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MOOSE RESEARCH CENTER REPORT

by
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and
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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Marilyn Sigman, Albert W. Franzmann and Paul D. Arneson

Project No.: W-17-8 Project Title: Big Game Investigations

Job No.: 1.13R Job Title: Moose Behavior

Period Covered: July 1, 1975 through June 30, 1976

SUMMARY

The behavioral study, initiated during January 1975 by graduate student Marilyn Sigman, did not entail substantial field work at the Kenai Moose Research Center (MRC) during this reporting period. The student was at the MRC from November 24, 1975 through December 12, 1975 for tracking and observation of moose, however, lack of snow negated her efforts. Results of her studies at the MRC and in the adjacent browse rehabilitation area will be incorporated into her thesis which is in preparation.

Paul Arneson took the Sea Bird Biologist position in Anchorage in August 1975, and his replacement, Theodore Bailey, started work May 6, 1976. Behavioral observations at the MRC were not undertaken by MRC personnel during this reporting period.

JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Albert W. Franzmann and Paul D. Arneson

Project No.: W-17-8 Project Title: Big Game Investigations

Job No.: 1.14R Job Title: Evaluation and Testing Techniques for Moose Management

Period Covered: July 1, 1975 through June 30, 1976

SUMMARY

A combination immobilizing drug (etorphine + xylazine) was tested on moose with satisfactory results. Each drug was used at the rate of one-half the dose required when used alone as an immobilizing drug. The best qualities of each drug were obtained by this combination, with reduction in cost over use of etorphine alone and retention of antagonist drug (diprenorphine) capabilities.

The pellet-group count census technique was tested over a 4-year period at the Kenai Moose Research Center (MRC). Pellet groups were randomly distributed within each of seven vegetation types and there were significant differences ($P > 0.01$) between densities of pellet groups by vegetation type. The number of pellet groups per type was summed to obtain a stratified estimate of the number of pellet groups in the enclosure and the pellet groups deposited/moose/day. Pellet groups/moose/day of from 20.7 to 28.7 calculated from known moose days in the enclosure were considered high. Using a range from 10 to 25 pellet groups/moose/day, a range of calculated estimates of moose numbers was computed. During only one of four winters did the actual moose numbers fall into the calculated range. Actual moose numbers were lower than the low extreme of the calculated range for every winter but one. Some improvements and refinements of our technique may improve accuracy and avoid overestimations of numbers, however, in general it is doubtful whether we could greatly improve our accuracy due to the many variables involved in this procedure. Pellet group counts indicated some validity in population trend assessment. The distribution of pellet groups, in broadly classified vegetation types, corresponded to reported and observed habitat use.

Recorders and transmitters to obtain internal temperature and heart rate information were implanted into several moose. Difficulties were encountered with moose in poor condition during late winter and two moose died. Another moose died from peritonitis due to a tree limb puncture through the laparatomy incision. Some malfunction of equipment was also experienced, but information was obtained which should be helpful on future attempts. Moose will be handled in the fall when in near prime condition, and improved equipment and procedures will be used based upon our experience. We were able to obtain internal temperatures from February 26 to March 22, 1976 from Olivia, a semi-tame moose calf.

These ranged from 38.04C (100.47F) to 40.23C (104.41F) and averaged 39.36C (102.85F). With most of the "bugs" worked out of the system we anticipate correlating heart rate and body temperature data with various natural and induced activities.

Location and activity transmitters were also placed on these moose. Activity transmitters, which transmit at a steady pulse when animals are not moving, versus a bi-pulse transmission when animals are moving, improved our ability to locate moose, particularly in heavy cover.

CONTENTS

BACKGROUND

Moose (*Alces alces*) research and management require methods of estimating numbers and handling, marking and following animals. These techniques necessarily vary with location of the management/research problem. The Kenai Moose Research Center (MRC), with known numbers of confined animals, provided a unique test-ground for numbers-related techniques and for methods and equipment whose effectiveness can only be estimated by relocation of the animal. Developments in diverse fields providing drugs, equipment and procedures potentially applicable to moose management determined the thrust of activity under this job objective. A final report covering activities under this project from June 1969 through June 1974 was completed (Franzmann et al. 1974). The project has been renewed and will be continued corresponding to activity at the MRC.

Immobilizing, reversing and adjunct drugs applicable to handling moose at the MRC were reviewed and evaluated (Franzmann et al. 1974). Criteria for an ideal immobilizing drug for moose, as outlined by LeResche and Davis (1971), remain valid and testing of new drugs as they become available against these criteria will continue.

A pellet count census evaluation for moose was initiated at the MRC and preliminary findings were reported (Franzmann et al. 1974). As recommended in this report, daily winter defecation rates for moose at the MRC were required since published data from other areas may not be applicable. These rates were determined, reported (Franzmann and Arneson 1975) and published (Franzmann et al. 1976). With these data a final assessment of pellet count censusing at the MRC was possible.

Pellet group count census techniques, first described by Bennett et al. (1940), have been used for various species of big game. Neff (1968) extensively reviewed this subject and concluded, "...pellet-group counts are not a panacea or a shortcut to big game population data. However, it does appear that the method is valid, and that it can be made to yield reliable data under field conditions."

