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MOOSE RESEARCH CENTER REPORT

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Progress Report
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PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: None

Project No.: W-22-1 Project Title: Big Game Investigations

Job No.: 1.28R Job Title: Moose Nutrition and Physiology Studies

Period Covered: July 1, 1981 through June 30, 1982

SUMMARY

Major studies conducted during this period at the Moose Research Center (MRC) centered around estimating protein requirements for moose during winter. Four isocaloric diets varying in crude protein content from 8 to 16% were fed to 4 moose during winter. Chemical analysis indicated similar dry matter and gross energy digestion between protein levels. Chemical analysis was incomplete for nitrogen on several samples, so nitrogen balance, metabolic fecal nitrogen, and minimum nitrogen requirements were not estimated for this report. A complete digestion and balance trial was conducted with equal mixtures of birch (*Betula papyrifera*), aspen (*Populus tremuloides*), and willow (*Salix spp.*) by wet weight. Dry matter digestion (42.0% ± SE 0.6%) was similar to results of an identical experiment in 1980. Rumen and body turnover rates were slower for the browse diet when compared to the standard "MRC Special" diet and to a mixture of MRC Special and clipped aspen. Data on life histories for the MRC enclosures, and weight data for the tame moose herd are also presented.

Key words: moose, nutrition, physiology, productivity.

CONTENTS

BACKGROUND

Digestive physiology studies with captive moose (*Alces alces*) were initiated in 1979 (Franzmann and Schwartz 1979) as part of the moose productivity and physiology project outlined by Franzmann et al. (1976). The major goal of these studies was to develop and test a carrying capacity model for moose on the Kenai Peninsula. Background pertaining to this subject has been discussed (Franzmann and Schwartz 1979). In general, we were attempting to integrate information on the nutritional requirements of moose with that of the nutrients supplied from the vegetation.

The program is 2-fold: (1) vegetative biomass and nutrient quality will be determined by personnel of the U.S. Fish and Wildlife Service, and (2) moose nutrient requirements and digestive physiology will be measured by both State and U.S. Fish and Wildlife Service personnel. This report describes ongoing research into the nutrient requirements of moose. The overall objective of these digestive physiology studies is to obtain input data for use in a carrying capacity model. Major emphasis this year centered around estimating the minimum nitrogen (protein) requirements of moose in winter.

OBJECTIVES

To establish baselines by blood, hair, and milk parameters in moose by sex, age, season, reproductive status, area, drug used, excitability, and condition and to evaluate their usefulness as indicators of nutritional and general condition status of moose.

To apply the above criteria to various moose populations of the State.

To estimate browse production and utilization and to quantitatively and qualitatively estimate consumption of plant materials by moose at the MRC.

To determine nutritional value and digestibility of the common moose forage species and to relate hair element monitoring to moose mineral metabolism.

To measure natality, mortality, and general condition of moose at the MRC.

To develop and test a formulated diet capable of meeting the essential nutrient requirements of captive moose.

To determine crude protein and gross energy requirements for various sex and age classes of captive moose on a seasonal basis.

To determine the effects of various levels of nutrient quality on blood parameters in captive moose.

To compare the ability of captive moose to digest and assimilate a formulated diet versus 4 major food items consumed by wild moose either singly or in combination during winter.

The goal is to obtain a more thorough and specific knowledge of how moose affect vegetation and how vegetation affects moose. The application of the indicator species concept to moose by gaining knowledge specific to moose physiology is an integral part of this objective.

PROCEDURES

Digestive Physiology of Moose

Procedures for digestion/metabolism studies tested under this job were outlined by Schwartz and Franzmann (1981).

Experimental design for the protein digestion studies was a 4 x 4 latin square of design; moose were assigned randomly to treatments for the 1st digestion trial. Each trial consisted of a 15-day preliminary feeding period followed by 7 days of total excreta collection, a 1-day measurement of heat and methane production while on feed, 2 days of fasting, and finally a 12-hour estimate of fasting heat production (Regelin et al. 1981). Two pelleted, isocaloric feeds were manufactured to contain approximately 20 and 8% crude protein. Four diets (treatments) were prepared to contain 8, 11, 13, and 16% crude protein by blending appropriate proportions of the 2 feeds.

Rumen turnover time (Schwartz and Franzmann 1981, Schwartz et al. 1981) was used to estimate both solid and liquid movements through the digestive tract of moose. Rumen turnover studies

were done in cooperation with Drs. R. White and D. Hollaman, University of Alaska, Fairbanks. The diet tested was a mixture of equal parts of the current annual growth of birch, willow, and aspen.

Experimental Methods

The radioisotope-labeled markers were given as a single dose by mixing the markers with food. Chromium-51 EDTA and ruthenium-103 chloride were given at a dose rate of 20μ Ci per moose. Fresh fecal samples were collected at 2-hour intervals, for the 1st 24 hours after dosing, then 4-hour intervals for the next 24 hours and then at 6-hour intervals the following day. Subsamples were taken for radio assay and water content estimation. Samples were placed into preweighed counting vials, then freeze-dried to a constant weight. The samples were radio-assayed with a dual channel gamma spectrometer (Searle Analytical-Model 1195). Normal gamma stripping methods were used to calculate the marker concentrations of chromium-51 and ruthenium-103. Marker concentrations were expressed as cpm/g water (chromium-51 EDTA) and cpm/g dry matter (ruthenium-103).

The logarithm of the marker concentration was plotted as a function of time following the single dose of marker. A least-squares regression line was fitted to the linear portion (terminal portion) of the marker concentration versus time curve. The difference between marker concentration during the build-up portion of the curve and the corresponding marker concentration as calculated from the above least-squares regression line were plotted against time. These data were then fitted with a least-squares regression line. The 1st appearance time for the marker was calculated from the slopes of the 2 least-squares lines. Dry matter digestibility was calculated from dry matter intake and fecal output as measured by conventional methods.

Productivity and Mortality of MRC Moose

Mortality and natality within the MRC enclosures were assessed by ground observations, periodical aerial observations, and trapping.

Moose within the MRC enclosures were moved from 1 enclosure to another or released outside the enclosures in an attempt to obtain approximately the following numbers and distributions: Pen 1 (2 bulls, 2 cows); Pen 2 (8 moose); Pen 3 (5 cows and no bulls until late in rut); and Pen 4 (no moose).

Moose were moved utilizing an etorphine (M99) and xylazine hydrochloride (Rompun) mixture for initial immobilization of trapped animals. Each animal was routinely processed when immobilized (Franzmann et al. 1976).

RESULTS AND DISCUSSION

Composition of the high- and low-protein content feeds (Table 1) used to blend diets fed during the protein digestion trials was similar to the standard "MRC Special" ration (Schwartz et al. 1980) except that we added cottonseed hulls. Cottonseed hulls were used as a fiber-energy source in place of other ingredients (oats, barley) because they contained virtually no digestible protein. We attempted to balance the protein rations using 50% sawdust and no cottonseed hulls, but the ingredients would not form pellets. The mixture of cottonseed hulls and sawdust pelleted very well.

Blended diets (Table 2) varied in chemical composition, with the crude protein content slightly higher than 86% in the low diet. Cottonseed hulls are quite low in protein (3.8%), and practically none of it is digestible (Ensmigner and Olentine 1978). Consequently, the diet of 8% crude protein only contained 4-4.5% digestible protein.

The 20% protein feed (Table 1) was not used as a treatment because preliminary feeding trials indicated that it was not palatable to the moose. Consequently, the high-protein treatment was a blend of 75% high-protein feed and 25% low-protein feed. This resulted in a high-protein diet fed in these trials containing 16.0% crude protein.

Mean body weight decreased throughout the winter (Table 3) but at a nonsignificant rate ($P < 0.05$). Dry matter intake expressed per unit of metabolic body weight (DMI/kg 0.75) decreases from early winter (Trial 1) through late winter (Trial 3) and then increased again in early spring (Trial 3). Dry matter intakes in these trials were similar to those reported by Schwartz et al. (1981) for moose fed the "MRC Special." Mean body weights were higher for moose fed the high-protein diet, but no significant treatment effects were detected ($P < 0.05$).

Dry matter consumption (Table 3) was lowest for the high-protein treatment. This probably reflects a decrease in palatability. Smith et al. (1975) had similar results when feeding white-tailed deer (*Odocoileus virginianus*) varied protein diets. They consequently used intake as a covariate for statistical analysis and projected data which were corrected for equal (mean) dry matter intake. We plan to use similar analysis.

Apparent digestibility of dry matter (Table 4) was similar for all 4 treatments. Although analysis of variance data are not complete, it appears that all treatments were not significantly different in dry matter, gross energy, and fiber digestion. These similarities were expected since diets were compiled to contain varying levels of protein and remain isocaloric with regard to digestible energy. Apparent digestibility of crude protein (Table 4) varied as much as 25% between the high- and low-treatments.

Table 1. Composition (%) of the pelleted concentrate used for protein digestion studies.[a]

Ingredient	Protein content	
	Low (8%)	High (20%)
Corn, ground yellow	35%	15%
Sawdust[b]	25	25
Cottonseed hulls	25	25
Cane molasses, dry	15	5
Soybean meal	0	30
Vitamin premix[c]	T[d]	T
Trace mineral salt[e]	T	T
Dicalcium phosphate[f]	T	T
Pelaid[g]	T	T
Mycoban[h]	T	T

[a] The diet was formed in 4.8 mm pellets.

[b] Aspen sawdust (Fiberight, American Excelsior Co.)

[c] Each kg contained 5,004.4 USP units vitamin A, 13,228 IC units vitamin D_3 and 44 I units vitamin E.

[d] T = <1% of the diet.

[e] Guaranteed analysis: NaCl 95-98%, Zn 0.35%, Mn 0.28%, Fe 0.175%, Cu 0.035%, I 0.007%, and Co 0.007%.

[f] Guaranteed analysis: P 18.0%, Ca 31.0-34.0%.

[g] Pelaid (Rhodeia Inc., Ashland, Ohio) is a wood byproduct used to enhance pelleting.

[h] Mycoban (Van Waters and Rogers, Anchorage, Alaska) inhibits mold growth. T = 0.5 lbs/ton (0.025%).

Table 2. Mean chemical composition of protein diets, expressed as % of dry matter or units listed.

Component	Treatment (% crude protein content)			
	8	11	13	16
Gross energy (cal/g)	4.2 ± 0.04[a]	4.2 ± 0.02	4.3 ± 0.06	4.2 ± 0.06
Natural detergent fiber	48.0 ± 1.3	52.0 ± 6.3	50.2 ± 2.2	50.6 ± 04.6
Acid detergent	30.5 ± 1.7	30.6 ± 1.8	30.3 ± 1.3	29.4 ± 1.5
Lignin	6.6 ± 0.8	7.0 ± 0.7	6.8 ± 0.5	6.5 ± 0.8
Crude protein	8.2 ± 0.82	10.9 ± 0.97	12.9 ± 1.00	16.0 ± 1.04
Moisture	91.2 ± 0.45	91.5 ± 0.47	91.2 ± 0.53	90.8 ± 0.59
Ash	-- not complete for this report --			
Ration high feed:low feed (See Table 1)	0:100	25:75	50:50	75:25

[a] Mean ± standard deviation.

Table 3. Changes in mean body weight and intake rates by season and treatment for 4 moose fed 4 levels of protein during winter.

Time (trial)	Wt. (kg)	$W^{0.75}$ (kg)	Intake (g/kg .75/day)
17 December-5 January 1981	449.2 ± 40.1[a]	97.6	88.5 ± 4.8
11 January-1 February 1982	441.0 ± 35.3	96.2	65.8 ± 27.3
8-28 February 1982	439.5 ± 9.3	96.0	63.6 ± 6.1
8-28 March 1982	438.8 ± 14.1	95.9	82.4 ± 4.5
Treatment (protein level)			
High (16%)	451.2 ± 35.0	97.9	62.8 ± 21.9
Medium-high (13%)	442.2 ± 25.4	96.4	76.5 ± 15.5
Medium-low (11%)	437.8 ± 43.4	95.7	84.0 ± 14.4
Low (8%)	444.8 ± 19.0	96.9	77.0 ± 13.8

[a] Mean ± standard deviation.

Table 4. Apparent digestibility (%) of 4 isocaloric diets varying in crude protein content fed to 4 adult moose in winter.

Trait	Treatment (% crude protein content)			
	8	11	13	16
Dry matter	54.0 ± 4.2[a]	54.1 ± 1.7	53.3 ± 2.3	54.5 ± 4.7
Gross energy	53.1 ± 4.5	54.0 ± 1.1	53.9 ± 1.1	55.6 ± 4.4
Crude protein	45.0 ± 6.7	59.0 ± 4.2	62.8 ± 3.7	70.1 ± 2.9
Neutral detergent fiber	33.3 ± 6.3	38.2 ± 7.2	33.8 ± 3.0	35.5 ± 3.8
Acid detergent fiber	15.1 ± 4.5	17.0 ± 6.9	11.9 ± 4.2	12.3 ± 7.6

[a] % apparent digestion ± standard deviation.

Energy partitioning of the 4 treatments (Table 5) showed increased losses of dietary energy via urine proportional to crude protein levels. Other energy factors were not affected by treatment.

All nitrogen analysis was not complete for this report. Available nitrogen data (Table 6) indicate difference in nitrogen intake (NI) as related to treatment and consumption of dry matter. Fecal nitrogen output was inversely proportional to nitrogen level of the diet. Urinary nitrogen loss was not available for this report. Consequently, nitrogen balance, the relationship between urine nitrogen and digestible nitrogen, nitrogen intake and tissue balance, and digestibility of nitrogen and nitrogen intake could not be calculated. As a result, no estimate of metabolic fecal nitrogen production or minimum nitrogen requirements were available for this report.

