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Isoflurane as an Inhalation Anesthetic for Muskrats (*Ondatra zibethicus*)

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ABSTRACT: The effectiveness of isoflurane as an inhalation anesthetic for muskrats (*Ondatra zibethicus*) was evaluated. Thirty muskrats were anesthetized in an enclosed chamber using 10 ml of isoflurane in Carlton County, Minnesota (USA), from 27 September to 24 October 1994. Mean (±SE) induction time for adults, juveniles, and kits was 20.6 ± 2.9, 21.5 ± 2.4, and 16.9 ± 5.3 min, respectively ($P = 0.77$). Respective mean arousal times for adults, juveniles, and kits were 5.1 ± 0.5, 5.7 ± 0.7, and 5.7 ± 0.6 min ($P = 0.78$). Heart rate, respiration rate, and body temperature were similar among age classes ($P = 0.08$ to 0.58). Mortality (3.3%) was comparable to that of other inhalation anesthetics. No short-term adverse effects were observed in recaptured individuals. Isoflurane is a safe and effective inhalation anesthetic for muskrats, although prolonged induction may limit its use in field studies.

Key words: Muskrats, *Ondatra zibethicus*, isoflurane, inhalation anesthetic, field study.

Muskrats (*Ondatra zibethicus*) have been immobilized using ketamine hydrochloride (Gilbert, 1976) and sodium pentobarbital (MacArthur, 1978). However, the prolonged recovery times from these agents frequently is unsuitable when nonsurgical procedures are employed. Inhalation anesthetics such as halothane and methoxyflurane have been used previously to anesthetize muskrats (Blanchette, 1989; Lacki et al., 1989). Undesirable features of these agents include prolonged induction and recovery time using methoxyflurane and potential effects of halothane on reproductive function (Collins, 1976; Lacki et al., 1989).

Isoflurane is an isomer of enflurane that yields smooth induction and recovery for anesthetized animals (Seal and Kreeger, 1987). It is an excellent muscle relaxant that allows for maintenance of cardiac output through increased heart rate. Although isoflurane has been used for a variety of domestic and wild animals (Steffey and Howland, 1977; Auer et al., 1978; Seal and Kreeger, 1987), no data exist regarding its use for muskrats. Our objective was to evaluate behavior and physiological responses of muskrats anesthetized in the field using isoflurane.

The study was conducted at Kettle Lake (247 ha), located in Carlton County, Minnesota (USA) (46°38′N, 92°43′W). Muskrats were captured in live traps (Model 103, Tomahawk Live Trap Co., Tomahawk, Wisconsin, USA) baited with carrots and apples from 27 September to 24 October 1994. Ambient temperatures during this period ranged from 3 to 19.5 C. Muskrats initially were anesthetized by placing the trap, containing the animal and an open 250-ml jar containing cotton wetted with 10 ml of isoflurane (IsoFlo®, Solvay Animal Health, Inc., Mendota Heights, Minnesota), into a clear plastic bag. Because of difficulties observing animals through the plastic bag, perforations to the bag from the trap, and inconsistent air volumes during anesthetization, a wooden chamber (18 × 19 × 59 cm) with lexan® (Andren's, Inc., Duluth, Minnesota) viewing panels that would contain the live trap was constructed and used.

Procedures used to document muskrat response to anesthetization followed Belant (1991, 1992). Induction time was the interval between live trap placement in the anesthesia chamber and lateral or sternal recumbency. Arousal time was recorded as the interval between recumbency and head mobility. Standing time was the interval between recumbency and upright posturing. Recovery time was the interval between recumbency and the animal's ability to maintain an upright posture and respond aggressively while moving the live trap to different positions. Rectal temper-

TABLE 1. Physiological responses of muskrats anesthetized with isoflurane, 27 September to 24 October 1994, Carlton County, Minnesota, USA.

	Adults (n = 11)			Juveniles (n = 14)			Kits (n = 4)		
	Mean	SE	Range	Mean	SE	Range	Mean	SE	Range
Induction time (min)[a]	20.6	2.9	7.0–37.5	21.5	2.4	11.5–39.0	16.9	5.3	9.6–32.7
Arousal time (min)[b]	5.1	0.5	2.0–6.9	5.7	0.7	2.0–13.0	5.7	0.6	4.1–6.6
Standing time (min)[c]	7.2	0.9	5.6–15.1	7.0	0.7	2.4–14.0	8.5	0.8	7.4–10.9
Recovery time (min)[d]	8.9	0.7	6.7–15.3	8.9	0.7	4.7–15.0	11.4	1.0	8.4–13.1
Heart rate at 0 min (beats per minute)[e]	197	15	96–272	224	11	120–300	208	38	120–304
Respiration at 0 min (breaths per minute)[f]	65	3	54–90	77	3	60–96	70	6	56–84
Rectal temperature at 0 min (C)[g]	96.8	0.6	93.8–100.8	97.5	0.5	94.0–100.4	95.8	0.8	93.9–97.2

