TWENTY YEARS OF MOOSE IMMOBILIZATION WITH SUCCINYLCHOLINE CHLORIDE

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ABSTRACT: Adult moose (*Alces alces*) in 4 populations in Minnesota and Alaska were immobilized with succinylcholine chloride during 1968-88. Data on 362 immobilizations of 296 individuals were obtained. Doses ranged from 20-30 mg for moose weighing 400-640 kg. The overall mortality rate was 2.5%. Despite the replacement of this drug by narcotics during the past decade, succinylcholine chloride retains certain advantages for immobilizing moose including a high safety margin for humans, low cost, lack of narcotics licensing procedures, absence of recycling, and rapid, full recovery to normal behavior in 5-50 minutes. Conservative doses are stressed; when used conservatively and in the absence of painful, invasive procedures, this drug may be used humanely and with low mortality. A persistent problem with succinylcholine chloride is that when used conservatively a high proportion (30-40%) of darted moose may not be immobilized with the first dose; this increases costs of helicopter immobilization. Succinylcholine chloride does not depress the central nervous system; immobilized animals are conscious and may experience pain.

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In 1968 when I began collaring moose, succinylcholine chloride (SCC) was the drug of choice for field immobilization of ungulates. Taber and Cowan (1963) featured only two drugs for immobilizing deer, SCC and nicotine salicylate. In the late 1960's, published references on immobilizing moose included Bergerud *et al.* (1964), Nielson and Shaw (1967), and Houston (1968); all used SCC. At that time, immobilization of ungulates in the field was in its infancy.

A decade later narcotic drugs became available and etorphine hydrochoride (M-99) with a suitable antagonist generally replaced SCC. Franzmann *et al.* (1982) compared SCC with these drugs and listed several advantages and problems with each. During the early to mid-1980's carfentanil became the drug of choice for moose (Franzmann et al. 1984) but problems with recycling of this narcotic (due to the action of its antagonist) and problems with capture myopathy (Spraker 1982) persisted. Recent advances in developing other antagonists, including naltrexone, may eliminate renarcotization (Schmitt and Dalton 1987).

During the past decade, I have continued to use SCC in lieu of narcotics to capture and collar wild moose. The purpose of this paper is to present data on immobilization of 296 moose in 4 different studies in Minnesota and Alaska during 1968-1988, and to discuss the advantages and problems inherent in using this drug.

STUDY AREA AND METHODS

In 1968-69, moose were immobilized in northeastern Minnesota adjacent to logging roads in the Superior National Forest. A detailed description of this area is contained in Van Ballenberghe and Peek (1971). In 1974-76, moose were immobilized in the Nelchina Basin of south-central Alaska, an area described by Van Ballenberghe (1977). During 1980-88 moose were immobilized in eastern Denali National Park, Alaska, located in central Alaska astride the Alaska Mountain Range. Van Ballenberghe (1982) provided a detailed description of this area. Finally, moose were immobilized in 1987 on the Copper River Delta in south-central Alaska. This is a coastal area of low elevation and flat topography with vegetation ranging from low shrub thickets to closed-canopy coniferous forests. Moose were immobilized in March when snow cover ranged from nearly absent

to about 60 cm.

In the Minnesota study I immobilized moose primarily during winter from vehicles and on foot, but some animals were captured near roads and from canoes during the snow-free seasons. In both Minnesota and Alaska, drug was administered with Palmer Cap-Chur equipment using 3 cc darts and 3.8 cm barbed needles.[1] Accuracy of the projectile system generally required moose to be within 60 m. Large muscles of the hind leg, shoulder, or brisket were preferred targets.

In the Nelchina Basin and Copper River Delta, Alaska studies, moose were immobilized from Bell Jet Ranger helicopters during months with snow cover. Fixed-wing spotter planes were used to find moose for darting and to observe moose during drug induction. Moose were pursued for distances up to one km and darted at close range. Darts were preloaded with fixed, predetermined drug doses for cows and bulls; if large numbers of darted moose failed to become immobilized, doses were increased about 10% until an effective dose was determined. We avoided yearlings and adults that were excessively thin or of small body size.

Immobilized moose in the Minnesota, Denali, and Copper River Delta studies were ear-tagged, collared, and measured. Blood samples were drawn from the jugular vein of Nelchina Basin and Copper River Delta moose. These procedures took 5-10 minutes. We then retreated about 30-m and quietly observed the animal until it rose.