Rumen and Water Turnover

As outlined in the original objectives of these studies (Franzmann and Schwartz 1979), rumen turnover time was considered an important component of moose digestive physiology and a major factor leading to the success of the "MRC Special" as a ration. Preliminary results of rumen turnover studies have been presented for MRC Special and a diet of one-third aspen and MRC Special (Schwartz and Franzmann 1981, Schwartz et al. 1981). Results of turnover studies with a diet of mixed browse (birch:willow:aspen) in equal parts (Table 7) indicated a turnover time of 35.0 ± 2.1 and 31.2 ± 2.2 hours for the solid and liquid materials of the rumen, respectively.

Water turnover rates (Table 8) were substantially slower for the browse diet when compared to the MRC ration and probably a result of lower mineral intake-output on mixed browse. The MRC ration has added salt and trace minerals while the browse did not. The 74% body water represents a fat index of 14% of body weight while the 81% represents 4% body fat. This compares with a 13% body fat (75.2% body water, MRC Special) in January 1980.

Moose Weights

We are continuing to weigh the tame moose biweekly (Tables 9, 10). Since those animals have not attained maximum body size, no attempt was made to fit equations to growth.

Productivity and Mortality of MRC Moose

Histories of individual moose through 31 May 1982 are listed in Tables 11-15. We experienced several breaks in the fenceline in

Table 5. Portion of gross energy (GE) in 4 moose fed isocaloric diets varying in crude protein during winter.

Trait	Treatment (% crude protein content) 8	11	13	16
Daily GE intake/body $W^{0.75}$ (Kcal/kg)	261.4 ± 78.0[a]	294.3 ± 78.9	223.7 ± 99.2	190.2 ± 72.2
Fecal energy (%GE)	46.9 ± 4.5	46.0 ± 1.1	46.1 ± 1.0	44.4 ± 4.4
Urine energy (%GE)	1.6 ± 0.6	2.9 ± 0.8	4.2 ± 1.5	4.5 ± 2.2
Methane energy (%GE)	3.3 ± 0.7	4.4 ± 1.3	3.8 ± 2.3	3.6 ± 1.6
Heat energy (%GE)	11.4 ± 3.9	7.3 ± 2.8	6.5 ± -[b]	9.2 ± 0
Metabolizable energy(%GE)	48.2 ± 4.0	46.8 ± 2.1	44.8 ± 4.2	47.5 ± 6.6
(Kcal/g)	1.00 ± 0.50	1.38 ± 0.40	1.02 ± 0.54	0.93 ± 0.49
Net energy (%GE)	36.8 ± 6.6	39.4 ± 1.9	38.8 ± 3.5	39.7 ± -[b]
(Kcal/g)	0.98 ± 0.35	1.06 ± 0.34	1.16 ± 0.43	0.64 ± -[b]

[a] Mean ± standard deviation.

[b] Only 1 value available for this treatment; therefore, no error estimation available.

Table 6. Partition of dietary nitrogen in moose for isocaloric diets varying in crude protein content.

Trait	Treatment (% crude protein content) 8	11	13	16
Daily N intake NI/body $_{W}^{0.75}$ (g/kg)	0.81 ± 0.22[a]	1.22 ± 0.35	1.07 ± 0.43	1.15 ± 0.44
Fecal nitrogen N/NI (%)	55.0 ± 6.7	41.0 ± 4.2	37.2 ± 3.7	29.9 ± 2.9

[a] Mean ± standard deviation.

Table 7. Rumen solid and liquid turnover rates of moose fed a diet containing equal parts of birch:willow:aspen during winter 1982.

Animal	Body wt. (kg)	Dry matter intake ($g/kg_W^{0.75}$/day)	DMD (%)	1st appearance (hour)		Turnover time (hour)	
				Liquid	Solid	Liquid	Solid
Flo	410	20.4	41.3	18.1	19.4	25.9	30.2
Chester	458	38.1	42.4	14.2	15.7	34.0	34.8
Lucy	444	20.0	40.8	19.0	20.7	35.6	40.7
Angel	418	28.3	43.5	10.5	12.8	29.5	34.4
Mean		26.7	42.0	15.8	16.8	31.2	35.0
± S.E.		±2.1	±0.6	±1.9	±1.9	±2.2	±2.1

Table 8. Summary of water metabolism in moose fed equal parts of browse (birch:willow:aspen) during winter and the MRC Special.

Technique	Moose	Body weight (kg)	Bodywater pool size (l)	Space (% of body weight)	Water transfer rate (1/day) (ml/d.kg)		Bodywater turnover time (day)	Water intake drinking (l/day)	Water intake food (l/day)	Water output Urine (l/day)	Water output Feces (l/day)
Urine	Flo	410	267	65.0	6.9	16.8	39	7.2	2.1	1.8	1.1
	Chester	458	338	73.8	10.5	22.8	32	5.9	3.1	4.0	1.9
	Lucy	444	335	75.5	2.4	5.4	139	7.5	2.3	2.4	1.1
	Angel	418	339	81.1	3.9	9.3	87	7.5	2.7	2.9	1.6
	Mean			73.8		13.6	74	7.0	2.6	2.8	1.2
	± SE			±3.3		±3.9	±25	±0.2	±0.1	±0.2	±0.1
Feces	Flo	410	289	70.5	11.8	28.7	24				
	Chester	458	362	79.1	10.5	22.9	34				
	Lucy	444	343	93.6	1.1	2.6	298				
	Angel	418	343	82.1	7.4	17.7	46				
	Mean			81.3		18.0	100				
	± SE			±4.8		±5.6	±66				
					MRC Special[a]						
Feces	Chief	352	270	76.6	20.0	56.9	13.5				
	Chester	346	261	75.4	25.8	74.7	10.1				
	Rodney	358	266	74.2	23.2	64.7	11.5				
	Angel	355	266	74.8	17.2	48.5	15.4				
	Mean	353	265	75.2	21.5	61.2	12.6				
	± SE	±2	±0.9	±0.5	±1.8	±5.5	±1.1				

[a] Data originally presented by Schwartz and Franzmann (1981), Table 2. This table was accidently omitted during printing in Juneau, so these data are presented here for comparison.

Table 9. Weights (kg) of 7 captive moose at Kenai Moose Research Center, 1981-82.

Date	Animal name (sex) Chief (M)	Chester (M)	Rodney (M)	Lucy (F)	Angel (F)	Jezebel (F)	Flo (F)	Comments
28 May 1981[a]	439							
28[b]	444	401	426	349	377	345	248	
29				361	376	345		
31				358	384	349		
1 June 1981				358	379	349		
2				367	388	347		
3				363	383	347		
4				361	381	346		
5				362	387	356		
6		409		360	388	352	251	
7				361	384	352		
9	473	426	444	360	390	351	256	Moose slightly wet.
10				360	389	357		
11				370	397	362		
12				364	397	365		
13				371	396	355		
14	467			370	403	366	250	
15			450	370	402	359		
16		435		369	405	365		
17				370	401	363		
18				374	400	360		
19				380	400	367		
20				381	400	367		
21		445		383	394	374	260	
22		450	461	380	393	369		
23	485			380	399	373	262	
24				380	400	370		
25				382	397	374		
26				390	399	375		
27				383	407	364		
28				383	402	367		
29	489			383	404	373	267	
30		467	464	389	410	383	279	
1 July 1981				380	410	377		
2				383	410	379		
3				388	412	383		

Table 9. Continued.

Date	Animal name (sex) Chief (M)	Chester (M)	Rodney (M)	Lucy (F)	Angel (F)	Jezebel (F)	Flo (F)	Comments
4				388	415	382		
5 July 1981				391	403	380		
6				391	409	376		
7	503	455	482	394	405	382		
8				396	408	375	279	
9	486		460	396	405	382		Rodney and Chief weighed after fasting.
11				398	417	389		
12				401	421	388		
13				396	418	390		
14				402	416	386		
15				402	421	390		
16	516	482	492	404	418	392	281	
17				403	423	393		Lucy and Angel released.
18						400		
19						397	289	
20				392		397		
21				401	430	396		
22						398		
23	535	500		390		398	290	
24			504		419			
25						400		
26		499				398		
27					416	394		
29	532	506				404	302	
31						407		
3 Aug. 1981	544	503	513			404	296	
4				401	415	399	296	
5						406		
8					429			
10						402		
11	567	506	516	400	438	406	306	
13						412		
14						402		
16						406		Began feeding orts to all moose.

Table 9. Continued.

Date	Animal name (sex) Chief (M)	Chester (M)	Rodney (M)	Lucy (F)	Angel (F)	Jezebel (F)	Flo (F)	Comments
18 Aug. 1981	554	528	534	401		411	304	On new feed beginning
21					414			20 Aug. 1981. (All moose).
24					414			Jezebel turned out on 22 Aug. 1981.
27	557	533		387	418	398	328	
1 Sept. 1981	550	528	532			398	317	
3	559	533	544					Bull's antlers removed. Bull wet.
8	516	494	522	390	433	412	325	Began intake trial (not Flo).
17	494	467	488	377	425	406	324	
22	480	451	477	382	428	418		
2 Oct. 1981	458	425	450	382	429	405	333	
5	463	442	452	385	421	410		Moose released into large pen.
12	466	439	452	395	433	405	340	Raining; moose wet.
15	453	445		393		410	343	
16					432			Jezebel escaped 17 Oct. 1981.
19	459			392				Chamber trials began.
20			454		441			Weights for chamber trials.
21	457			382				After fasting; Chief wet.
22[a]	452				419			After fasting.
22[b]			453		413		344	Rodney and Angel fasted.
23		435	451					Rod fasted, Chester not.
27						391		Jezebel outside pens from 17-27 Oct. 1981.
30	463		461		426	403	337	
31				397				
6 Nov. 1981	477					416	352	
8	480	429	462			408	347	
9					450			

Table 9. Continued.

Date	Animal name (sex) Chief (M)	Chester (M)	Rodney (M)	Lucy (F)	Angel (F)	Jezebel (F)	Flo (F)	Comments
14 Nov. 1981	484	423	474		447	411	348	
16	496				443			Began chamber trials.
17	476	429	480	397				Chamber trials (not Chester).
18	465	425	469	394	425/420			
19	461		464	392/393				
20			464					End chamber trials.
25						437	362	
27	480		474	411	440	426	360	
30				411	451	440	359	
4 Dec. 1981	479	446	475	415	450	432	365	
15			475		453	440	363	Rodney and Angel pre-chamber.
16		458			440			Angel after chamber; Chester before.
21	503	449	477	411	456			Lucy off feed 5 days.
28	503		477		465	441	377	Began protein feed trials no. 1 (except Flo).
31		450		415				
4 Jan. 1982	488		475		461	434	386	Digestion trial ended. Flo not in trial.
5	503				468/465			Chamber trials.
6	484		482			436/419		Chamber trials.
7	475/481		475/458		457/442	417		Chamber trials.
8			464			415		End of chamber trials.
11	484		471		447	432	388	
13		460						Chester given anti-biotics for infected foot.
14		456						
15		454						
18	480		466	451	442	448	391	
24		468					397	
25	459		463		441	457		Began protein feed trial no. 2.
29				457				

Table 9. Continued.

Date	Animal name (sex)							Comments
	Chief (M)	Chester (M)	Rodney (M)	Lucy (F)	Angel (F)	Jezebel (F)	Flo (F)	
1 Feb. 1982	451/460		447		437/438	443		End of digestion trial. Began chamber trials.
2	453	465	446			444	398	Chamber trials (not Chester and Flo).
3	449/454		446	440	435/433	439/438		Chamber trials (not Lucy).
4						436		End of chamber trials.
5			447					
7			436					
8	457	467	445		434	445	397	Began intake trial (not Chester and Flo).
9				441			394	
16	448		428		437	444		
17		468		439			400	
22 Feb. 1982	447	471	426		439	453	403	Began protein feed trial no. 3 (not Chester and Flo).
27				442				
1 Mar. 1982	442/445	477	415	454	425	430/428	404	Began chamber trials (not Chester, Lucy and Flo).
2	446		427		424/421			Chamber trials.
3	443/437		423		425	426/420		Chamber trials.
4	437		415/415		421			
6			423					Rodney given anti-biotics for infected leg.
8	451		428		431	429		Began intake trial.
9		477					410	
10				459				
11		475	423					Chester's hoof trimmed.
12			428					
15	463	463	437		437	435	417	
18				453				
22	447		428		433	447		Began protein feed digestion trial no. 4.
24		467		440			408	

Table 9. Continued.

Date	Animal name (sex)							Comments
	Chief (M)	Chester (M)	Rodney (M)	Lucy (F)	Angel (F)	Jezebel (F)	Flo (F)	
29 Mar. 1982	435		408		428/425	425/429		End of digestion trial. Began chamber trial.
30		460	412		420			
31	431/431		409/410		418/419	420/418		
5 Apr. 1982		463		450	423		411	Browse turnover trial.
7		458		444	418		410	Locked in digestion stalls.
9						426		
12		441		424	412		400	Released from digestion stalls.
14	432	449	426	435	418	422	402	
27	439	--	437	438	416	426	406	Chester found dead; 10 Apr. 1982.
3 May 1982	446		422	442	427	432	412	
11	470		446	450	439	448	420	
16	471		460	450	434	452	427	
17				457	435	454	431	
18				450	428	450	432	
19				449	428	438/408	429	Jez weighed pre- and postpartum.
20				445	423/392	402	432	Angel weighed pre- and postpartum.
21				414	394	397	431	Lucy weighed post partum.
22				410	387	398	431	
24	479		453	401	389	395	432	
25				399	379	394		
26				400	388	384	439	
28				404	388	388	440	
29				396	388	385	441	
31	485		460	393	393	385	441	

[a] Weight taken in a.m.
[b] Weight taken in p.m.

Table 10. Weight (kg) of 4 moose calves born in captivity at Kenai Moose Research Center, 1981.

