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FIELD IMMOBILIZATION OF BIGHORN SHEEP WITH XYLAZINE HYDROCHLORIDE AND ANTAGONISM WITH IDAZOXAN

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ABSTRACT: Xylazine hydrochloride was used to immobilize 124 Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) between 1983 and 1988. Doses of xylazine for free-ranging lambs ranged from 70 to 130 mg with amounts increasing with lamb age. Average doses for 11 free-ranging adult males and 21 adult females darted from the ground were ($\bar{x} \pm$ SE) 363 ± 16 and 251 ± 7 mg, respectively. Adult females captured in "Stevenson's" box traps ($n = 7$) could be immobilized with significantly ($P < 0.001$) less xylazine (93 ± 9 mg) than free-ranging females but had similar induction times. Long recovery times associated with xylazine immobilization were eliminated with the intravenous administration of idazoxan (*RX* 781094) at an approximate dosage of 0.1 mg/kg. Eighteen sheep given idazoxan appeared fully recovered within 3 min of injection ($\bar{x} \pm$ SE = 1.2 ± 0.2 min). Four mortalities (three lambs, one yearling male) (3% of total) occurred before idazoxan was available for trial.

Key words: Bighorn sheep, idazoxan, chemical immobilization, *Ovis canadensis canadensis*, reversal, xylazine hydrochloride.

INTRODUCTION

Xylazine hydrochloride has been used to immobilize a variety of wild mammals including white-tailed deer (*Odocoileus virginianus*) (Roughton, 1975), moose (*Alces alces*) (Franzmann and Arneson, 1974), elk (*Cervus elaphus*) and mule deer (*O. hemionus*) (Renecker and Olsen, 1985), and caribou (*Rangifer tarandus*) (Doherty and Tweedie, 1989). Jessup et al. (1985) reported using xylazine at a dosage of 0.18 mg/kg for the sedation of five desert bighorn sheep (*Ovis canadensis nelsoni*) captured in drive nets. Xylazine has also been used in combination with ketamine hydrochloride to immobilize Rocky Mountain bighorn sheep (*O. canadensis canadensis*) (Festa-Bianchet and Jorgenson, 1985).

Whether alone or in combination with ketamine, xylazine immobilization is characterized by long recovery times. Average duration of immobilization in black-tailed deer (*O. hemionus columbianus*) (Jacobsen, 1983), bighorn sheep (Festa-Bianchet and Jorgenson, 1985), and white-tailed deer (Roughton, 1975) were 144, 64, and 101 min, respectively. Prolonged ataxia with increased vulnerability to predation, risk of tympany, regurgitation and aspiration pneumonia have prompted the use of antagonists to reduce recovery time.

Yohimbine hydrochloride, yohimbine hydrochloride plus 4-aminopyridine, tolazoline hydrochloride, and doxapram have all been used to antagonize xylazine or xylazine-ketamine (Dendi, 1978; Hsu, 1981; Jacobson et al., 1985; Jessup et al., 1985; Ramsay et al., 1985; Renecker and Olsen, 1985; Allen, 1986). These antagonists effectively block the action of xylazine at the alpha-2 adrenergic receptors within nerve cells (Hsu, 1983).

Idazoxan (*RX* 781094) (2-(2-(1,4-benzodioxanyl)-2) imidazoline-hydrochloride) is another potent alpha-2 antagonist (Doxey et al., 1983) with the potential to reverse xylazine immobilization. Using idazoxan, successful reversal of xylazine sedation has been achieved in rats (Freedman and Aghazanian, 1984), and domestic calves (Doherty et al., 1987). Recently, idazoxan (*RX* 781094) and a 2-methoxy analogue (substance *RX* 821002) have been used to successfully reverse immobilization in moose and caribou (Doherty and Tweedie, 1989). This paper reports the immobilization of free-ranging and trapped bighorn sheep with xylazine and the use of idazoxan as a reversal agent.