Moose in the Nelchina Basin study were handled as above; in addition one incisor tooth was extracted and females captured in March 1975 were rectally palpated for pregnancy determination. These procedures took an additional 5-15 minutes.

RESULTS

A total of 362 immobilizations of 296 individual adults was accomplished in 4 study areas during 1968-88 (Table 1). Sixty-four percent of the immobilizations occurred in the Nelchina Basin in 1974-76. Most moose in 3 of the 4 studies were immobilized only once but moose in Denali National Park were immobilized a mean of 2.5 times each. Forty-seven percent of the Denali moose were immobilized 3 or more times and one individual was immobilized 5 times.

Drug doses ranged from 20 to 30 mg per individual with lighter doses administered to thin moose or bulls during the post-rut. Moose darted from the ground in the Minnesota and Denali studies were first assessed for condition and then dosed accordingly. Doses exceeding 26 mg were rarely used except in the Copper River Delta study where moose were unusually fat; 44% of the moose in that study received 27-30 mg.

Table 1. Moose immobilizations using succinylcholine chloride in four study areas in Minnesota and Alaska during 1968-88.

Study area	Year(s)	Adult males immobilized	Adult females immobilized	Total immobilizations	Deaths
Northeastern Minnesota	1968-69	5	8[a]	14	2
Nelchina Basin, Alaska	1974-76	11	203	232	6
Denali National Park, Alaska	1980-88	22	11	80	1
Copper River Delta, Alaska	1987	6	30	36	0
Totals		44	252	362	9

[a]includes one female calf mistakenly dosed as an adult.

[1]The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.

Reaction to the drug ranged from light immobilization for periods as short as 5 minutes to complete paralysis. Most animals retained control of their neck muscles; loss of neck muscle control was interpreted as a key sign of an overdose, although most animals displaying this sign recovered.

Many moose in these studies were darted but not immobilized. At the Copper River Delta only 57% of those darted were captured, a much lower percentage than in the 3 other areas. This resulted in higher average costs per animal immobilized as all moose were observed for up to 30 minutes post-injection. At Denali, moose were habituated to humans and were re-darted with about 10% more drug after one hour if the first dose failed.

Nine of 362 (2.5%) immobilizations resulted in death (Table 1). No moose were killed at the Copper River Delta; 2 died in Minnesota including a calf mistakenly dosed as an adult and an adult female mistakenly darted twice in 10 minutes. Six moose expired in the Nelchina Basin, perhaps due to our inability to assess condition prior to darting from helicopters. After 8 years with no fatalities at Denali, one old, adult male died in 1988 after his weight was overestimated.

DISCUSSION

The main purpose for capturing moose in the 4 studies cited here was to mark them with radiocollars or numbered neck bands; SCC was a satisfactory drug for this purpose. In addition, moose at Denali were used for behavioral observations. We required a drug with no lingering physiological or behavioral effects when changing defective or depleted radiocollars during the course of these studies. Certain moose at Denali have been continuously monitored for 10 years during which we changed collars several times. During the rut, we were at times obliged to change collars and quickly restore animals to their social environment.

The drug delivery system of Palmer Cap-Chur rifles firing green or yellow powder charges to propel 3 cc darts worked well from both helicopter and ground positions. However, moose were too wary in Minnesota for close approach and were also difficult to find after darting. At Denali, I failed to recapture a study animal only once, this was due to repeated malfunctions of defective darts.

The mortality rate observed in this study, 2.5% overall (Table 1), is relatively low for moose immobilization efforts (Gasaway *et al.* 1978, Franzmann *et al.* 1982). Some deaths could have been prevented by better identification of animals or more careful condition assessment prior to darting. I was especially anxious to keep mortality minimal at Denali because of its National Park status and to allow long-term observation of individual animals. Because all moose in the Minnesota, Denali, and Copper River Delta studies were radiocollared, we know that none expired post-capture following their initial recovery. SCC apparently does not induce capture myopathy.

Use of SCC on moose has been criticized because of its alleged high mortality rate, inconsistent effects (Gasaway *et al.* 1978), possibility of inducing abortion (Ballard and Tobey 1981), and inhumane character, the latter due to lack of anesthetic effects. However, when used conservatively, mortality with SCC is generally not higher than with narcotics such as etorphine or carfentanil. Certain individuals with serum cholinesterase abnormalities resulting from liver disease or acute stress may be sensitive to SCC, but these normally constitute a very low fraction of most populations.

