.8[b]	5.4	7.2–19.5
Recovery time (min)	62.2[b]	15.6	44.5–80.0	37.0[b]	15.1	23.4–56.7
Heart rate at 0 min (beats/min)	155[a]	21	120–180	136[a]	35	116–188
Respiratory rate at 0 min (breaths/min)	55[a]	34	24–128	78[a]	20	52–96
Rectal temperature at 0 min (C)	35.6[a]	1.4	33.9–38.2	36.2[a]	1.9	33.4–37.7

[a] Means are not significantly different ($P > 0.05$).
[b] Means are significantly different ($P < 0.05$).

quate anesthesia. Little comparable data on injectable anesthetics for muskrats exists. Based on available published information, Seal and Kreeger (1987) recommended 20 to 40 mg/kg of ketamine and 1 mg/kg of xylazine to immobilize muskrats. Dell et al. (1983) immobilized muskrats using an estimated 10 mg/kg of ketamine. Gilbert (1976) used 8.8 mg/kg of ketamine for muskrat immobilization. Induction or recovery times, or level of anesthesia observed, were not reported in these latter two studies; however, Dell et al. (1983) performed procedures on muskrats similar to those done during this study.

Although recovery times I observed were not unusually long, additional studies should be conducted with varying dosages and combinations of ketamine and xylazine in conjunction with an antagonist such as yohimbine. Yohimbine reverses the sedation effects of xylazine (Hsu and Lu, 1984) and may partially antagonize the effects of ketamine (Deresienski and Rupprecht, 1989). Although yohimbine was not specifically recommended for muskrats by Seal and Kreeger (1987), it has been used previously for other rodent species.

A 20:1 mixture of ketamine and xylazine is a safe and effective immobilization agent for muskrats. Although muskrats were successfully immobilized using a relatively wide range of dosage levels (11.7 to 26.3 mg/kg ketamine and 0.6 to 1.3 mg/kg xylazine), I recommend using 15 mg/kg ketamine and 0.75 mg/kg xylazine for nonsurgical field procedures (e.g., radio-tagging, blood sampling). This dose will provide about 10 min handling time before arousal and allow full recovery within 60 min. If weighing the animal accurately before immobilization is not possible, an initial standard dose of 15 mg ketamine and 0.75 mg xylazine should result in an adequate level of sedation.

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