MATERIALS AND METHODS

We captured sheep in the Sheep River Wildlife Sanctuary (50°40'N, 114°35'W) and near Canmore (51°05'N, 115°18'W) in southwestern Alberta, Canada, between 1983 and 1988. Sheep in the Sanctuary were captured during August to December while sheep from Canmore were captured during July to August. A Paxarms MK 21 long-range rifle (Paxarms Co., Timaru, New Zealand) with 5 ml barbed syringe darts was used to administer xylazine to bighorns at Sheep River after approaching slowly to within 10 to 30 m on foot or by vehicle. At Canmore, sheep were either first trapped in a "Stevenson's" box trap baited with salt and administered xylazine intramuscularly using a pole syringe ($n = 14$) or darted with the Paxarms rifle from a vehicle parked on the roadside ($n = 5$). Trapped sheep required less xylazine for immobilization than free-ranging sheep, but we purposely increased the dose of xylazine in seven adult ewes to an amount approximately equivalent to that required by a free-ranging ewe (250 mg). These ewes were given idazoxan. Xylazine (Rompun®, Bayvet Division, Etobicoke, Ontario, Canada M9W 1G6) was used as supplied at a concentration of 100 mg/ml.

Doses of xylazine for free-ranging sheep were based on sex, age class, and season (Festa-Bianchet and Jorgenson, 1985). We attempted to gauge the amounts of xylazine so as to administer the minimum amount sufficient to achieve immobilization. We could not weigh sheep in the field but estimates of body weight were made following immobilization and used to calculate an approximate dosage rate. These rates are reported but contain an unknown amount of error.

After blindfolding and tagging, idazoxan (*RX* 781094, Reckitt and Colman, Kingstone-upon-Hull, England) was administered intravenously to 19 sheep at an approximate dosage of 0.1 mg/kg (Doherty et al., 1987) from estimated body weights. Idazoxan was supplied in powder form and dissolved in distilled water to a concentration of 5 mg/ml.

Induction was defined as the time between xylazine injection and when the animal was recumbent with its head down. When tagging was completed, the blindfold was removed and sheep were encouraged to stand by hand clapping or gentle prodding. The time between immobilization and when the animals could stand and walk at least 2 m was defined as duration time. When idazoxan was administered, we also recorded the time between administration and when animals could stand and walk at least 2 m. This was defined as reversal time.

Differences between means were compared with t-tests. Significance was set at $P < 0.05$, and all P values reported are two-tailed. Results are all reported as $\bar{x} \pm$ SE.

RESULTS

One hundred seven free-ranging sheep were immobilized at Sheep River and Canmore. They included 11 adult males (2 to 7 yr), 21 adult females ($\geq$2 yr), two yearling males, one yearling female, and 72 lambs. At Canmore, an additional 11 sheep (seven adult females, two yearling males, two yearling females) were trapped in "Stevenson's" box traps. Higher than required doses of xylazine (250 mg) were given to seven more trapped adult females. Idazoxan was administered to one adult male, 10 females (including two yearlings), and eight lambs.

Sheep were easily approachable to within darting range (10 to 30 m) by foot or vehicle. Vehicles were a common sight in the Sanctuary and sheep often grazed and bedded along the roadside. Reaction of individuals to dart impact varied from running (up to 200 m) to turning to look at the dart. Most often, darted sheep remained with the group and could be observed until immobilized. Some sheep struggled to stay with the group or were often stimulated to rise by the noise or pawing by other sheep. It was important to wait 4 to 5 min after sheep first became recumbent, then approach quietly as all sheep appeared sensitive to noise. Premature disturbance of recumbent sheep invariably led to longer induction times. A blindfold was essential to keep the animals calm.

Doses of xylazine required for immobilization varied with capture method, sex and age class (Table 1). The dose required for lambs increased from 70 mg in mid-August to 130 mg by early December. Similarly for adults, higher doses were needed in summer and fall compared to late winter (Festa-Bianchet and Jorgenson, 1985).

TABLE 1. Xylazine hydrochloride doses, estimated dosage rates, induction times, and duration times for free-ranging bighorn sheep successfully immobilized at Sheep River and Canmore, 1983 to 1988. Dosage rates were calculated using estimated body weights.

Sex-age class	*n*	Xylazine (mg) $\bar{x}$ ± SE (range)	Dosage (mg/kg) $\bar{x}$ ± SE (range)	Induction (min) $\bar{x}$ ± SE (range)	Duration[a] (min) $\bar{x}$ ± SE (range)
Adult males (2 to 7 yr)	11	363 ± 16 (260–450)	3.7 ± 0.03 (3.2–4.7)	9.4 ± 1.9 (3–19)	63.6 ± 11.4 (36–124)
Adult females (>2 yr)	21	251 ± 7 (170–270)	3.7 ± 0.11 (2.7–4.3)	7.9 ± 0.8 (3–16)	32.3 ± 3.6 (18–50)
Yearling males	2	260[b]	3.8 ± 0.36 (3.5–4.2)	9.0 ± 5.0 (4–14)	60[c]
Lambs (males and females)	72	96 ± 1 (70–130)	3.5 ± 0.06 (2.2–4.6)	5.4 ± 0.5 (1–16)	45.2 ± 4.3 (7–90)

[a] Only for sheep not given idazoxan.
[b] Both given same dose.
[c] One of the two yearlings died during immobilization.

