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Field Immobilization of Muskrats (*Ondatra zibethicus*) for Minor Surgical Procedures

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ABSTRACT: A combination of ketamine hydrochloride and xylazine hydrochloride at doses of 50 mg/kg and 5 mg/kg, respectively, was used to immobilize 48 muskrats (*Ondatra zibethicus*) from October 1993 to November 1994 in Tennessee (USA). Mean (±SD) time for induction was 2.97 ± 1.1 min. After a mean (±SD) duration of 27.2 ± 3.5 min intramuscular yohimbine hydrochloride at a dose of 0.125 mg/kg was administered. Mean (±SD) recovery time was 48.1 ± 21.6 min. All anesthetic inductions were smooth and sufficient depth of anesthesia was achieved to allow surgical collection of adipose tissue. Recovery times were more variable than expected. There was a significant ($P \leq 0.05$) drop in heart rate, respiratory rate, and body temperature during anesthesia. One animal died during recovery.

Key words: Muskrat, *Ondatra zibethicus*, ketamine, xylazine, field immobilization, minor surgical procedures.

Various methods of immobilization of free ranging muskrats have been described. Inhalation anesthesia with methoxyflurane, halothane, and isoflurane using an open drop method has been described (Lacki et al., 1989; Blanchette, 1989; Belant, 1995); however, this method lacks fine control of anesthetic dosage, and also carries the unnecessary risk of exposure of potentially toxic anesthetic agents to the anesthetist (Muir and Hubell, 1989). Precision vaporizers and the associated anesthetic equipment are usually too cumbersome for field use. Prolonged induction and recovery times were also reported in muskrats immobilized with methoxyflurane, leading to a greater incidence of hypothermia and metabolic derangement (Lacki et al., 1989).

Injectable anesthetic agents, ketamine hydrochloride and sodium pentobarbital, have also been used in muskrats (Gilbert, 1976; MacArthur, 1979; Dell et al., 1983). However, ketamine alone can induce excitement, seizures, and has poor muscle relaxant properties (Muir and Hubell, 1989). Pentobarbital has a prolonged duration of effect and has a high mortality rate in rodents (Heard, 1993). Xylazine, an alpha 2 adrenergic agonist sedative, with analgesic and muscular relaxant effects, has been used in combination with ketamine for minimal chemical restraint in a number of rodent species, including muskrats (Belant, 1996). Xylazine also has the advantage that the effects can be reversed with alpha 2 adrenergic antagonists such as yohimbine and thus decrease recovery time. In this paper we describe the use of ketamine and xylazine to chemically immobilize 48 muskrats in the field for the performance of a minor surgical procedure.

From October 1993 to November 1994, 48 muskrats were captured along streams and impoundments on the U.S. Department of Energy's Oak Ridge Reservation, Oak Ridge, Tennessee (USA; 35°56′N, 84°18′W) using two door cage-style live traps (Tomahawk Live Trap Co., Tomahawk, Wisconsin, USA) baited with apples or carrots (Takos, 1943). Captured muskrats were transported in the trap to the immobilization site within 1 hr of capture. A cotton cloth was placed over the trap during transport. Animals and the trap were weighed with a spring balance and the animal's weight was determined by subtracting the weight of the empty trap.

Each muskrat was injected intramuscularly in the trap using a 1-ml hand held syringe containing a combination of ketamine (Ketaset, Fort Dodge Laboratories, Inc., Iowa, USA) and xylazine (Rompun, Miles, Shawnee, Kansas, USA). An initial dosage of 20 mg/kg ketamine and 2 mg/kg

xylazine was used, which was similar to dosages used for restraint by Belant (1996), but the depth of anesthesia was inadequate to allow minor surgical procedures to be performed. During a preliminary dosage trial, doses were incrementally increased until 50 mg/kg ketamine and 5 mg/kg xylazine were found to be the lowest dosage that achieved an adequate level of anesthesia. These dosages were considerably greater than those recommended for restraint by Belant (1996) and were the dosages used in the remaining animals of the present study. If necessary, an additional 25 mg/kg ketamine and 2.5 mg/kg xylazine was given intramuscularly to maintain anesthesia, particularly if the initial injection may have been incomplete. At the end of the procedure yohimbine (Sigma Chemical Company, Gaithersburg, Maryland, USA) was administered intramuscularly with a 1-ml hand held syringe at a dosage of 0.125 mg/kg.

Sex and age class were determined (Baumgartner and Bellrose, 1943); measurements of body, tail, hind foot, and ear length were taken; and a monel ear tag (National Band and Tag Co., Newport, Kentucky, USA) was placed in each ear. A 0.5- to 1.5-g hair sample was collected and the inguinal region was aseptically prepared to allow surgical excision of a small amount of adipose tissue, as part of a concurrent toxicological investigation. Induction time, duration of anesthesia and recovery times were recorded for all individuals. Induction time was defined as time from initial injection until the animal failed to respond to tactile stimulation. The duration of anesthesia was defined as the time from initial injection to the administration of the yohimbine. Recovery time was defined as time from injection of the yohimbine until the animal was upright and able to walk in a coordinated fashion.

Anesthesia was monitored by measuring body temperature, heart rate, and respiratory rate. Body temperature was measured using a rectal thermometer at initial handling and at 10 min intervals. Heart and respiratory rates were measured at the same time intervals. Heart rate was measured by auscultation of the thorax using a stethoscope and respiratory rate was calculated by observing thoracic movements.