Date	Animal name (sex) Trixie (F)	Punch (M)	Bud (M)	Oly (F)	Comments
17 May 1981	16				Angel's calf born. Weighed with spring scale.
18	15				Weighed on spring scale.
20	17				
21		17			Jezebel's calf (Punch) born.
22					Lucy's twins (Bud and Oly) born.
25 (a.m.)		18			Weighed with spring scale.
25 (p.m.)	21	19	18	15	
26	21-23	19	17	16	
27	23	21	18	17	
28	23	22	20	19	
29	24	24	22	20	
31	25	25	23	20	
1 June 1981	26	27	24	21	
2	27	28	27	22	
3	28	30	27	22	
4	28	30	28	24	
5	30	30	29	25	
6	31	32	29	25	
7	31	32	29	26	
9	34	33	31	28	
10	34	34	31	27	
11	34	34	32	28	
12	36	33	33	30	
13	36	33	34	31	
14	38	35	34	32	
15	38	34	36	33	
16	40	33	37	34	
17	40	34	36	33	
18	41	34	37	34	
19	44	37	39	35	
20	43	36	38	36	
21	45	37	41	37	
22	46	37	41	37	
23	47	37	42	39	
24	48	36	43	39	
25	49	37	44	41	
26	51	36	44	40	
27	52	37	46	41	
28	53	36	46	42	
29	55	35	48	43	
30	57	35	47	43	
1 July 1981	57	36	47	43	
2	57	35	47	45	
3	58	34	48	44	
4	62	36	51	49	
5	61	36	50	49	
6	63	35	51	50	

Table 10. Continued.

Date	Animal name (sex) Trixie (F)	Punch (M)	Bud (M)	Oly (F)	Comments
7 July 1981	63	36	52	51	
8	65	36	52	51	
9	66	37	53	53	
11	71	36	55	56	
12	72	36	55	56	
13	74	36	57	60	
14	73	34	56	57	
15	73	34	57	58	
16	73	35	58	60	
17	76	33	58	61	Trixie and twins released.
18		36			
19	77	35			
20		34	60	64	
21	80	34	60	63	
22		34			
23	81	34	64	70	
24	84	34			
25		33	63	67	
26		33			
27	86	33			
28		33			
29		33		75	
30		33			
31		33			
2 Aug. 1981		34			
3		35			
4	103	35	75	81	
5		36			
6	104	37			
7		36			
8	106				
9		37			
10		37		87	
11	112	37	83	89	
13		38			
14		39			
15		40			
16	121	38	88	96	
17		38			
18	120	38	89	103	
19		39			
21		40			
22		38			Punch died.
24	133				
27	138		96	107	
2 Sept. 1981					Bud and Oly separated from mother (Lucy).

Table 10. Continued.

Date	Animal name (sex) Trixie (F)	Punch (M)	Bud (M)	Oly (F)	Comments
3 Sept. 1981					Trixie separated from mother (Angel).
5	144		99	115	
7					Bud died.
8	145			118	
17	153			132	
22	159			140	
30	170			146	
7 Oct. 1981	171			151	
15	180			161	
20	185			167	Released into big pen.
22	187				
30	190				
31	191			168	
15 Nov. 1981	204			180	
21	208			183	
27	210			186	Locked up.
28	212			187	
29	212			187	
30	207			182	
1 Dec. 1981	205			181	
2	205			179	
5	214			181	
9	210			188	
31	221			197	
1 Jan. 1982	224			201	
4	225			199	
8	227			203	
11	227			199	
18	235			208	
26	232			210	
29	234			211	
2 Feb. 1982	234				
9	235			206	
17	238			207	
27	239			208	
1 Mar. 1982	244			215	
15	247				
18	248			217	
24				212	
4 Apr. 1982	250			220	
14	252			220	
27	250			229	
3 May 1982	255			231	
11	267			236	
16	264			243	
24	278			249	
31	273			245	
15 June 1982	282			259	

Table 11. Histories of Pen 1 moose at Kenai Moose Research Center.

Moose No.	Sex	Year of birth	Significant observations			No. of times observed	No. of times captured
			Date	Event	Remarks		
58	M	1970	June 1982	Observed	Seen several times in June.	15	0
8	M	1978	June 1982	Observed	Seen several times in June.	18	0
125	F	1966	3 Oct. 1981	Observed	Most recent sighting. With twin calves.	12	0
R-70-8	F	1968	15 June 1982	Observed north of Pen 1.	Escaped from Pen 1 between mid-July and mid-August 1981.	8	0
UC[a]	F	1980	31 July 1981	Observed	Another UC yearling female seen on same date.	2-9	0
UC[a]	F	1980	29 Oct. 1981	Observed	Most recent sighting of moose known to be this age.	2-9	0
UC[b]	F	1981	20 June 1982	Observed	Most recent sighting.	2	0
UC[c]	F	?	16 June 1982	Observed	Most recent sighting of an of an UC cow.	10	0

[a] Two yearlings were seen on 2 occasions. One yearling was seen on 7 occasions. One of these moose may be 1980 calf of R-70-8.

[b] This moose may be 1 twin of cow no. 125. A calf was also seen twice with R-70-8 in 1981 but was not seen on several subsequent occasions.

[c] Portions of Pen 1 fenceline were down twice during this reporting period. It is not known whether outside moose entered Pen 1.

Table 12. Histories of Pen 2 moose at Kenai Moose Research Center.

Moose No.	Sex	Year of birth	Significant observations			No. of times observed	No. of times captured
			Date	Event	Remarks		
31	F	?	27 Feb. 1982	Trapped in 30N. Not in Pen 2.	Moose evidently left Pen 2 when gate was deliberately left open for her. She was not seen at that time.	1	1
UC	M	1979(?)	6 June 1982	Observed	Most recent sighting.	5	0
UC	F	?	9 Sept. 1981	Observed	UC cow seen with young UC male on 4 occasions.	?	0
UC	F	?	April 1982	Observed	UC cow seen with calf on 2 occasions.	?	0
UC	?	1981	April 1982	Observed	Calf seen with UC cow on 2 occasions.	2	0
UC[a]	?	?	9 Oct. 1981	Moose broke into Pen 2.	Moose was not seen.	?	0

[a] Other UC moose were sighted prior to date of break-in. Therefore, this is a different moose.

Table 13. Histories of Pen 3 moose at Kenai Moose Research Center.

Moose No.	Sex	Year of birth	Significant observations			No. of times observed	No. of times captured
			Date	Event	Remarks		
5	M	1974	2 Oct. 1981	Observed	Had previously been moved into Pen 4. Broke back into Pen 3 between 30 Sept. and 2 Oct. 1981.	4	0
17[a]	F	?	1 Oct. 1981	Observed(?)	UC cow with green flag in left ear seen.	2	0
13	F	1970-72	5 June 1982	Observed	Most recent sighting.	2	0
20	F	?	21 Sept. 1981	Caught in trap 35W.	Most recent sighting.	5	3
75(15)[b]	F	1969	7 June 1982	Observed(?)	UC cow with light blue flag in right ear seen.	1	0
18	F	?	27 Sept. 1981	Caught in trap 3N.	Most recent sighting.	2	2

[a] No other moose known to be in Pen 3 has green ear flags.

[b] No other moose known to be in Pen 3 has blue ear flags. However, ear flags of No. 75(15) were originally dark blue.

Table 15. Mortality within enclosures at Kenai Moose Research Center from 1 July 1981 through 30 June 1982.[a]

Pen No.	Moose No.	Sex	Year of birth	Date	Remarks
4	71	F	1969	26 Jan. 1982	Killed for a scientific study.
4	--	M	1980	2 July 1981	Killed for a scientific study.

[a] It is probable that some of the calves born in the enclosures in 1981 were killed by predators or died of other causes. However, the calves were not marked and were not often sighted, so these deaths were not documented.

Table 14. Histories of Pen 4 moose at Kenai Moose Research Center.

Moose No.	Sex	Year of birth	Significant observations			No. of times observed	No. of times captured
			Date	Event	Remarks		
71	F	1969	26 Jan. 1982	Killed	Collected for scientific studies.	1	0
UC[a]	F	?	7 June 1982	Observed	Cow seen with yearling. She had a metal eartag in left ear.	1	0
UC[a]	F	1981	7 June 1982	Observed	Yearling seen with UC cow.	1	0
UC[a]	M	1979-80	5 Dec. 1981	Caught in trap 4SE	Small bull lost both antlers in trap.	1	1

[a] During a helicopter survey on 15 June 1981, sightings were made of 3 UC cows with calves, 1 UC cow without a calf, 1 small UC bull, and 1 mature UC bull. Since that time, a 1-way gate has been constructed at the southeast corner of Pen 4 which would allow moose to leave the pen. It is not known how many moose have left Pen 4.

1981-82, consequently some moose escaped from MRC enclosures, while others entered them. Because we did not intensively trap MRC enclosures this winter, several unidentified moose appear in the records.

ACKNOWLEDGMENTS

We thank the Morris Animal Foundation, Denver, Colorado, for partial funding of the moose digestive physiology studies. Their assistance has enabled us to expand our studies with the tame moose. We also thank YACC workers William Glick and Greg Lewis for their help with protein digestion studies and laboratory analysis. Drs. Robert White and Dan Hollaman, Institute of Arctic Biology, University of Alaska, Fairbanks helped with water and rumen turnover studies.

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PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: None

Project No.: W-22-1 Project Title: Big Game Investigations

Job No.: 1.31R Job Title: Evaluating and Testing of Techniques for Moose Management

Period Covered: July 1, 1981 through June 30, 1982

SUMMARY

Evaluation of immobilizing drugs presently available continues. A permit to test an experimental immobilizing drug for moose was obtained, and the drug will be tested and evaluated for moose. Ear tag transmitters for a moose calf mortality study were tested and proved not to be useful under field conditions associated with handling newborn moose calves. The time required to fasten the radio transmitter to the ear was too long for the time allowable for this type of study. Neck collars were made using Ace bandage material with the ear tag transmitters incorporated; they were excellent for application, expansion, and positioning. It is not known how they will hold up or if moisture absorbency of the material will cause problems.

Key words: evaluation, management, moose, testing, techniques.

CONTENTS

BACKGROUND

The Kenai Moose Research Center (MRC) (Figs. 1, 2, 3), with known numbers of confined animals, provides unique conditions for developing and testing techniques applicable to moose (*Alces alces*) management. Initiation and completion of programmed studies under this job were not always possible because developments in related fields providing drugs, equipment, and procedures potentially applicable to moose management determined the thrust of our activity. A final report covering activities under this project from July 1974 through June 1981 was completed (Franzmann and Schwartz 1982). This is the 1st progress report following renewal of the job.

Franzmann and Schwartz (1982) recommended efforts should continue in testing and evaluating new immobilizing drugs for moose based upon their conclusion that an ideal immobilizing drug for moose was not presently available. Efforts were continued to inform drug manufacturers of the problems associated with immobilizing large ungulates.

Radio transmitters equipped with mortality sensors were applied to moose calves using an expandable neck collar (Schlegel 1976) and were used for the Kenai Peninsula moose calf mortality study (Franzmann and Schwartz 1979). This study was done in the 1947 Kenai Peninsula burn. A calf mortality study in the 1969 Kenai Peninsula burn began in 1981, and ear tag transmitters were purchased to test on moose calves. Their feasibility was tested and reported in this report.

OBJECTIVES

To test and evaluate techniques that are potentially useful for determining factors necessary for management of moose.

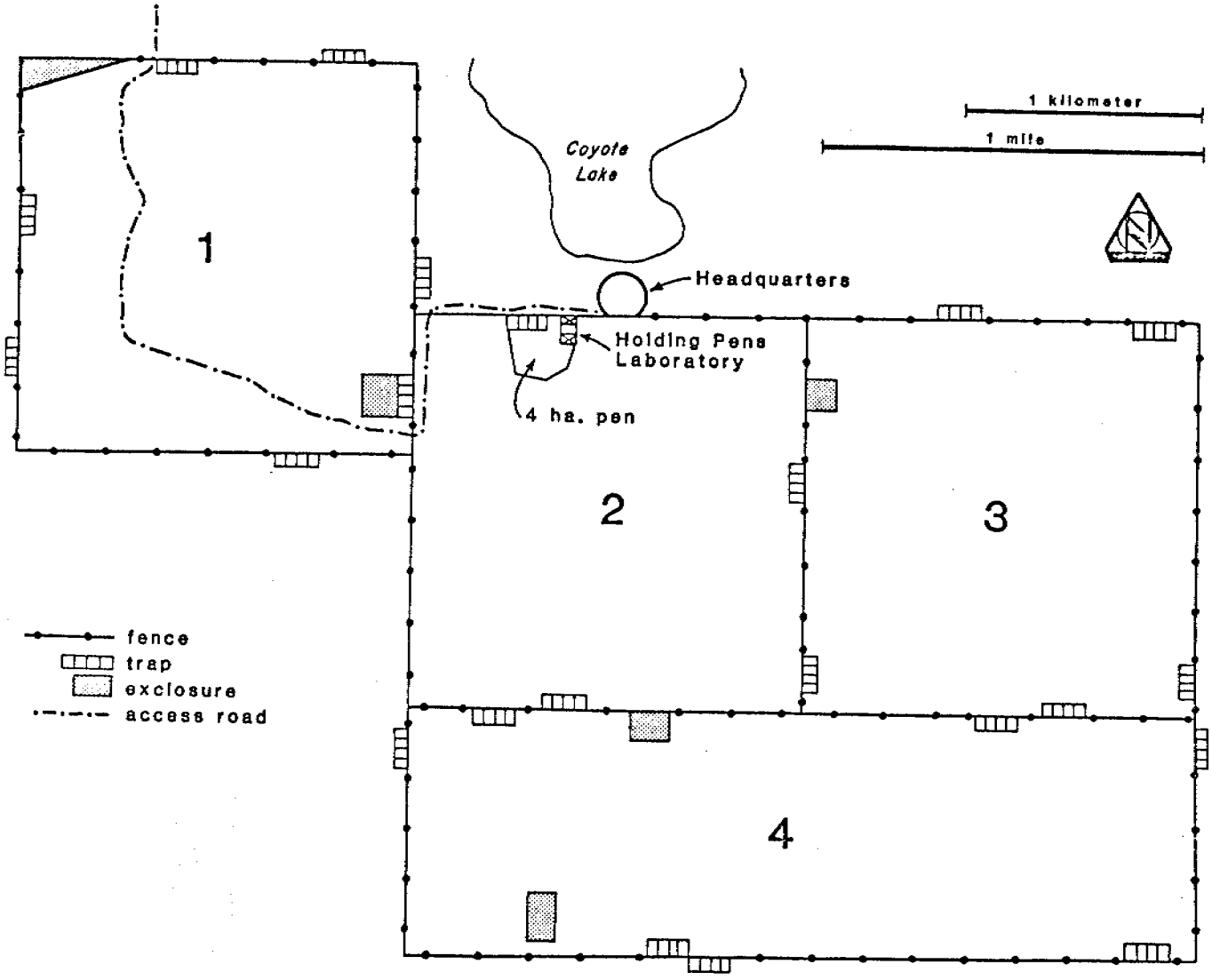

Fig. 1. Moose Research Center.