For example, three adult females in October 1983 required an average of 257 mg of xylazine while the average dose for three females immobilized in April 1988 was 190 mg.

Lambs required less xylazine than older sheep and also had shorter induction times than adult males ($P = 0.02$) and females ($P = 0.006$) (Table 1). Induction times were not different ($P = 0.40$) for adult males and females. Low doses usually resulted in longer induction times and increased the risk of losing sight of a moving animal or of an animal reaching precipitous escape terrain. However, none of the sheep darted in this study were either killed or injured by falls while under the effects of xylazine. Adult females initially captured in box traps required less than one half the dose (93 ± 9 mg) needed for free-ranging females (251 ± 7 mg) ($t = 11.24$, $P < 0.001$) but had similar induction times ($t = 0.52$, $P = 0.61$). Trapped yearling females ($n = 2$) required only 50 mg of xylazine for immobilization while an average of 125 mg was needed for two yearling males.

Heavy doses of xylazine shortened induction times. Induction times for trapped adult females administered 250 mg of xylazine (4.8 ± 0.8 min) were shorter ($P < 0.05$) than for either trapped females administered a low dose (9.0 ± 2.4 min), free-ranging adult females (7.9 ± 0.8 min) or free-ranging adult males (9.4 ± 1.9 min) (Table 1). An estimated 45 kg yearling female trapped with two adult females was inadvertantly administered a 300 mg dose prepared for the adult females. This female had an induction time of 3.7 min and displayed severe respiratory distress. From our experience we suspect that it would have died had not idazoxan been administered. Mean respiration rate (breaths/min) at 20 min post immobilization was slower ($P < 0.05$) for trapped females and heavily dosed trapped females (54 ± 8 bpm and 43 ± 6 bpm respectively) than for free-ranging females (90 ± 8 bpm).

Copious salivation was noted in all individuals from just prior to immobilization until shortly after recovery. In addition, slight amounts of rumenal fluid were regurgitated from a few animals. When no antagonist was used, average duration of immobilization for all free-ranging sheep was 47 ± 4 min (range 7 to 124, $n = 40$). Duration times were longer for adult males than adult females (Table 1). Duration for trapped females (47 ± 18 min) was similar to free-ranging females. Since all heavily dosed trapped females were given idazoxan, comparisons in duration of immobilization could not be made. Although they were able to stand and walk, sheep not given idazoxan were ataxic and if not stimulated to walk, most animals usually resumed recumbency. However, if approached, they could stand and run.

All sheep given idazoxan stood and appeared fully recovered within 3 min, with four individuals recovering in less than 1 min (Table 2). Only one adult female took more than 2 min to recover. Lambs appeared to take less time than adult ewes to recover, but the difference was not significant ($0.10 > P > 0.05$). Recovery was complete and eight sheep appeared highly excited as they rapidly ran out of sight into tree cover. The remaining 11 were observed for approximately 1 hr and exhibited no detectable signs of xylazine sedation. The yearling female inadvertantly overdosed with 300 mg xylazine appeared to stop breathing soon after recumbency. External cardiopulmonary massage and 5 mg of idazoxan were administered. Respiration resumed and the yearling stood and ran 1.7 min post injection.

Three lambs and one yearling ram (3% of total) died during the immobilization procedure before the antagonist was available. The three lamb mortalities were characterized by short induction times (≤2 min) and convulsions prior to death. One lamb was submitted for necropsy to the provincial veterinary laboratory and found to have died from cardiac failure causing hypoxia and pulmonary edema. Field necropsy of the yearling ram revealed extensive froth in the bronchi and trachea. Xylazine immobilization did not appear to affect pregnancy. All six females immobilized during the last 6 wks of gestation produced lambs.

TABLE 2. Recovery time for bighorn sheep administered intravenous injection of idazoxan (*RX* 781094) following xylazine immobilization at Sheep River and Canmore, 1983 to 1988.

