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Sufentanil Citrate Immobilization of Alaskan Moose Calves

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ABSTRACT: Free-ranging Alaskan moose calves (*Alces alces gigas*) were immobilized with 0.12 mg/kg sufentanil (S; $n=16$), 0.12 mg/kg sufentanil plus 0.27 mg/kg xylazine (SX; $n=11$), or 0.007 mg/kg carfentanil plus 0.36 mg/kg xylazine (CX; $n=13$). Immobilants were antagonized with 1.2 mg/kg naltrexone (S) or 1.2 mg/kg naltrexone plus 2.4 mg/kg tolazoline (SX, CX). There were no differences in induction ($P\geq0.29$) or processing ($P\geq0.44$) times between groups. Moose given either S or SX had significantly shorter recovery times than moose given CX ($P=0.001$) and recovery times from S were shorter than from SX ($P=0.02$). Oxygen saturation values for all groups averaged 85± 8%, but were significantly higher ($P=0.048$) for CX (89±7%) than for S (82±8%). Based on these data, sufentanil at 0.1 mg/kg or sufentanil at 0.1 mg/kg plus xylazine at 0.25 mg/kg could provide effective remote immobilization for Alaskan moose calves and could be substituted for carfentanil or thiafentanil should the need arise.

Key words: Alaska, *Alces alces gigas*, carfentanil, immobilization, moose, sufentanil, xylazine.

Although moose (*Alces alces*) can be remotely immobilized with either cyclohexane or opioid drugs, the opioids are generally preferred because of their potency and complete reversibility (Franzmann et al., 1984; Arnemo, 1995; Arnemo et al., 2003). The two most widely used opioids in North America are carfentanil and thiafentanil, both of which are only available from a single supplier (ZooPharm, Laramie, Wyoming, USA). If either of these drugs were to become unavailable, biologists would be left with few effective options for the remote chemical capture of large ungulates.

Sufentanil citrate (N-[4-(methoxymethyl)-1-[2-(2-thienyl) ethyl]-4-piperidyl] propionanilide citrate) is the citrate salt form of sufentanil, a synthetic congener of fentanyl widely used in human medicine as an analgesic supplement in maintenance of general anesthesia (Lacy et al., 1998). Both carfentanil and sufentanil are extremely potent opioids: carfentanil being 10,031 and sufentanil 4,521 more potent than morphine in rats (Van Bever et al., 1976). Although potent, sufentanil has an unusually high safety margin (LD_{50}/lowest ED_{50}) of 25,211 compared to 10,594 for carfentanil in rats (Niemegeers et al., 1976; Van Bever et al., 1976). Previously, sufentanil had rarely been used to immobilize wildlife because its low concentration in the human formulation (50 μg/mL) required large volumes to administer (Kreeger and Seal, 1990). However, sufentanil is now available in powder form, which can be formulated in high concentrations suitable for remote injection and immobilization of wild ungulates (Kreeger et al., 2011). The objective of this study was to determine at least one effective dose of sufentanil or sufentanil and xylazine to immobilize free-ranging Alaskan moose calves (*Alces alces gigas*) remotely.

This study took place in February–March 2012 in the vicinities of Delta Junction and Fairbanks, Alaska. Prior to this, two sufentanil doses based on known elk doses (Kreeger et al., 2011), were successfully tested on two captive Shira's moose calves (*Alces alces shirasi*) at the Wyoming Game and Fish Department's Thorne-Williams Wildlife Research Unit, Wheatland, Wyoming (Kreeger, unpubl. data). This study was approved by the Alaska Department of Fish and Game's (ADFG) Institutional Animal Care and Use Committee (2012-03). Drugs used in this study included sufentanil citrate (Letco Medical, Decatur, Alabama, USA), xylazine hydrochloride (300 mg/mL; ZooPharm), carfentanil citrate (3 mg/mL; ZooPharm), naltrexone hydrochloride (50 mg/mL; Zoo-

TABLE 1. Immobilization data for Alaskan moose (*Alces alces gigas*) calves immobilized with 20 mg of sufentanil (S), 20 mg of sufentanil plus 45 mg xylazine (SX), or 1.2 mg of carfentanil plus 60 mg xylazine (CX). Means are reported with standard deviations.

Parameter	S	SX	CX
Sample size	16	11	13
Induction (min)	3.7±1.8	4.8±3.8	4.5±2.6
Processing time (min)	18.9±4.6	19.4±6.1	20.0±2.5
Recovery (min)	1.4±0.9*	2.2±0.7*	4.6±0.7*
Oxygen saturation (%)	82±8	87±7	89±7

* Significantly different from other groups at $P \leq 0.5$.