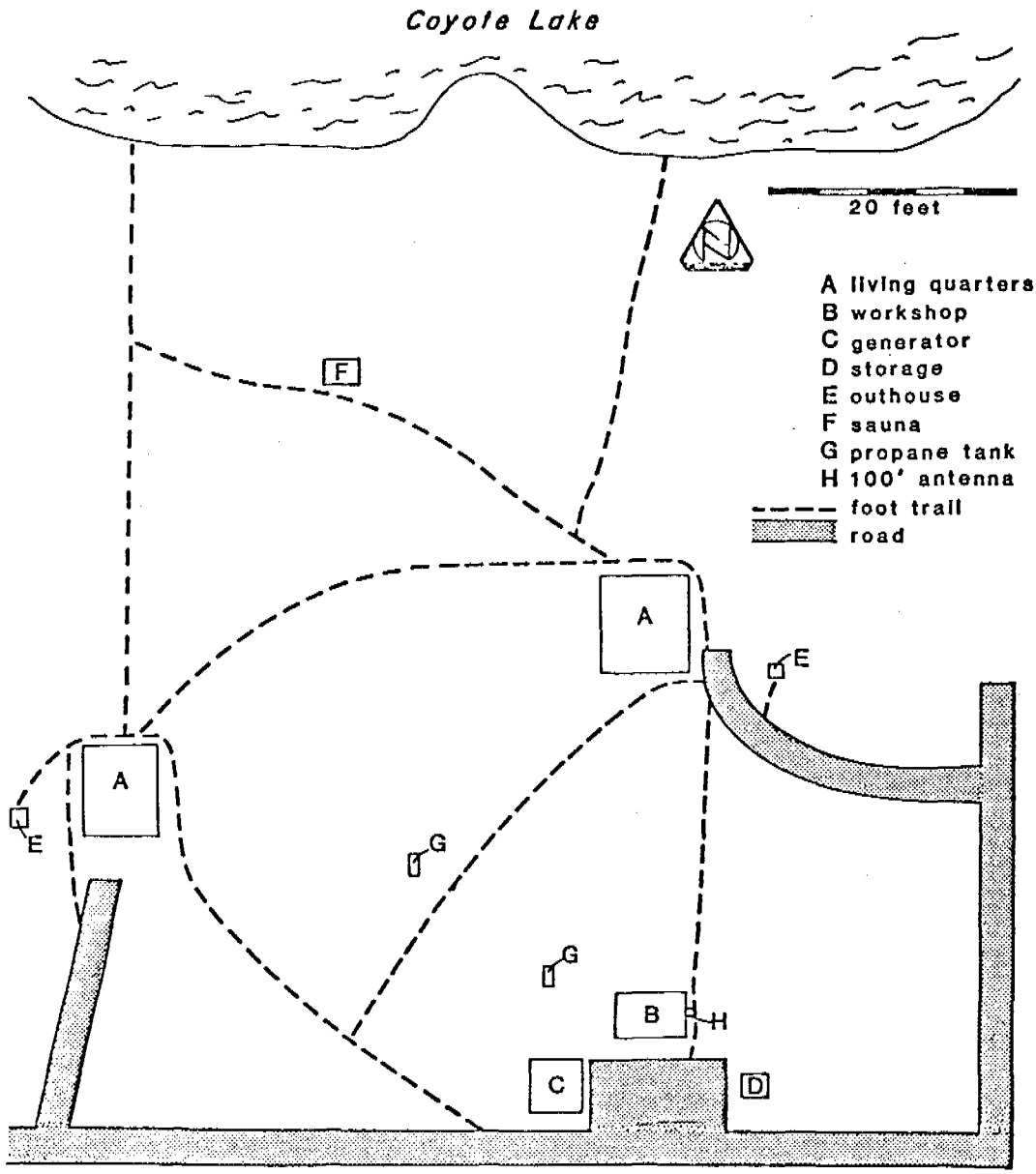

Fig. 2. Moose Research Center headquarters area.

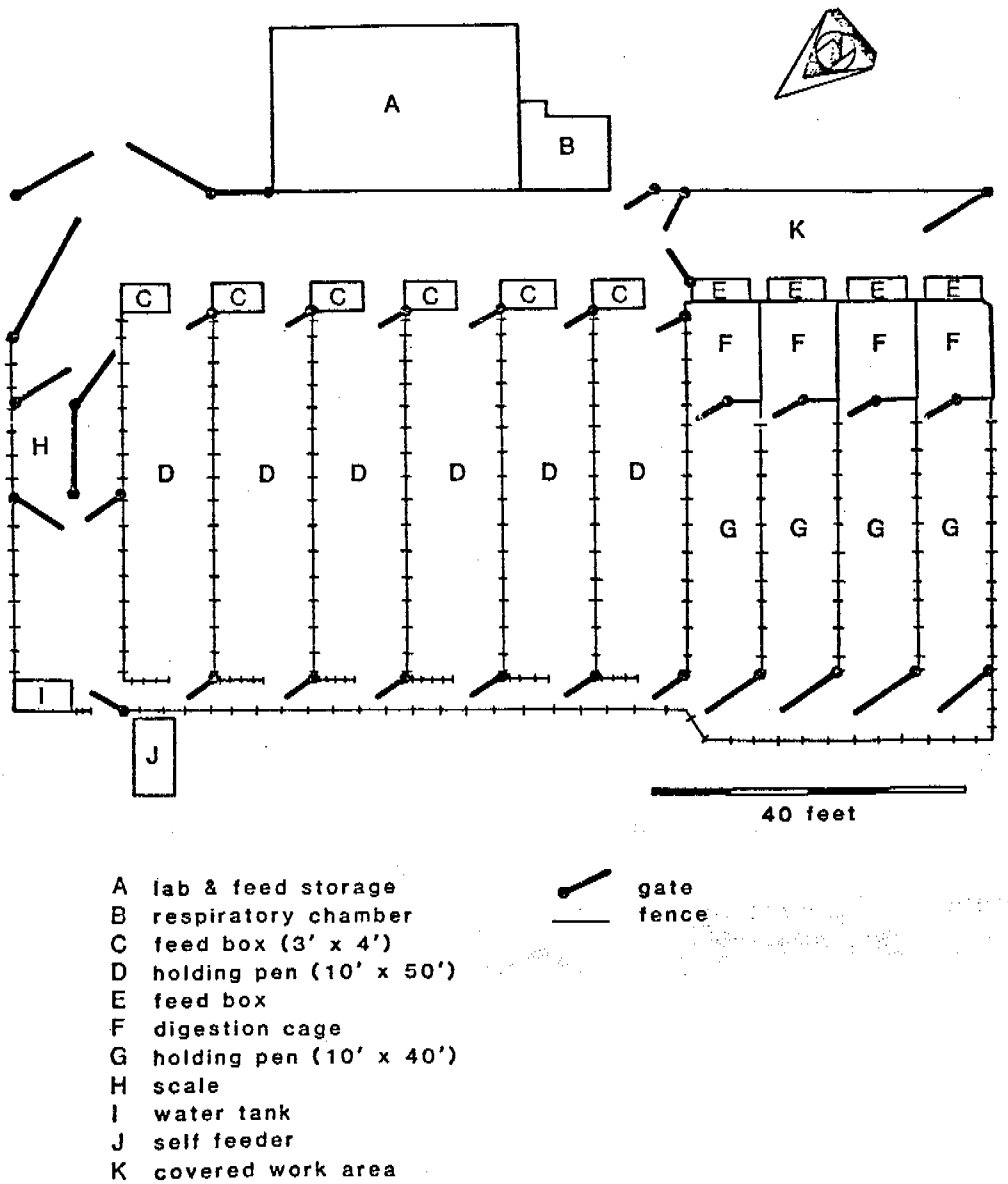

Fig. 3. Moose Research Center tame moose experimental area.

PROCEDURES

Immobilizing, Reversing, and Adjunct Drugs

No new drugs were tested on moose at the MRC, but etorphine hydrochloride (M99, Lemmon Co., Sellersville, Pa.) and its antagonist diprenorphine hydrochloride (M50-50, Lemmon Co., Sellersville, Pa.) were routinely used and evaluated.

An Investigational New Animal Drug (INAD) permit was obtained from the Food and Drug Administration to test a new immobilizing drug (Carfentanil, Janssen Pharmaceutica, Beerse, Belgium). The drug was recently obtained from the manufacturer but has not been tested on moose. Carfentanil was tested on a variety of African species with good success (DeVos 1978). The advantage for large ungulates is that it is highly concentrated and adult moose will require no more than 3 ml of the drug.

Radio telemetry

Ear tag radio transmitters weighing 50 g and equipped with a 27 cm antenna (Telonics, Mesa, Ariz.) were purchased for a calf mortality study. The transmitters were fastened to the ear with 2 plastic flange fasteners. The transmitter was designed to conform to the shape of the ear of moose calves. The pulse was adjusted to provide 6-month battery life which was adequate for the requirements of the study.

FINDINGS

Immobilizing, Reversing, and Adjunct Drugs

No new drugs were tested, but an experimental immobilizing drug (Carfentanil) was obtained for testing and evaluating. Two papers were prepared relative to MRC experiences with immobilizing drugs. The paper, "An Assessment of Chemical Immobilization of North American Moose (*Alces alces*)" was presented at the North American Symposium of Chemical Immobilization of Wildlife (Appendix A). The paper, "Chemical Immobilization of Moose at the Moose Research Center, Alaska (1968-1981)" was prepared for the 18th North American Moose Conference and Workshop (Appendix B).

Radio telemetry

Ear tag radio transmitters were applied to 3 moose on 26 May 1982 as the 1969 Kenai Peninsula burn calf mortality study fieldwork was initiated. Problems developed immediately due to the difficulty associated with the fasteners for the ear. The holes were readily punched in the calf's ear and the fasteners inserted. However, completion of the fastening process required forcing a round plastic disc over a plastic rod expanded on the

end. This operation required more time than allowable under conditions of calf radio collaring. The calves were less than 48 hours old. The helicopter dropped off the tagging crew and then kept the cow at a distance from the calf during application of the radio transmitter. It is important that this procedure occur quickly due to possible abandonment of the calf (Franzmann and Schwartz 1979).

The 3 radio transmitters that were applied tended to pull the calf's ear down and appeared to be too heavy for newborn calves. We subsequently fastened the ear tag transmitters to neck collars (Franzmann and Schwartz 1979, Ballard et al. 1980). Our supply of these neck collars was limited. For the remaining ear tag transmitters (16), we made neck collars from Ace bandage material. The transmitter and antenna were placed between layers of Ace bandage material and sewn with cotton thread. The expandability of the material is excellent; they were easily placed on the calves and fitted well.

Several unknowns regarding the Ace bandage neck collars are the following: (1) how long they will remain intact; and (2) will moisture absorbed by the material be a problem.

RECOMMENDATIONS

1. Ear tag transmitters for newborn moose calves did not provide effective method for field conditions demanded by a moose calf mortality study.

2. Ace bandage material was an excellent material to make neck collars incorporating the radio transmitters. Further evaluation is required to determine longevity of these collars.

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APPENDIX A. AN ASSESSMENT OF CHEMICAL IMMOBILIZATION OF NORTH AMERICAN MOOSE (*Alces alces*).

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The development of chemical immobilization of moose (*Alces alces*) parallels that of other ungulates. Refinements in pharmacology and delivery systems over the past 25 years have placed animal chemical immobilization into the realm of a routine procedure. Nevertheless, there are many misconceptions regarding chemical immobilization. This paper will deal with those misconceptions and problems as well as the benefits relative to North America's largest Cervid, the moose. The history and development of chemical immobilization has been outlined by several authors (Harthoorn 1965, Harthoorn 1975, Young 1975, Hebert and McFetridge, 1979, Fowler 1978).

Although chemical immobilization of moose follows a pattern of development similar to other ungulates, it has its own peculiarities and problems. A review is necessary to understand the present status and to permit us to project our needs and direction for the future.

Rausch and Ritcey (1961) were the first to report on the use of a chemical agent (nicotine salycilate) to immobilize moose using the Cap-Chur delivery system (Palmer Chemical Co., Douglasville, GA). Each author worked independently (Rausch in Alaska, 1957-58; Ritcey in British Columbia, 1959). Rausch reported of 15 animals surviving the test, 6 experienced complete paralysis, 6 partial paralysis, and 3 no paralysis. Two animals died (12%). Ritcey reported of 17 animals surviving the test, 4 experienced complete paralysis, 8 partial paralysis, and 5 no paralysis. Six animals died (26%). The higher mortality in British Columbia was attributed to fatigue and stress associated with approach and handling. Moose in Alaska were easily approached on winter range and stress was minimal. Other possible sources of variations in response were attributed to physical condition of animals, effectiveness of drugs from 3 different suppliers, dosage levels, and equipment problems. It was noted that the carbon dioxide-operated equipment did not function satisfactorily in extremely cold weather. They concluded that nicotine salycilate was unsatisfactory on excited or fatigued moose and that mortality rate was much too high.