I have not experienced inconsistent effects with SCC except in the Copper River Delta study where many moose were in unusually good condition and it was difficult to find an effective, fixed dose to administer from helicopters. At Denali, it is my experience that SCC effects relate directly to body weight. Seasonal variation in drug dosage was well correlated with the annual cycle of

weight gain and loss. Habituated moose at Denali allowed careful pre-darting condition assessment and in this environment SCC has been very consistent within and between individuals. I have used SCC at Denali during all months on animals in all stages of the annual cycle including the rut, post-rut, late winter, and early summer when females were lactating.

Ballard and Tobey (1981) suggested but did not prove that SCC administered to pregnant female moose in the third trimester could lower calf survival. They speculated that capture stress including that from rectal palpation was involved. However, sample sizes in that study were very small and SCC doses were very high (maximum = 37 mg; mean = 27.6 mg for pregnant females); mortality of cows immobilized in March was 21%. Neonatal calf mortality in my studies has been high due principally to predation, and limited opportunity has existed to evaluate effects of SCC on calves *in utero*. But some cows immobilized with light doses as late as 2 weeks before parturition have produced calves that survived at least one year.

Larsen and Gauthier (1989) reported that immobilization of female moose with narcotics in the last 2-3 months of pregnancy may have lowered postnatal calf survivorship. If so, and if the results of Ballard and Tobey (1981) were real, it appears that immobilization during late pregnancy with any drug may influence calf mortality but more data are needed to confirm this.

I agree that procedures such as tooth extraction or rectal palpation are inhumane when practiced on moose immobilized with SCC and have not applied these procedures since 1976. Whether or not it is inhumane to briefly handle and collar moose without anesthetics is an open question. Moose, unlike deer, have a placid disposition and seem difficult to stress. Stress can be minimized by keeping doses light so animals retain control of neck muscles, quietly and slowly handling moose without causing pain, and quickly retreating 30 or more meters to quietly observe the animal until it recovers. Many moose do not struggle excessively during the immobilization period if these procedures are employed.

What are the advantages that SCC offers? These include: (1) Human safety. Compared to etorphine and carfentanil, SCC is not hazardous to humans from spillage, and risk of death by accidental injection is minimal. Narcotics pose grave threats to careless people. (2) Cost. Narcotics cost about $60-80 per immobilization; SCC costs about $1.00. This may be important for low budget studies. (3) Licensing procedures for acquisition, storage, and use. SCC does not require the stringent licensing procedures required for narcotics, which may render narcotics unavailable to those without access to license holders or proper storage facilities. Narcotics pose a constant threat of theft and possible liability problems from people retrieving undischarged darts in the field. (4) Recovery time. When animals stand after being down 5 to 50 minutes with SCC, they are recovered and will behave normally. Animals administered heavy doses may rest more than normal for up to 24 hours post-capture; this is rare. Renarcotization followed by 2 or more days of abnormal behavior, and capture myopathy leading to death have affected some moose anesthetized with narcotics, but these problems apparently can be minimized with new advances in antagonists (Schmitt and Dalton 1987). Rapid, full recovery and ability to interact normally with conspecifics is especially important to behavioral studies. In addition, slow recovery and altered behavior may influence susceptibility to predation.

Disadvantages of SCC include: (1) A narrow range of effectiveness compounded by seasonal variations in body weight. Doses must be carefully tailored to body weight; errors in estimating weight may result in high mortality. (2) No central nervous system depression. This makes SCC unsuitable for a variety of capture procedures including tooth

extraction and telemetry implants. (3) High proportion of first-dose failure. This increases costs, especially for helicopter operations where animals are observed for up to 30 minutes post-injection.

CONCLUSIONS

SCC has been used to immobilize moose in North America since the first efforts to capture animals with chemicals and dart guns began in the early 1960's. Despite its replacement by narcotics during the last decade, it still offers those who wish to capture moose certain advantages when used conservatively. These include a low mortality rate, high degree of human safety, low cost, lack of narcotics licensing procedures, and rapid, full recovery to normal behavior with no risk of drug recycling. Doses of 20-30 mg per animal for adult moose weighing between 400-640 kg have proved effective when animals were assessed for size, sex, and condition predarting. Doses exceeding 26 mg should be applied with caution. Painful, invasive procedures should be avoided as this drug has no anesthetic effects. Doses should be adjusted so immobilized animals retain control of their neck muscles. A notable disadvantage of this drug is that when it is used conservatively, a relatively high proportion of animals will not be immobilized with the first dose.

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