Pharm), and tolazoline hydrochloride (200 mg/mL; ZooPharm). Powdered sufentanil was dissolved in sterile water for injection and titrated to pH 4.0 with hydrochloric acid to achieve a 10 mg/mL concentration.

Moose calves of both sexes were captured to compare average weights with previous and future data. Only female calves were immobilized in the Delta Junction area. Moose were alternately immobilized with one of three fixed doses: 20 mg of sufentanil (S), 20 mg of sufentanil plus 45 mg xylazine (SX), or 1.2 mg of carfentanil plus 60 mg xylazine (CX). The CX dose was the ADFG standard dose used for moose calves and was the control drug combination for S and SX data. The target dosage for S was 0.1 mg/kg sufentanil and for SX it was 0.1 mg/kg sufentanil and 0.2 mg/kg xylazine. Immobilants were antagonized with 200 mg naltrexone (S) or 200 mg naltrexone plus 400 mg tolazoline (SX, CX). All moose were darted from a helicopter using a .22-blank projector and 1–2-mL, barbed darts (Pneu-Dart, Willamsport, Pennsylvania, USA). The 2.15-mL total volume for the SX group could be completely contained in the 2-mL darts. A fixed-wing aircraft was used to locate and monitor moose. Samples and data, including weight, body measurements, blood, fecal, and oxygen saturation (Vet/Ox 4401, Heska, Loveland, Colorado, USA), were taken from immobilized calves.

Times for induction (time from being struck with dart to recumbency), processing (time from recumbency to antagonist administration), recovery (time from antagonist administration to ambulatory), and pulse oximetry measurements were compared with the use of one-way analysis of variance (ANOVA) at a significance level of $P \leq 0.05$ (Statistics Open For All [SOFA], v. 1.1.5, Paton-Simpson & Associates Ltd., Aukland, New Zealand). Means were reported with standard deviations.

Forty moose (30 female, 10 male) were immobilized. Treatment groups were unequal because if a dart missed or failed to discharge (confirmed upon examination of the dart), the next dart in sequence was administered. All moose were immobilized with a single administration. There were no differences in times to induction ($P \geq 0.29$) or for processing ($P \geq 0.44$) among groups (Table 1). Moose in both S and SX groups had significantly shorter recovery times than moose in the CX group ($P = 0.001$) and recovery times in S were shorter than in SX ($P = 0.02$; Table 1). There was no difference ($P \geq 0.12$) among groups from recumbency to when oxygen saturation was measured (14.2±3.8 min). Oxygen saturation values for CX were significantly higher ($P = 0.048$) than S (Table 1). There was no difference ($P = 0.467$) in weights between females (170±30 kg) and males (161±28 kg). Actual dosages were 0.12 mg/kg sufentanil for S, 1.2 mg/kg sufentanil and 0.27 mg/kg xylazine for SX, and 0.007 mg/kg carfentanil and 0.36 mg/kg xylazine for CX. Actual dosages for antagonists were 1.2 mg/kg naltrexone and

2.4 mg/kg tolazoline for all groups. No moose died or were injured.

Immobilizations with S resulted in moose invariably remaining sternal with their heads upright, which were typical of opioid immobilizations (Kreeger et al., 2010). Although xylazine is noted for its muscle relaxing properties (Kreeger and Arnemo, 2012), moose given only S were easily manipulated for all processing requirements. Moose given SX or CX demonstrated far more muscle relaxation, often with the head on the ground, which could lead to regurgitation and aspiration of rumen contents, resulting in fatal pneumonia (Kreeger, 2000).

Combining a primary immobilant with a sedative has long been considered advantageous because the combination usually improves inductions and recoveries (Kreeger and Arnemo, 2012). In this study, however, sufentanil alone had numerically shorter inductions and significantly faster recoveries than either SX or CX (Table 1). It is not known why sufentanil alone was superior in this regard.

Potent fentanyl congeners are preferred drugs for remote large ungulate immobilization, but may cause severe respiratory depression resulting in hypoxemia and hypercapnea (Paterson et al., 2009). However, oxygen saturation values in this study were higher than in elk given sufentanil and xylazine (Kreeger et al., 2011) and were considered acceptable without the addition of supplemental oxygen for all groups.

This is the first report on the use of sufentanil or sufentanil and xylazine to immobilize Alaskan moose calves. Sufentanil alone at a recommended dose of 0.1 mg/kg should provide quick inductions and recoveries and subjectively was the preferred immobilant for moose calves in this study. It is not suggested that sufentanil replace either carfentanil or thiafentanil, because sufentanil offers no significant advantage other than its higher safety margin. Nonetheless, should carfentanil or thiafentanil become temporarily or permanently unavailable, sufentanil or sufentanil plus xylazine offer acceptable alternatives to immobilize Alaskan moose calves.

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