The next major drug reported for moose immobilization was succinylcholine chloride (SCC) by Bergerud et al. (1964). They reported of 42 moose darted 31 (16 bulls, 13 cows, 2 yearlings) were successfully immobilized, but 7 bulls and 4 yearlings were killed (26% mortality). The effective dose was 0.044 to 0.063 mg SCC/kg. Overdosed moose received 0.087 mg/kg. They concluded a major problem was to accurately estimate weights of moose. They

also noted that females had higher tolerance to the drug than males and that artificial respiration was not effective for moose. Mean induction time was 9.5 $\pm$ 0.5 minutes and mean time immobilized was 32.8 $\pm$ 2.6 minutes. These investigators were first to report using helicopters to approach moose for darting. The first major moose immobilizing project via helicopter was reported by Nielson and Shaw (1967). They immobilized 97 moose using SCC and reported a mortality rate of 5%. They used 15 mg SCC during winter on yearling males and small females and 20 mg SCC on large adults. Houston (1969) successfully immobilized 107 moose with SCC from 1963 to 1967. Ten moose produced highly variable results and were excluded from his calculations, and 26 moose did not respond to darting (20%). Only 2 moose died (2%). Mean induction time was 9 minutes and mean time immobilized was 24 minutes. Artificial respiration was successfully used on 4 of 14 moose which were heavily dosed. Dosages for late winter-early spring had to be reduced by 20 to 30% from dosages used to late spring to midwinter. Late spring to mid-winter dosages recommended by Houston were 0.034 to 0.039 mg SCC/kg body weight for adult males and 0.044 to 0.048 mg SCC/kg for adult females and yearlings.

Franzmann et al. (1974) reported darting 1,098 moose in Alaska with SCC from 1968 to 1974, of which 770 were successfully immobilized (70.1%). Forty-six of 1,098 moose were killed (4.1%). The mean induction time (N = 722) was 8.5 minutes and mean time immobilized (N = 463) was 25.8 minutes. Induction time was shortened by a mean time of 2.3 minutes or 33%, with the addition of hyaluronidase (HD) to SCC (9NF units HD/mg SCC). They reported higher mortality rates with the SCC/HD combination. Artificial respiration was administered to 20 moose suffering from respiratory distress at the Moose Research Center (MRC) of which 12 survived. Using weight data from MRC moose (Franzmann et al. 1978) the SCC dosage/kg body weight for MRC adult females was 0.048 to 0.052 mg and 0.042 to 0.046 mg for adult males. Franzmann and Arneson (1974) concluded that in spite of undesirable qualities of SCC (seasonal variation, individual variation, narrow safety factor, and no CNS depression it was the drug of choice at that time.

In other areas of Alaska SCC was used extensively to immobilize moose during the early to mid 1970's: 49 in lower Susitna Valley (Didrickson et al. 1977); 50 on the Copper River Delta (Franzmann and Arneson 1975); 208 along the Trans-Alaska Pipeline corridor (Van Ballenberghe 1978); 112 in the Upper Susitna River Basin (Ballard and Taylor 1978); and 140 in interior Alaska (Gasaway, pers. comm.). Mortalities ranged from 2% in Copper River Delta to 7.6% in the Upper Susitna River area.

Recently, Ballard and Tobey (1981) reported decreased calf production of moose immobilized with SCC from a helicopter. They reported 0.39 calves/cow from moose immobilized while pregnant versus 1.15 calves/cow from moose immobilized before pregnant in the same population.

Etorphine hydrochloride (M-99, 1 mg etorphine HCl/ml, Lemmon Co., Rockville, MD) was first reported as an immobilizing drug for moose by Houston (1970). He reported that 90% of attempted immobilization were successful with 38 moose being immobilized. Induction time ranged from 4 to 34 minutes and averaged 14 minutes. Effective dosage ranged from 0.009 to 0.015 mg/kg. He concluded that the wide range of effectiveness of etorphine with minimum side effects, and availability of an effective fast-acting antagonist (Nalorphine - M-285, American Cyanamid, Princeton, NJ) were obvious advantages over other drugs. He considered the longer induction time a minor disadvantage. Other reports following Houston (1970) reported using diprenorphine hydrochloride (M 50-50, 2 mg diprenorphine HCl/ml, Lemmon Co., Rockville, MD) as the antagonist. Roussel and Patenaude (1975) compared use of the antagonists diprenorphine and nalorphine and concluded that diprenorphine had the advantage of (1) a ratio of 1:2 etorphine to diprenorphine is used instead of a ratio ranging from 1:10 to 1:20 required with etorphine-to-nalorphine, and (2) less residual narcosis was noticed after IV administration of diprenorphine.

In 1970, 28 moose were immobilized at the MRC with etorphine (LeResche and Davis 1971). The conclusions were that etorphine was the only drug safe enough to use on calves, yearlings and rutting bulls. They were first to report dosage variation with season; 0.013 mg/kg in spring and 0.017 mg/kg in fall for adult cows. Franzmann et al. (1974) classified response to etorphine immobilization of moose as satisfactory if induction time was less than 15 minutes with a single injection. Forty-three of 68 (63%) of adult moose, 15 of 17 (88%) of yearling moose, and 22 of 22 (100%) of moose calves experienced satisfactory responses. Mean successful dosage of etorphine for adult moose and moose calves was 0.02 mg/kg and for yearling moose the dosage was 0.013 mg/kg.

Roussel and Patenaude (1975) reported successfully immobilizing moose with dosages of 4 to 5 mg/moose. Induction time with 5 mg dosage was 9.8 minutes and 11.6 minutes with 4 mg dosage. Reversal time using diprenorphine IM was 5 to 15 minutes.

Lynch and Hanson (1981) reported immobilizing 118 adult moose in Alberta with etorphine. The dosage ranged from 5 to 7 mg per moose and the mortality rate was 8.5%. Lynch (1978) reported attempted immobilization of 11 moose with phencycladine hydrochloride (Sernylan, Parke-Davis and Co., Detroit, MI) of which 6 died. Xylazine hydrochloride (Rompun, 100 mg xylazine hydrochloride/ml, Haver-Lockhart, Shawnee, KS) was attempted on a single moose and it died. Franzmann and Arneson (1974) used xylazine dosed at 2.2 mg/kg in moose for immobiliation with success. Mean induction time for 4 adult moose was 10.5 minutes. They indicated the usefulness of the drug was limited for most applications on free-ranging animals due to the prolonged ataxia experienced during recovery (up to 2 hours).

Franzmann and Arneson (1974) also reported on tests using CI-744. (Parke-Davis and Co., Detroit, MI) to immobilize moose. CI-774 is a 1:1 combination of tiletamine HCl (CI-634) a CNS depressant and diazepionone (CI-716) a tranquilizer. Five of 13 animals did not go down and of those responding induction time varied from 1 to 42 minutes. A long period of ataxia was noted during recovery. Dosage of CI-744 ranged from 2.4 to 4.8 mg/kg and improper dosage may have been the cause of problems experienced.

By the mid 1970's etorphine with diprenorphine as an antagonist had essentially replaced SCC as the principal chemical immobilizing agent for North American moose. Alford et al. (1974) reported that field tests of 1,600 animals (89 different species) resulted in 74% good immobilization, 21% fair, and 2.1% poor. Mortality was 2.9%. The report indicated effective immobilization of Cervidae was obtained with dosages averaging 0.022 mg etrophine/kg body weight. They also reported some side effects commonly noticed in free-ranging animals, such as tachycardia, bellowing, bradycardia, respiratory depression, opisthotonos, muscular tremors, mydriasis, and hyperpyrexia.

The hyperpyrexia concerned us the most at the MRC, because most of the etorphine mortalities we experienced had hyperpyrexia prior to death. We began mixing xylazine with etorphine at the rate of 0.009 mg etorphine and 1.1 mg xylazine per kg body weight (Franzmann and Arneson 1976). For a 500 kg moose we administered 4.5 mg etorphine and 550 mg xylazine. The advantages of the mixture were (1) one-half etorphine dose was used thereby cutting cost, and (2) salivation, anxiety, and overheating were diminished. There was a great disadvantage in that the recovery time with the antagonist was extended and this created problems for free-ranging animals. It appeared that the proportion of xylazine was too high in the mixture and we subsequently altered the ratio to 7 mg etorphine and 300 mg xylazine.

Forty-eight adult moose were immobilized during fall 1976 in interior Alaska, and 57 adult female moose were immobilized during April 1977 on the Alaska Peninsula using the etorphine/xylazine mixture (Gasaway et al. 1978). The dosage producing the best immobilization response on adult female moose, both in spring and fall ranged from 0.016 to 0.014 mg etorphine and 0.67 to 0.60 mg xylazine per kg body weight. Adult male dosage was 0.014 to 0.011 mg etorphine and 0.6 to 0.47 mg xylazine per kg body weight. Adult moose each received 7 mg etorphine and 300 mg xylazine. Four mortalities were experienced during fall immobilization due to (1) high ambient temperature, (2) stress from pursuit and darting, and (3) prolonged recovery with xylazine. Three of the 4 mortalities received 6 mg etorphine and 400 mg xylazine. Capture myopathy (Haigh et al. 1977a) was not identified as a cause of mortality, but it was suspected.

Hyaluronidase (Wydase, Wyeth Laboratories, Philadelphia, PA) at the rate of 250 units was added to the etorphine/xylazine mixture to immobilize 14 cow moose with newborn calves in May 1977 (Franzmann and Bailey 1977). The mean induction time was 7.3 minutes, but the addition of hyaluronidase may have not been solely responsible because the cows were in poor condition.

Haigh et al. (1977b) reported using fentanyl citrate (McNeil Laboratories, Don Mills, Ontario) with xylazine to immobilize 47 moose. A dosage of between 0.14 and 0.53 mg/kg of fentanyl and 0.15 to 0.53 mg/kg of xylazine provided satisfactory immobilization. A reduction of induction time from between 36 and 45% was noted when hyaluronidase was added to the mixture. They also strongly emphasized the importance of injection site for good immobilization response. Heavy muscle masses of shoulders and rump were considered ideal sites.

Immobilon (2.45 mg etorphine HCl and 10 mg acepromazine maleate/ml, Rickett and Coleman Pharmaceutical Division, Hull, England) has been used in Canada to immobilize moose. The product is not commercially available in the U. S. David Fong (pers. comm.) indicated that 4 to 5 ml of Immobilon™ was used to satisfactorily immobilize adult moose in Newfoundland. The dosages (9.8 to 12.25 mg etorphine plus 40 to 50 mg acepromazine) were higher than was reported for other areas. This may have been related to the availability of a more concentrated product. Etorphine availability in U. S. is presently in a 1 mg/ml concentration. The powdered form of etorphine was not available after 1972 when the 1 mg/ml product was marketed.

In Alaska, several major moose immobilizing projects were conducted using the dosage of 7 mg etorphine/300 mg xylazine other than those reported by Gasaway et al. (1978) and they include 42 adult females in Yakutat Forelands with 1 mortality (2.4%) (Smith and Franzmann 1980); 16 adult moose at Thomas Bay with 2 mortalities (12.5%) (Doerr et al. 1980); 111 adult moose in Interior Alaska with 7 mortalities (6.3%) (W. Gasaway, pers. comm.); 20 adult moose at the MRC with 1 mortality (5%); and 72 adult moose in the Upper Susitna with 2 mortalities (2.8%) (W. Ballard, pers. comm.). Gasaway indicated all their losses in interior Alaska were during warm weather. Up to 1981, in Alaska 308 adult moose were immobilized with 7 mg etorphine/300 mg xylazine with 13 mortalities (4.2%).

Nowlin et al. (1979) reported successfully transplanting 12 moose using 7 mg etorphine/300 mg xylazine from Utah to Colorado. They reported no mortalities with the operation, but experienced mortalities earlier with dosages less than recommended by Gasaway et al. (1978).

Based upon most reports and our own experiences, the 7 mg etorphine/300 mg xylazine dosage for immobilizing moose was working

satisfactorily in spite of the inherent negative aspects of the drugs. However, during November and December 1980, the 7 mg etorphine/300 mg xylazine dosage was not adequate to immobilize moose on the Kenai National Wildlife Refuge and had to be adjusted upward to 12 mg etorphine/400 mg xylazine to effectively immobilize adult moose (Franzmann and Schwartz 1981). This required double darting each moose. Similar problems were experienced by others in Alaska during this period of time (W. C. Gasaway and W. B. Ballard, pers. comm.). Conversely, 40 Seward Peninsula, Alaska, moose were immobilized using 7 mg etorphine/300 mg xylazine during April 1981 with only a few moose requiring additional drug for immobilization (Franzmann and Schwartz 1982). It was difficult to explain the sudden need for greater dosages, and then the subsequent drop in dosage requirements. Condition of moose, season of use, and ambient temperatures were all considered, but the pattern was not consistent. One certainly could not negate the possibility of lower drug potency, but this was not tested or proven.

Hauge and Keith (1981) immobilized 66 moose in Alberta using various dosages of (1) etorphine, (2) etorphine with xylazine, and (3) fentanyl and xylazine. They used hyaluronidase with the latter 2 mixtures to reduce induction time. The drugs used in this study represent the present state-of-the-art for immobilizing moose in North America.