The muskrats were returned to the trap after immobilization, the trap was covered with a cotton cloth and placed in a quiet place. Animals were kept in the trap until fully recovered and then released at the capture site.

Animal weights, age classes, and gender, and anesthesia times were analyzed using unpaired student *t*-tests (GraphPad Instat 1990, GraphPad Software Version 1.13, San Diego, California, USA). Physiological data were tested for normal distribution by the method of Shapiro and Wilk (1965). A repeated measures analysis of variance was used to distinguish among measurements of body temperature, heart rate and respiration taken at time 0, 10 and 20 minutes after initial contact. Specific comparisons between time periods were made with the method of Fisher (Einot and Gabriel, 1975). Level for alpha error to determine statistical significance was set at $P \leq 0.05$ for all tests. One individual died approximately 45 min after administration of yohimbine and this individual was not included in the statistical analyses.

The mean (±SD) weight of muskrats trapped was 0.92 ± 0.39 kg (n = 47). Mean (±SD) induction time was 2.97 ± 1.1 min (n = 47). All inductions were smooth and no untoward side effects were noted. Thirty-one of the 47 animals included in the study had no response to manipulations while two animals responded throughout the procedures. The remaining 14 animals responded to stimuli after a mean (±SD) time of 16.3 ± 8.7 min. The mean (±SD) duration of anesthesia and recovery times were 27.2 ± 3.5 and 48.1 ± 21.6 min, respectively (n = 47). Thirty-seven of the animals had an uneventful recovery. Of the remaining nine, six had some mild thrashing and three thrashed violently during recovery. Twenty-seven males and 20 females were

TABLE 1. Summary of physiological data (mean ± SD, range) collected during ketamine (50 mg/kg) and xylazine (5 mg/kg) anesthesia of 46 muskrats, Tennessee, 1993 to 1994.

Time (min)	Heart rate (beats per min)	Respiratory rate (breaths per minute)	Temperature (C)
0[a]	209[b,c] ± 28.8 (156–276)	15[d] ± 5.8 (8–32)	36.6[e] ± 1.2 (33.4–41.0)
10	184[b] ± 32.0 (104–240)	13[d] ± 5.4 (4–24)	35.9[e] ± 1.2 (33.2–38.2)
20	180[c] ± 37.3 (96–272)	15 ± 6.6 (6–32)	35.4[e] ± 1.3 (32.7–38.2)

[a] Time of initial contact with animal.
[b,c,d,e] Paired values are significantly different ($P \leq 0.01$).

used in the study. Twenty-one of the animals were juveniles, based on a body weight of less than 900 g. There were no differences in response to anesthesia between males and females, nor between adults and juveniles as compared by unpaired t tests ($P \leq 0.01$).

Complete data sets of physiological data were only available on 46 animals. There was a significant drop in heart rate, respiratory rate, and body temperature from time 0 to 10 min (repeated measures analysis of variance, $P \leq 0.05$) (Table 1). There was also a significant difference between the initial heart rate and the heart rate at 20 min post contact. Body temperature decreased slowly throughout anesthesia and the mean temperature at 20 min was significantly lower than the mean values for 0 and 10 min.

The induction times reported in this study compared very favorably to the previously reported techniques (Blanchette, 1989; Lacki et al., 1989; Belant, 1995, 1996). The inductions were smooth and rapid and a plane of anesthesia was achieved that allowed minor surgical procedures to be performed. However, the recovery times were more variable than expected. It appeared that yohimbine was not as effective in reversing the effects of the xylazine as has been seen in other species, but it is impossible to establish the degree of yohimbine effectiveness as no control recoveries were performed. In one previous study that used ketamine and xylazine in muskrats, Belant (1996) reported recovery times similar to the present study, despite using lower doses of ketamine and xylazine. Thus, yohimbine may have had some effect in shortening recovery times.

There are a number of possible explanations for the variable recoveries. Yohimbine has a varying clinical effect in different species; for example, yohimbine has no effect on the time until recovery from xylazine sedation in calves (Guard and Schwark, 1984). Muskrats may be similarly refractory or partially refractory to the effects of the yohimbine. The route of administration of yohimbine may have also affected the rapidity of recovery. Muskrats have a considerable layer of subcutaneous adipose tissue. Adipose tissue has a poor vascular supply and would lead to significantly slower absorption if the yohimbine were injected into it. The yohimbine used was not refrigerated and this may have also affected its potency.

The mortality rate (2.1%) was similar to or lower than previous reports. A necropsy was performed but the carcass was severely autolyzed, which precluded a diagnostic examination. The animal was in extremely poor condition which may have predisposed it to multiple metabolic derangements during anesthesia. It is difficult to assess long term survival; however 26 (55%) muskrats were retrapped at least once, from one day to 157 days after initial capture, and did not appear to be detrimentally affected.

In conclusion, ketamine and xylazine combination at this dose appeared to be an excellent anesthetic combination for field immobilization of muskrats that allowed minor surgical procedures to be performed, and is recommended for such

use. However, the recoveries were more variable than desired. Further studies with an investigation of alternative routes of administration or higher dosage of the yohimbine, particularly administered intravenously, may improve recovery times. Medetomidine, a new alpha 2 adrenergic agonist, is thought to potentiate the effects of ketamine to a greater extent leading to a lower dose of the latter drug. Medetomidine can also be reversed by a more specific reversal agent, atipamezole (Jalanka and Roeken, 1990). Use of these two drugs may lead to quicker recoveries and merit investigation.

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