[a] Means are not different among age classes (F = 0.27; 2, 26 df; P = 0.77).
[b] Means are not different among age classes (F = 0.25; 2, 26 df; P = 0.78).
[c] Means are not different among age classes (F = 0.49; 2, 26 df; P = 0.62).
[d] Means are not different among age classes (F = 1.73; 2, 26 df; P = 0.20).
[e] Means are not different among age classes (F = 0.55; 2, 26 df; P = 0.58).
[f] Means are not different among age classes (F = 2.82; 2, 26 df; P = 0.08).
[g] Means are not different among age classes (F = 1.25; 2, 26 df; P = 0.30).

ature, respiration rate, and resting heart rate were recorded as soon as practical after anesthetization. Resting heart rate was determined by placing fingertips against the muskrat's chest and counting beats for 15 sec. Muskrats were classified into age classes using weight (adults: 1,050 to 1,410 g; juveniles: 520 to 890 g; kits: 390 to 430 g). Each muskrat received a tag in each ear and hindfoot (Model 1005-1, National Band and Tag Co., Newport, Kentucky, USA). All animals were released at the capture site upon full recovery from anesthesia. Analysis of variance was used to compare muskrat behavior and physiological responses to anesthesia among age classes.

Thirty muskrats (11 adults, 15 juveniles, 4 kits) were captured a total of 52 times. Induction times for adults, juveniles, and kits ranged from 16.9 to 20.6 min; based on a single factor analysis of variance (Zar, 1984), there was no significant difference among the age groups (P = 0.77, Table 1). There also was no difference in recovery times among age classes (P = 0.78). Muskrats that began to recover before procedures were completed were given additional isoflurane by placing the jar over the animal's nose for 5 to 15 sec. Heart rate, respiration rate, and rectal temperature was similar among age classes (P = 0.08 to 0.58).

One muskrat (3.3%) died during handling after it was anesthetized and was not included in Table 1. This juvenile was captured simultaneously with a kit. These individuals were observed fighting when I approached the trap, and fresh scarring was noted for each during handling. Although no necropsy was performed, trauma or stress may have contributed to or been responsible for this fatality.

Muskrat behavior in response to anesthetization generally was uneventful. Most individuals appeared relaxed within 2 to 3 min of placing the drug in the anesthetizing chamber. No mucous secretions or vomiting was observed. Attaching tags, particularly to the hindfeet, appeared to accelerate recovery. Three individuals regained mobility within several seconds during handling but were readily re-anesthetized. Fourteen muskrats were recaptured 1 to 7 days after anesthetization. No short-term adverse effects of isoflurane were observed; behavior of recaptured individuals appeared similar to behavior of muskrats captured initially.

Induction times were comparable to muskrats anesthetized with methoxyflurane, but were considerably longer than those of muskrats anesthetized using halothane (Blanchette, 1989; Lacki et al., 1989). In contrast to Blanchette (1989), mean induction time for kits was similar to mean induction time for adults and juveniles during this study. This may be explained in part by the larger kits anesthetized during this study. Variability in reported induction times among respective inhalation anesthetics may be related to different vapor pressures. Temperature also can influence vapor pressure and subsequent induction times, particularly during field studies when temperature cannot readily be controlled. Recovery times were similar to those reported for halothane (10 to 15 min) but considerably less than those described for methoxyflurane (up to 2 hr) (Blanchette, 1989; Lacki et al., 1989).

Isoflurane compares well with other inhalation anesthetics. Reported disadvantages of halothane and methoxyflurane include mild hepatic dysfunction, cardiac and respiratory arrest, arterial hypotension, kidney failure, and adverse effects on reproductive function (Collins, 1976; Aronson, 1984; Seal and Kreeger, 1987). Fetal malformation from use of isoflurane in laboratory mice and rats has not been reported (IsoFlo material safety data sheet, 1993, Solvay Animal Health, Inc., Mendota Heights, Minnesota). Potential disadvantages of isoflurane include depressed respiration and arrhythmias. However, it is likely the least toxic of inhalation anesthetics currently available. Isoflurane is a safe and effective inhalation anesthetic for muskrats, although prolonged induction may limit its use in field studies.

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