All moose immobilizing projects have not been reviewed, since many were not published but the outline depicts the development of chemical immobilization of moose. It is apparent that where we are today does not present a satisfactory position. This may be quantified by evaluating the drugs used today on 10 criteria that an ideal immobilizing drug should possess:

1. Rapid absorption and action
2. Concentrated form - small quantity for injection
3. Wide range of tolerance for animal
4. Safe for handler
5. Reversible
6. No side effects
7. Effective anesthesia level
8. Not subject to Dangerous Drug licensing
9. Cleared for use on animal for food
10. Low cost

Etorphine, as available, in United States, can qualify for only 4 criteria. The negative aspects are that it is not in concentrated form, it is dangerous to handler, it has side effects of hypothermia (Gasaway et al. 1978) and capture myopathy (Haigh et al. 1977a), it is subject to Dangerous Drug licensing, it is not cleared for use in animals for food, and it is expensive. Combining etorphine with xylazine improves the side effect problem and lowers cost, but nevertheless it is far from qualifying as an ideal drug. Fentanyl would receive a similar evaluation, and may be preferred by some users. Succinylcholine chloride qualified on 5 criteria, but has generally been discarded because of the

extremely narrow range of tolerance. It is obvious that a simple grade on these criteria is not a perfect evaluation, but it does provide an assessment. The drug evaluation problem is further complicated by other factors including:

1. Problems with delivery systems:
    a. Swelling and distortion of dart body
    b. Internal charge malfunction
    c. Needle fracture and bending
    d. Plugged needles
    e. Bleeding out at injection sites
    f. Improper injection site
    g. Drug quality

2. Species Differences

3. Physiological Status of Animals
    a. Age
    b. Sex
    c. Reproduction status
    d. Lactation
    e. Disease/health
    f. Condition
    g. Individual variation
    h. Time of day - food fill
    i. Stress

4. Behavior and Stress
    a. Overexcited
    b. Excessive driving
    c. Innate excitability
    d. Seasonal and nutritive stress
    e. Presence of other animals

5. Environmental Factors
    a. Climate
    b. Temperatures
    c. Terrain

The message from immobilizing experiences in different populations is that adjustments must be made in considerations for all possible influences. What may work in one circumstance may not in another. We will always be faced with certain variables, but we must always attempt to minimize these. Today, our greatest and I consider first problem, given no new drugs become available, is that our available supply of etorphine is too dilute. A concentrated liquid form or powdered product should be made available. This would eliminate many problems; projectile systems would be made more simple and practical, double-darting would be eliminated, absorption by animal would be facilitated, erratic flight of dart would improve, danger to the operator associated with poor immobilizing performance would be minimized and a more humane and aesthetic operation would result.

If we cannot obtain etorphine in a more usable form for moose (and other larger ungulates), we must seek other possibilities such as reconsidering the use of SCC for immobilization. The mortality rate in Alaska for SCC in 1,098 moose was 4.1% (45 mortalities) and with etorphine and etorphine combinations in 754 moose was 5.2% (39 mortalities). A great difference between SCC and etorphine use was that only 70.1% of moose which were darted for immobilization attempts went down, while 94.5% of attempts with etorphine were successful (MRC data).

Carfentanil (R33799, Janssen Pharmaceutica, Beerse, Belgium) is a potent morphine-like analgesic which has been successfully used on large ungulates in South Africa (DeVos 1978). The drug is not commercially available, but it appears to have most of the qualities we need for large ungulate immobilizations. Encouraging the manufacturer to market the drug is another option to consider.

Some products that are manufactured outside the United States should be made available to us. For example: Immobilon from England has a more concentrated etorphine content (2.45 mg/ml); powdered Rompun is marketed in West Germany; and Carfentanil, although still experimental, is made in Belgium. Import restrictions should be adjusted to make these products available. There is no justification to continue to use inferior products when these could be used.

Several enumerated conclusions and statements may be made which summarize the experiences encountered with moose chemical immobilization.

1. Nicotine salycilate, sernylan, and CI-744 did not provide good immobilization characteristics when tested on moose.

2. There is not at present a drug we can consider ideal for immobilizing moose.

3. If there is a method other than chemical immobilization to handle or capture moose to obtain one's objectives, it should be selected.

4. Immobilization of moose with ambient temperature above 10°C (50°F) should be discouraged.

5. Snow cover of 32 cm (12') or more is a great assist when immobilizing free-ranging moose. It helps put them down quicker and helps prevent hyperthermia.

6. In extreme cold weather with snow cover etorphine alone will suffice as an immobilizing drug, but if stress or excitability is anticipated or the ambient temperature is above 5°C (40°F), xylazine should be mixed with etorphine.

7. Xylazine dosage for an adult moose when mixed with etorphine should not exceed 300 mg.

8. Hyaluronidase decreases induction time significantly and should be used as an adjunct drug.

9. Season and condition of moose require dosage adjustments. It is best to be on high side with etorphine.

10. Site of injection is important--heavy muscles of hind limb and shoulder are preferred.

11. Minimum harassment of the animal provides minimum problems.

12. After darting animal, one must keep disturbances to an absolute minimum with etorphine. An animal receiving excess stimuli will be difficult to put down.

13. Concentration of drug should be such that a dart no larger than 3 ml is required.

14. Vital signs should be checked first when arriving at immobilized animal. (Respiration rate, heart rate, mucosa color, temperature, evidence of hemorrhage).

15. Proper positioning and protection of immobilized animal are second concerns.

16. Be familiar with projectile system peculiarities and problems.

17. Use clean and well functioning equipment. Have backup or spare equipment for field procedures.

18. When a helicopter is used for immobilization projects, an experienced helicopter pilot is important for success.

19. Artificial respiration, when oxygen is not available (most situations), is best accomplished on moose by mouth (human) to nose (moose) procedure.

20. If an antagonist is used, make an effort to give drug intravenously. Do not force animal up sooner than necessary.

21. Assure adequate protection and safety of all persons concerned with an operation. Have a human antidote available for concentrated morphine products.

22. Agencies or users of immobilizing drugs should be required to take a short course on proper use of drugs and equipment and care for animals and operators.

23. Etorphine in present form for United States is not acceptable for moose.

24. Carfentanil holds promise as a drug which may replace etorphine in present form.

25. A unified and organized force consistency of persons, groups, and agencies concerned with immobilizing animals is needed to lobby for change and improvement of drugs to assure better and more aesthetic results with higher margins of safety.

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APPENDIX B. CHEMICAL IMMOBILIZATION OF MOOSE AT THE MOOSE RESEARCH CENTER, ALASKA (1968-1981).

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Abstract: Data from chemical immobilization of Alaskan moose (*Alces alces*) from 1968 through 1981 at the Moose Research Center were compiled and assessed. Immobilizing drugs tested during that period were succinylcholine chloride, CI 744, xylazine hydrochloride and etorphine hydrochloride. Other adjunct and reversing drugs were discussed. From 1968 to 1975 succinylcholine chloride was the routine drug used for immobilization at the Moose Research Center with 1,258 moose darted and 908 immobilized. Mean induction time was 8.5 minutes and mean time immobilized was 25.7 minutes. Hyaluronidase added to succinycholine chloride decreased induction time by 33% with no increase in mortality. Mortality rate for succinylcholine chloride was 5.5% of moose immobilized, however, only 72.2% of moose darted were immobilized. Etorphine hydrochloride became the routine immobilizing drug in 1975 and is used routinely. To date, 138 adult moose and 98 calves and yearlings have been immobilized. Mean induction time for etorphine was 11.4 minutes, and time immobilized was dependent upon time of antagonist injection. The mortality rate using etorphine on adults was 8.7%, but nearly all moose darted went down but many required supplemental doses. The mortality rates were inflated because these figures include data from early experimental work with the drugs. Familiarization with the drugs and the conditions for their use has decreased mortality significantly. Etorphine with xylazine is the drug combination presently preferred, but it is far from the ideal drug as presently available. The conclusion is that the ideal drug or drug combination to immobilize moose has not been found.

INTRODUCTION

Chemical immobilization for capture of free-ranging animals became an accepted procedure during the 1950's with development of efficient projectile systems and drugs. The history and development of chemical immobilization has been documented (Harthoorn 1965, 1975; Young 1975). Franzmann (1982) reviewed and assessed chemical immobilization of North American moose (*Alces alces*). This paper outlines our experiences with chemical immobilization of Alaskan moose (*Alces alces gigas*) from 1968 through 1981 at the Moose Research Center (MRC) on the Kenai Peninsula, Alaska. Several reports and papers have provided information from various segments of our research (Franzmann and

Arneson 1974, Franzmann et al. 1974, Franzmann and Schwartz 1982), but a compilation and an assessment of our data are lacking.

STUDY AREA

The MRC is located within the Kenai National Wildlife Refuge (KNWR, formerly the Kenai National Moose Range) on the Kenai Peninsula in southcentral Alaska. Several papers have described the topography and vegetation of the Kenai Peninsula (Oldemeyer and Seemel 1976, Oldemeyer et al. 1977, and Sigman 1977). Research facilities at the MRC were described by Franzmann and Schwartz (1982) and Figure 1 is a schematic drawing of the MRC.

METHODS

Approaching Animal

Most moose captured at the MRC were initially trapped using rectangular corral traps (LeResche and Lynch 1973) located strategically along 24 km of MRC fenceline both inside and outside the 4 enclosures (Fig. 1). The traps measure 30x5 m and when a moose was caught it was approached on foot and subsequently immobilized.

In a few instances it was necessary to utilize a helicopter to approach a moose in the enclosures when specific animals were required. All free-ranging moose outside the MRC enclosures which were not caught by perimeter traps were approached by helicopter (Bell Jet Ranger). Helicopter use was limited to immobilization with succinylcholine chloride (Anectine, Burroughs-Wellcome and Co., Research Triangle Park, NC).

Tame and semi-tame moose have been maintained at the MRC in various numbers and in most cases have been approached to immobilize with a hand-syringe.

Projectile System

The projectile system for nearly all MRC moose immobilizations was the Cap-Chur system (Palmer Chemical Co., Douglasville, GA). The only exception was the use of hand-held syringes to inject tame or semi-tame moose. Projectile dart body size varied from 3 to 15 ml depending upon drug used and the internal charge was adjusted accordingly. The firing charge used was primarily green or low for moose in the traps and moose darted from the helicopter. Occasionally a brown or extra low charge was used in a trap.

Drugs

The principal immobilizing drugs used at the MRC were: succinylcholine chloride which is a paralyzing drug acting at the

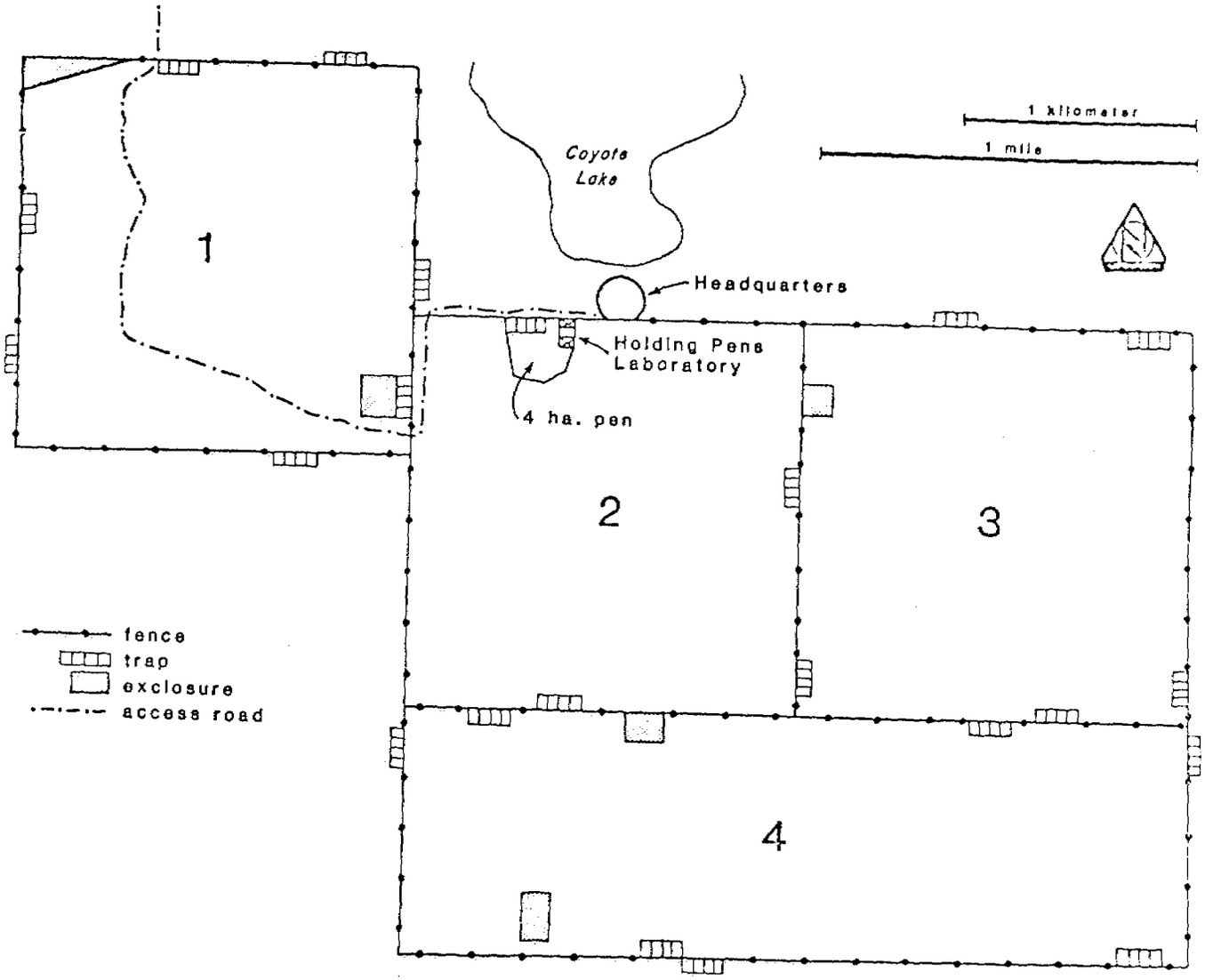

Fig. 1. Moose Research Center.

myoneural junction; etorphine hydrochloride (M-99, Lemmon Co., Sellersville, PA) a synthetic narcotic and potent CNC analgesic; xylazine hydrochloride (Rompun, Haver-Lockhart, Shawnee, KS) a non-narcotic CNS sedative, analgesic, and muscle relaxant; and CI-744 (Parke-Davis and Co., Detroit, MI) which is a 1:1 combination of tiletamide hydrochloride (CI-634) a CNS depressant and diazepionone (CI-716) a tranquilizer.