Sex-age class	n	Recovery time (min) $\bar{x} \pm$ SE (range)	Idazoxan dose (mg) $\bar{x} \pm$ SE (range)
Adult male (6 yr)	1	0.6	11.0
Female (>1 yr)	10	1.5 ± 0.25 (0.8–3.6)	5.3 ± 0.28 (3.5–6.5)
Lambs (male and female)	8	0.9 ± 0.14 (0.4–1.7)	3.1 ± 0.14 (2.5–3.5)

DISCUSSION

While we previously reported the successful immobilization of bighorn sheep with a mixture of xylazine and ketamine (Festa-Bianchet and Jorgenson, 1985), this study demonstrates the effective use of xylazine alone. Lambs and trapped sheep appeared more sensitive to xylazine: they had lower dose requirements, shorter induction times and three of four mortalities were lambs. White-tailed deer fawns (Roughton, 1975) and black-tailed deer fawns (Jacobsen, 1983) also showed greater sensitivity to xylazine than adults. Therefore, care should be exercised when preparing doses for lambs.

The long recovery time typical of xylazine immobilization was avoided by the use of idazoxan which proved to be extremely fast acting antagonist. Reversal times were more rapid than reported for yohimbine antagonism in mule deer ($\bar{x}$ = 2.0 min) and desert bighorn sheep (within 4.0 min) (Jessup et al., 1985). Renecker and Olsen (1985), using a combination of yohimbine and 4-aminopyridine, reported longer reversal times in mule deer ($\bar{x}$ = 8.2 min), moose ($\bar{x}$ = 19.0 min) and white-tailed deer ($\bar{x}$ = 8.0 min). While these antagonists reversed sedation and permitted animals to stand, individuals remained drowsy with full recovery taking much longer. With idazoxan, full recovery was more rapid, with the resumption of feeding usually occurring as soon as the animals calmed down. Convulsions, as reported with yohimbine antagonism in one mule deer (Jessup et al., 1985), and bears (Ramsay et al., 1985; Page, 1986) were not observed. All mortalities of sheep immobilized with xylazine occurred during handling and were preceded by respiratory distress. These deaths may have been prevented had idazoxan been available.

Excitement levels of individuals at the time of darting have a profound effect on the dose of xylazine required for immobilization (Jacobsen, 1983; Riebold et al., 1986). In this study, all free-ranging sheep were either standing or feeding at the time of darting, with excitement levels judged to be minimal. Reaction by individuals, however, varied upon dart impact and may account for much of the variation in induction times and respiration rates. The dark confines of the box traps and subsequent lack of outside stimulation apparently increased the efficacy of xylazine and allowed for much lower effective doses than required by free-ranging sheep. Although free-ranging females received about twice the dose of xylazine as trapped females, induction times were not different. Similar findings were reported by Jacobsen (1983) in black-tailed deer. Increasing the xylazine dose for trapped females to that of free-ranging females did significantly reduce induction.

Because of the relationship between excitement and drug efficacy, it was important to avoid pursuit and disturbance of sheep prior to darting. During our study, we avoided darting more than one sheep from any group in any one day unless it was obvious that a capture had caused little or no disturbance. If more frequent attempts were made, sheep became wary and unapproachable. While not efficient if large numbers of sheep are to be captured in a short time, the technique was neither labor intensive nor expensive. Since 1981, we have immobilized approximately 350 sheep using xylazine or xylazine and ketamine, with an overall mortality rate of about 2%.

Jessup et al. (1985) claimed xylazine was unsafe and ineffective for immobilizing bighorn sheep, and reported four deaths from aspiration pneumonia or cardiovascular collapse. Koch et al. (1987) concluded drug immobilization was the least desirable method for capturing free-ranging bighorns. However, in both studies helicopters were used to either chase sheep into drift nets or to dart from. These are highly stressful activities, likely to compromise survival even before drug injection. Unfortunately, Koch et al. (1987) did not discuss the possibility that mortality could at least have been partly due to the helicopter chase. Our data suggest that chased sheep would require very large injections of xylazine to achieve immobilization. We suggest that a sensible recommendation to wildlife managers would be to not dart sheep from helicopters. Xylazine can be used effectively for undisturbed sheep and the availability of idazoxan further lessens the possibility of accidental mortality.

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