The primary antagonist used to reverse the effects of etorphine was diprenorphine hydrochloride (M50-50, Lemmon Co., Sellersville, PA). Cyprenorphine hydrochloride (M285, American Cyanamid Co., Princeton, NJ) was the first antagonist used with etorphine but was replaced by diprenorphine.

Adjunct drugs used were: hyaluronidase (Wydase, Wyeth Laboratories, Philadelphia, PA) which is an enzyme that breaks down connective tissue at the injection site hastening absorption of the immobilizer; and xylazine which was used as a sole immobilizing drug and as an adjunct drug with etorphine. Occasionally a tranquilizer such as acepromazine maleate (Acepromazine, Fort Dodge Laboratories, Inc., Fort Dodge, IA), or promazine hydrochloride (Sparine, Wyeth Laboratories, Inc., Philadelphia, PA) were used after immobilization for their tranquilizing effect.

Adult (36+ months) female moose from MRC had a mean weight of 339.2 kg ($\underline{N}$ = 81). Non-MRC moose had a mean weight of 400.5 kg ($\underline{N}$ = 81). Adult males from the MRC averaged 402.3 kg ($\underline{N}$ = 81) bodyweight and non-MRC weight 454.6 kg ($\underline{N}$ = 81) (Franzmann et al. 1978). Yearling moose immobilized in late summer/fall ranged in weight from 200 to 225 kg. Moose calves immobilized in late summer/fall ranged in weight from 90 to 175 kg (Franzmann et al. 1978).

RESULTS AND DISCUSSION

Approaching Animal

Fenceline traps at the MRC were useful to catch and hold moose for subsequent immobilization. From 1969 to 1974, during our most intensive trapping period, 824 moose were trapped during 4,322 trap nights (trap success = 0.19). Generally, moose in traps were easily approached and darted. On occasion, however, some were hyperactive and would charge or flee from the person darting making dart placement more difficult.

Moose escaping from the trap by jumping and breaking through the trap walls was more prevalent in traps on the outside of the MRC enclosure than those inside (Fig. 1) (3.5% escaped from outside traps and 1.4% from inside traps). Moose within the enclosures were free-ranging, but had more experience with the fenceline and some had been trapped repeatedly. Male moose under 3 years of age were the most excitable in a trap of all sex and age classes.

The use of a helicopter to approach moose was effective with a good pilot, and in most instances, the animal could be forced into an open area for darting. Occasionally, moose would enter a stand of large trees and could not be forced out; in such cases, they could be darted if the overstory was not too thick.

Dart placement was extremely important and the heavy muscles of the hind limb was the site of choice. This was relatively easily accomplished with moose in MRC traps. Moose darted from a helicopter could be darted in the hind limb musculature under ideal conditions. Often the top of rump and loin had to be selected and if the moose did not have a heavy subcutaneous fat layer the injection was absorbed more rapidly.

Moose immobilized with a hand held syringe were generally injected in the neck muscle dorsal to the jugular furrow.

Projectile Systems

Cap-Chur guns and darts were generally satisfactory for immobilizing moose. The advantages of the system were:

1. Simplicity of design which afforded less opportunity for mechanical failure.

2. Availability of a variety of dart sizes to accommodate various drug volumes.

3. Interchangeability of dart components with different dart body sizes.

4. Availability of supply.

5. Darts could be reused if not damaged.

No system is without fault, and the major disadvantages of the system were:

1. Errant flight of the dart.

2. Variability in projecting charge.

3. Swelling and distortion of dart body.

4. Incomplete injection - primarily with large (7 ml or greater) darts.

Other systems became available during the studies, but were not evaluated because the system being used was satisfactory, conversion would be costly, and volume of drug needed limited our choices. Blow-dart systems have a great potential for darting moose in the MRC traps, but were not used for moose because the maximum volume of the darts is 3 ml. The drugs being used for moose after development of blow-darts required much larger

volumes. If an effective and safe drug becomes available for moose in North America whose total dosage volume is 3 ml or less, it is believed the blow-dart system would be the projectile system of choice for moose in MRC traps.

Drugs and Immobilization

Succinylcholine chloride (SCC) used in the concentration of 10 mg/ml was the first immobilizing drug used at the MRC, and it was routinely used up through 1976. Hyaluronidase (HD) was added to SCC (9 NF units/mg SCC) for 510 of 838 moose immobilized. Tables 1, 2, and 3 list the mean induction time and time immobilized for the various dosages of SCC and SCC/HD for adult moose inside MRC, outside MRC and free-ranging. Dosages varied from 12.5 to 25.5 mg SCC/adult moose. This variability was primarily influenced by condition of moose which is a function of season. Lower dosages were used during late winter and spring for both sexes and during the late rut (October) for bulls.

Combined sex and drug mean induction time was 8.5 minutes ($\underline{N}$ = 838) and mean time immobilized was 25.7 minutes ($\underline{N}$ = 505) (Table 4). We were unable to record all times up for moose thereby explaining the lesser sample size on time immobilized. Likewise, some of the down times for free-ranging moose were recorded when the animal was observed down. In some cases the helicopter would return late to the immobilized moose and the moose may have been down for a few unknown minutes.

The most accurate induction time data was provided by MRC immobilizations where the moose were in traps and were observed through the entire immobilization process. The mean induction time for inside MRC moose was 10.0 minutes ($\underline{N}$ = 105) for SCC and 6.5 minutes ($\underline{N}$ = 148) for SCC/HD (Table 1). Outside trapped MRC moose had a mean induction time of 10.2 minutes ($\underline{N}$ = 55) with SCC and 6.9 minutes ($\underline{N}$ = 94) with SCC/HD (Table 2). The combined mean induction time for all MRC trapped moose was 10.1 minutes ($\underline{N}$ = 160) with SCC and 6.7 minutes with SCC/HD.

Mean induction time was lessened with the use of HD by 3.4 minutes (33%). We reported the decrease in induction time with HD (Franzmann et al. 1974), but also reported an increase in mortality using HD. Additional data disputes this finding with 22 of 554 (4.0%) moose killed with SCC/HD and 22 of 554 (4.0%) killed with SCC (Table 5). The mortality rate was the same for both drugs.

Lowered dosage did not decrease induction time (Tables 1, 2, 3). Lowered dosages were used on animals in poor condition. The major influence on induction time was the addition of HD. Sex and location did not influence dosage other than that which could be attributed to condition of the moose.

The most disturbing data are that only 72.2% (908 of 1258) (Table 5) of moose darted were immobilized. This quickly converts to time, and when darting is done by helicopter, it converts to

Table 1. Effects of succinylcholine chloride (Anectine) [1] and hyaluronidase (Wydase) [2] administered to trapped adult [3] Alaskan moose within the Kenai Moose Research Center (MRC) enclosures, 1968 to 1976. (Sample size in parenthesis).

Dosage (mg of Anectine)	Mean Induction Time (min)				Mean Time Immobilized (min)			
	Anectine		Anectine w/Wydase		Anectine		Anectine w/Wydase	
	Male	Female	Male	Female	Male	Female	Male	Female
13	0	8.0(1)	0	6.0(1)	0	10.0(1)	0	14.0(1)
13.5	7.5(3)	10.6(23)	2.5(1)	8.3(13)	41.5(3)	20.4(23)	22.0(1)	34.4(12)
14	9.1(7)	8.9(9)	4.5(1)	5.2(5)	9.1(7)	18.6(9)	14.1(1)	20.0(5)
15	9.7(3)	9.0(1)	0	6.0(1)	15.7(3)	25.0(1)	0	17.0(1)
15.5	0	10.5(2)	8.0(1)	0	0	16.5(2)	27.0(1)	0
16	9.0(2)	0	6.0(1)	6.0(1)	26.0(2)	0	21.0(1)	31.0(1)
17	6.3(3)	0	21.0(1)	0	19.3(3)	0	7.5(1)	0
17.5	0	0	0	9.0(1)	0	0	0	21.0(1)
18	10.5(2)	8.4(4)	6.3(18)	7.6(17)	15.0(1)	19.8(4)	25.1(15)	26.1(14)
18.5	0	0	18.0(1)	0	0	0	39.0(1)	0
19	6.5(2)	7.2(6)	5.2(6)	6.6(28)	38.5(2)	30.3(6)	26.0(5)	30.8(23)
20	15.0(2)	12.6(5)	3.8(3)	6.4(14)	17.8(2)	22.9(4)	32.3(2)	32.8(13)
21	8.0(1)	10.7(6)	7.0(3)	6.6(15)	31.0(1)	30.0(6)	28.0(2)	28.9(14)
21.5	0	0	4.0(1)	0	0	0	44.0(1)	0
22	0	10.8(9)	11.0(1)	4.9(13)	0	27.9(9)	18.0(1)	0
23	0	11.1(13)	0	0	0	30.6(13)	0	0
24	19.0(1)	0	0	0	34.0(1)	0	0	0
Mean	9.4(26)	10.2(79)	6.4(38)	6.6(110)	21.5(25)	24.2(78)	25.6(32)	29.9(98)
Sex Combined Mean	10.0(105)		6.5(148)		23.5(103)		28.8(130)	
Sex and Drug Combined Mean	8.0(253)				26.5(233)			

[1] Anectine - Burroughs Wellcome and Co., Research Triangle Park, NC.

[2] Wydase - Wyeth Laboratories Inc., Philadelphia, PA - 9 NF units Wydase per mg Anectine.

[3] Adult female moose mean body weight was 339.2 kg (N = 81); male moose mean body weight was 402.3 kg (N = 21) (Franzmann et al. 1978).

Table 2. Effects of succinylcholine chloride (Anectine) [1] and hyaluronidase (Wydase) [2] administered to trapped adult [3] Alaskan moose outside the Kenai Moose Research Center (MRC) enclosures, 1968 to 1976. (Sample size in parenthesis).

Dosage (mg of Anectine)	Mean Induction Time (min)				Mean Time Immobilized (min)			
	Anectine		Anectine w/Wydase		Anectine		Anectine w/Wydase	
	Male	Female	Male	Female	Male	Female	Male	Female
12.5	0	12.0(1)	0	0	0	34.0(1)	0	0
13	0	12.8(5)	0	0	0	22.4(5)	0	0
13.5	10.0(1)	13.3(3)	0	15.0(1)	37.0(1)	12.3(3)	0	23.0(1)
14	19.0(1)	0	0	3.0(1)	25.0(1)	27.0(2)	0	14.5(2)
15.5	10.0(1)	0	0	9.0(2)	20.0(1)	0	0	14.5(2)
16	0	11.0(1)	0	0	0	14.0(1)	0	0
18	5.0(1)	6.0(4)	5.5(2)	6.5(15)	32.0(1)	21.8(3)	25.5(2)	25.8(15)
19	6.0(1)	0	5.3(3)	5.6(21)	35.0(1)	0	33.3(3)	30.0(1)
20	0	7.9(10)	6.5(2)	6.5(20)	0	34.5(9)	22.5(2)	25.6(20)
21	0	10.0(6)	5.0(2)	9.6(8)	0	29.0(2)	26.0(2)	29.0(6)
22	0	9.8(14)	6.0(1)	10.1(10)	0	24.8(13)	2.0(1)	0.9(10)
23	0	15.5(4)	0	5.1(5)	0	30.5(4)	0	35.4(5)
24	0	0	0	7.5(1)	0	0	0	17.0(1)
Mean	10.0(5)	10.2(50)	5.6(10)	7.0(84)	29.8(5)	26.6(47)	30.0(10)	26.4(81)
Sex Combined Mean	10.2(55)		6.9(94)		26.9(52)		26.8(91)	
Sex and Drug Combined Mean	8.1(149)				26.8(143)			

[1] Anectine - Burroughs Wellcome and Co., Research Triangle Park, NC.

[2] Wydase - Wyeth Laboratories Inc., Philadelphia, PA - 9 NF units Wydase per mg Anectine.

[3] Adult female moose mean body weight was 400.5 kg (N = 66); male moose mean body weight was 454.6 kg (N = 5) (Franzmann et al. 1978).

Table 3. Effects of succinylcholine chloride (Anectine) [1] and hyaluronidase (Wydase) [2] administered to free-ranging adult [3] Alaskan moose outside the Kenai Moose Research Center (MRC) enclosures, 1968 to 1976. (Sample size in parenthesis).

Dosage (mg of Anectine)	Mean Induction Time (min)				Mean Time Immobilized (min)			
	Anectine		Anectine w/Wydase		Anectine		Anectine w/Wydase	
	Male	Female	Male	Female	Male	Female	Male	Female
20	10.6(6)	11.3(10)	9.1(28)	8.9(18)	9.0(1)	30.3(4)	19.9(10)	26.5(2)
21	7.2(14)		9.0(36)	9.2(30)	14.0(2)	36.0(2)	21.5(13)	18.3(7)
22	0	9.7(11)	8.1(15)	7.5(51)	0	17.2(4)	14.0(1)	25.8(8)
22.5	13.5(2)	5.7(3)	0	0	0	0	23.0(2)	0
23	10.8(8)	9.6(41)	6.4(7)	8.2(34)	40.0(1)	17.6(9)	0	23.6(17)
23.5	0	14.4(5)	0	0	0	20.5(4)	0	0
24	0	7.7(22)	6.0(3)	9.5(24)	0	37 (1)	21.0(2)	18.8(11)
24.5	12.0(1)	15.0(1)	0	0	30.0(1)	25.0(1)	0	0
25	8.0(1)	8.2(5)	8.4(8)	8.7(24)	0	30.8(5)	24.8(4)	24.8(12)
25.5	13.0(1)	4.0(1)	0	0	0	16.0(1)	0	0
Mean	9.4(33)	9.3(135)	8.8(87)	8.8(181)	20.3(6)	24.6(34)	21.8(32)	22.6(57)
Sex Combined Mean	9.3(168)		8.8(268)		23.2(40)		22.3(89)	
Sex and Drug Combined Mean	9.0(436)				22.6(129)			

[1] Anectine - Burroughs Wellcome and Co., Research Triangle Park, NC.

[2] Wydase - Wyeth Laboratories Inc., Philadelphia, PA - 9 NF units Wydase per mg Anectine.

[3] No body weights available, but this group estimated larger by minimum of 50 kg than moose listed in Table 2.

Table 4. Effects of succinylcholine chloride (Anectine) [1] and hyaluronidase (Wydase) [2] administered to Kenai Moose Research Center (MRC) inside and outside trapped and free-ranging Alaskan moose, 1968 to 1976. (Sample size in parenthesis).

Moose Group	Mean Induction Time (min)				Mean Time Immobilized (min)			
	Anectine		Anectine w/Wydase		Anectine		Anectine w/Wydase	
	Male	Female	Male	Female	Male	Female	Male	Female
Inside MRC	9.4(26)	10.2(79)	6.4(38)	6.6(110)	21.5(25)	24.2(78)	25.6(32)	29.9(98)
Outside MRC	10.0(5)	10.2(50)	5.6(10)	7.0(84)	29.8(5)	26.6(47)	30.0(10)	26.4(81)
Free-ranging	9.4(33)	9.3(135)	8.8(87)	8.8(181)	20.3(6)	24.6(34)	21.8(32)	22.6(57)
Mean	9.4(64)	9.7(264)	7.9(135)	7.8(375)	22.4(36)	25.0(159)	24.6(74)	26.9(236)
Sex Combined Mean	9.6(328)		7.8(510)		24.5(195)		26.4(310)	
Sex and Drug Combined Mean	8.5(838)				25.7(505)			

[1] Anectine - Burroughs Wellcome and Co., Research Triangle Park, NC.

[2] Wydase - Wyeth Laboratories Inc., Philadelphia, PA - 9 NF units Wydase per mg Anectine.

Table 5. Effects of succinylcholine chloride (Anectine) [1] and hyaluronidase (Wydase) [2] on 1,285 adult Alaskan Moose, 1968 to 1976. (Sample size in parenthesis).

Moose Group	Percentage Immobilized of Moose Darted				Percentage Killed of Moose Darted			
	Anectine		Anectine w/Wydase		Anectine		Anectine w/Wydase	
	Male	Female	Male	Female	Male	Female	Male	Female
Inside MRC [3]	60.5 (26 of 43)	73.8 (79 of 107)	71.7 (38 of 53)	79.6 (109 of 137)	0 (0 of 43)	0 (0 of 107)	3.8 (2 of 53)	4.4 (6 of 137)
Outside MRC	45.5 (5 of 11)	69.4 (50 of 72)	83.3 (10 of 12)	79.2 (84 of 106)	0 (0 of 11)	1.4 (1 of 72)	0 (0 of 12)	2.8 (3 of 106)
Free-Ranging	75.0 (51 of 68)	73.5 (186 of 253)	64.2 (79 of 123)	70.0 (191 of 273)	7.4 (5 of 68)	6.3 (16 of 253)	2.4 (3 of 123)	5.1 (14 of 273)
Mean	67.2 (82 of 122)	72.9 (315 of 432)	67.6 (127 of 188)	74.4 (384 of 516)	4.1 (5 of 122)	3.9 (17 of 432)	2.7 (5 of 188)	4.5 (23 of 516)
Sex Combined Mean	71.7 (397 of 554)		72.6 (511 of 704)		4.0 (22 of 554)		4.0 (28 of 704)	
Sex and Drug Combined Mean	72.2 (908 of 1258)				4.0 [4] (50 of 1258)			

[1] Anectine - Burroughs Wellcome and Co., Research Triangle Park, NC.

[2] Wydase - Wyeth Laboratories Inc., Philadelphia, PA - 9 NF units Wydase per mg Anectine.

[3] MRC - Moose Research Center.

[4] Percentage killed of moose immobilized = 5.5% (50 of 908).

money. It was necessary to observe a darted moose for 20 minutes before repeating a SCC dose which meant much additional time and money. It was this characteristic of SCC along with its very narrow range of tolerance by moose which made us search for another immobilizing drug.

Experiences using CI-744 to immobilize for moose were reported by Franzmann and Arneson (1974). The test was limited and results inconclusive. However, moose successfully immobilized required 2.9 to 5.3 mg CI-744/kg body weight. The drug is not commercially available; thereby, its use in moose immobilization is limited. If the drug becomes commercially available, further studies on its use in moose are warranted.

Xylazine was used at the MRC as an immobilizer (Franzmann and Arneson 1974) but it has been limited to use for procedures when the animal can be closely monitored for long periods of time. Ataxia during recovery may last up to 2 hours. Immobilization was produced in moose using dosages of 2.2 mg/kg body weight. Xylazine has been primarily used at the MRC as an adjunct drug to etorphine.

Etorphine was first used at the MRC in 1969 but not routinely until 1975. All data are from trapped MRC animals. In 1976 we began combining xylazine with etorphine to alleviate some problems experienced with etorphine alone such as, hyperthermia, muscle tonus, and incomplete immobilization. Tables 6 and 7 summarize the results with etorphine and xylazine. In adult moose (Table 6) the mortality rate was 8.7% (12 of 138), but most occurred with dosages under 8 mg etorphine (9 of 78 - 11.5%). Adult moose receiving 8 mg or more of etorphine experienced mortality rate of 5.0% (3 of 60). The proportion of moose not immobilized was also greater for those receiving less than 8 mg etorphine (11.5% vs. 1.7%). Supplemental doses required for moose receiving less than 8 mg was 23 of 78 (29.5%) but for those receiving 8 mg or more was 5 of 60 (8.3%).

The data clearly indicate that the major problems experienced with etorphine and etorphine/xylazine mixtures (supplemental doses needed, not down, mortality) were related to underdosing. It is further indicated that induction time is lessened with etorphine/xylazine mixture when the etorphine dose is less than 10 mg. For 5 mg etorphine dose the mean induction time is lessened by 10.5 minutes, for 7 mg by 1.8 minutes, for 8 mg by 2.6 minutes, and for 9 mg by 2.8 minutes.

It is recommended that the minimum dosage for adult Alaskan 400 kg body weight moose should be 10 mg etorphine (0.025 mg/kg body weight) when used alone and 8 mg etorphine/200 mg xylazine (0.02 mg etorphine and 0.5 mg xylazine/kg body weight) when the combination is used. Moose in extremely poor condition may require a lesser dose. There are definite indications that higher doses may be needed for moose in extremely good condition. Franzmann and Schwartz (1982) reported that doses of 12 mg etorphine and 400 mg xylazine were needed to immobilize adult

Table 6. Immobilization of adult moose at the Moose Research Center with etorphine (M-99) [1] and etorphine with xylazine (Rompun) [2]. (Sample size in parenthesis).

Drug and Dosage	Number[3] of Moose	Supplemental Doses	Mean Induction Time (min)	Mean Time Immobilized (min)	Recovery Time	Not Immobilized	Mortalities
M-99 4 mg Rompun 400 mg	2	2	43 (1)			1	1
M-99 5 mg	23	12	15.8±11.9 (15)	21.6±12.4 (16)	2.4±3.6(15)	5	2
M-99 5 mg Rompun 500 mg	3	1	5.3±0.6 (3)	56.7±59.4 (3)	10.0 (1)		
M-99 6 mg	7	1	10.8±8.0 (6)	20.0±9.5(6)	6.6±6.8(5)		1
M-99 7 mg	23	5	12.0±8.5 (21)	18.7±8.7 (20)	2.5±2.6(16)	2	4
M-99 7 mg Rompun 300 mg	20	2	10.2±5.4 (14)	25.8±12.8 (8)	3.1±1.8 (8)	1	1
M-99 8 mg	12	2	12.8±9.4 (11)	35.0±44.5 (9)	4.1±3.8 (10)		
M-99 8 mg Rompun 200 mg	12		10.2±6.4 (9)	32.9±35.8 (7)	3.2±1.8 (5)		1
M-99 9 mg	6		14.8±12.5 (5)	16.3±6.6 (4)	2.0±1.4 (4)		
M-99 9 mg Rompun 100 mg	9	1	12.0±8.5 (7)				
M-99 10 mg	11	2	6.8±2.6 (10)	17.1±6.6 (8)	3.8±2.9 (5)	1	
M-99 10 mg Rompun 200 mg	4		9.2±1.0 (4)	11.5±6.2 (4)			
M-99 10 mg Rompun 300 mg	2		8.0 (1)		3.0 (1)		
M-99 12 mg Rompun 400 mg	4		8.0±1.0 (3)	16.3±1.3 (3)	9.5±0.7 (3)		1
TOTAL	138	28	11.4±9.1 (109)	23.5±18.2 (88)	3.6±3.4 (73)	10	12

1 M-99 - Lemmon Co., Sellersville, PA.

2 Rompun - Haver-Lockhart, Shawnee, KS.

3 Body weights ranged from 325 to 500 kg (estimated).

Table 7. Immobilization of moose calves and yearlings at the Moose Research Center with etorphine (M-99) [1] (Sample size in parenthesis).

Etorphine Dosage	Number of Calves	Number of Supplemental Doses	Mean Induction Time (min)	Mean Time Immobilized (min)	Recovery Time	Not Immobilized	Mortalities
			Calves (90-175 kg body weight)				
2 mg	10	4	10.6±7.3 (8) [2]	5.0±5.7 (8)	1.6±1.1 (7)		
3 mg	60	5	9.2±6.2 (48)	22.9±6.2 (47)	2.4±2.7 (44)	2	2
TOTAL	70	9	9.4±6.6 (56)	20.3±14.6 (55)	2.3±2.6 (51)	2	2
			YEARLINGS (200-275 kg body weight)				
3 mg	3		15±9.9 (2)	15.5±12.0 (2)	1.0 (2)	1	
4 mg	3	1	25.7±18.8 (3)	14.5±14.9 (2)	1.0 (1)		1
5 mg	14	2	9.1±9.0 (12)	17.7±10.4 (12)	1.3±0.5 (10)		
6 mg	5		8.6±3.8 (4)	25.0±8.7 (3)	1.0 (2)		1
7 mg	3		7.0±1.0 (3)	10.0±6.2 (3)	2.0 (1)		
TOTAL	28	3	11.0±8.4 (24)	14.4±10.2 (22)	1.3±0.4 (20)	1	2

[1] M-99 - Lemmon Co., Sellersville, PA.

Alaskan moose in excellent condition during late fall. Body weights were not available for these moose but were estimated greater than 400 kg.

The major benefit from using xylazine with etorphine appears to be lowered induction time based upon data presented. However, from our experiences we believe that moose receiving xylazine with etorphine were less stressed. This is an intangible that was not evident in the data, but rather an opinion. The use of HD with etorphine and etorphine/xylazine mixtures was not tested at the MRC; however, decreased induction times may result as was experienced with the HD and SCC mixture.

Table 7 summarizes the results of immobilizing moose calves and yearlings. Two dosages were used for calves (2 and 3 mg). Although a higher proportion of mortality (2.8%) was experienced with the 3 mg dosage, the important statistic is that with the 2 mg dosage 40% of calves had to be given supplemental doses, while only 8.3% of calves with the 3 mg dosage required supplementation. The calves were immobilized during fall and winter and weighed from 90 to 175 kg. The recommended dose for these calves is 3 mg etorphine (.017 to .033 mg/kg body weight). Mean induction time for the 3 mg dose was 9.2 minutes. Adding xylazine may lower the induction time and should be considered as an adjunct to etorphine for calves. Data (Table 7) relative to immobilizing yearling moose (200 to 275 kg body weight) indicates that the minimum dosage of etorphine should be 5 mg (0.018 to 0.025 mg/kg body weight). An etorphine/xylazine mixture may lower induction time and minimize stress but the combination was not tested for yearlings. It is interesting to note that the dosage of etorphine was increased from 5 to 7 mg the mean induction time decreased from 9.1 to 7 minutes.

Etorphine has been a satisfactory immobilizing agent for both moose calves and yearlings. The mortality rate has been low (3 of 82 - 3.6%), the need for supplemental doses has been minimal (7 of 82 - 8.5%), and only 2 of 82 (2.4%) calves and yearlings did not go down when properly dosed.

Etorphine and/or etorphine with xylazine appear to be effective immobilizing drugs for moose. Nevertheless, several important aspects of their use have not been presented: (1) etorphine is an extremely dangerous drug if accidentally injected or absorbed by humans; (2) etorphine is highly regulated because it is a narcotic; (3) etorphine and xylazine are not cleared for use in food animals; (4) neither drug is available in an adequately concentrated form for use in large ungulates such as moose. Etorphine is available in the United States in a concentrate of 1 mg/ml only. Xylazine is available in the United States in a concentration of 100 mg/ml. For moose requiring 12 mg etorphine/400 mg xylazine, the volume of drug is 16 ml. This means that the animal must be double darted adding to cost, hazard to operators, and to health and safety of the animal.

The conclusions reached are that etorphine and etorphine/xylazine mixture are the drugs of choice for moose at this time, but to increase efficiency, reduce hazard, reduce stress on animals and operators, reduce cost, and provide for an aesthetically acceptable immobilization technique the drugs must be made available in a more concentrated form. New drugs that become available for moose immobilization will be tested at the MRC, because the ideal drug for immobilizing moose has not yet been discovered.

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