Timmermann (1974) reviewed pellet group count procedures for moose and found that good information on moose deposition rates was lacking. He also discussed the potential of differential deposition rates as reported by Des Meules (1968) and Smith (1964). Timmermann (1974) concluded that it remains to be proven that pellet group counts provide reliable population estimates, although they do provide a good basis for comparing relative densities between areas, and from year to year in a single area.

Knowledge of the appropriate model is necessary for estimating reliable confidence intervals in estimated animal numbers (Bowden et al. 1969). Although areal distribution of pellet groups is quite variable most observers have found that they tend to be aggregated. Loveless (1967) found that mule deer (*Odocoileus hemionus*) pellet groups on north-facing slopes were randomly distributed while those occurring on south and west-facing slopes were contagiously distributed. Bowden et al. (1969) compared the distribution of mule deer pellet groups with four mathematical distributions. The Poisson distribution, which would represent a random placement of pellet groups, did not fit their data. All three contagious distributional models (negative binomial, Thomas and Neyman Type A) fit these data.

The Kenai Moose Research Center (MRC), with known numbers of moose enclosed in four 2.59 km^2 (1 mi^2) pens, provided an opportunity to test the application of the pellet group counting technique with Alaskan moose. The MRC is located in the glacially scoured Kenai Lowlands and contains a representative pattern of both burned (1947 Kenai Burn) and remnant vegetation types. Regrowth in the burn is a mixture of paper birch (*Betula papyrifera*), white spruce (*Picea glauca*), black spruce (*P. mariana*), willow (*Salix* sp.) and aspen (*Populus tremuloides*); remnant mature stands are mixed birch-white spruce-aspen with black spruce in wetter sites. Topography of the Kenai Lowlands is rolling and, with the interspersion of regrowth and remnant stands, there appears to be little influence of slope or aspect on vegetational use by moose.

The problems and promises of applying biotelemetry to MRC projects were reviewed (Franzmann et al. 1974). As a result of these investigations, a proposal entitled "Telemetric application to physiologic, metabolic, and behavioral studies of Alaskan moose" was prepared and submitted to the Morris Animal Foundation for funding. The proposal was accepted as scientifically sound, but was not funded. The approach and involvement were scaled-down and Wildlife Materials, Inc., Carbondale, Illinois was contracted to provide basic equipment to apply to moose at the MRC.

OBJECTIVES

To test and evaluate techniques that are potentially useful for determining population status, movements and other factors necessary for management of moose.

PROCEDURES

Immobilizing, Reversing and Adjunct Drugs

No new drugs were tested during this report period, however, complete records were maintained of all drugs routinely used to capture moose at the MRC and for tagging operations. A new combination of drugs, consisting of etorphine (M-99, D-M Pharmaceuticals, Inc., Rockville, Maryland) and xylazine (Rompun, Chemagro, Kansas City, Missouri), was tested for immobilizing and tranquilizing. Diprenorphine (M 50-50, D-M Pharmaceuticals, Inc., Rockville, Maryland) was used for an antagonist.

Pellet Count Census Evaluation

One-hundred and sixty (159 in winter 1970-71) 2.4 x 7.3 m (17.8 m^2) permanent browse utilization plots in Pen 1 were used for pellet group count plots. Plots were randomly located in each of seven vegetative types (Tables 1 and 2) representing 204.3 ha of the 241.1 ha in Pen 1. The sample plots constituted 0.14 percent (0.139 in 1970-71) of the area utilized. The nonsampled area of 36.8 hectares (91 acres) consisted of black spruce-*Ledum*, grass, sedge and water areas which (based upon winter feeding preference of 3 tame moose on natural forage [LeResche and Davis 1973]) were not considered winter use areas.

Plots were cleared of pellets in May 1970 and were first counted and cleared again on June 2-4, 1971. Fecal deposits in each plot were classified as winter (pelletized) or summer (not pelletized). Based on observations of the MRC trapped moose, the period of pelletized fecal groups was established as beginning about November 1 and continuing until about June 1. No plots were counted or cleared in spring 1972. On May 10, 11, 14 and 18, 1973 the 160 plots in Pen 1 were again counted and cleared. Separation of past year from present year groups was attempted on the basis of leaf and duff cover over pellet groups, deterioration of pellet groups and color and texture of these groups. The leaf cover use was enhanced by the fact that leaves fall during early October in this area, prior to pelletization of moose fecal droppings (November 1). On May 6, 7 and 8, 1974 the plots were counted and cleared with only winter-summer separation made as the plots had been cleared the previous May.

Moose days were calculated for the four winter periods in Pen 1 based upon the 210-day (November 1 to June 1) pellet forming period and known numbers of moose present, for either the entire period or parts thereof (Table 3). We considered this an accurate appraisal of moose numbers in Pen 1 as moose were trapped and observed throughout this period. The winters of 1972-73 and 1973-74 had 196 and 191 potential moose days, respectively, since the plots for each period were counted prior to June 1, when pellet formation generally ceased.

Daily moose defecation rates were determined at MRC by backtracking moose in fresh snow (Franzmann et al. 1976).

Table 1. Pellet-groups deposited by vegetative type per 17.9m² plot, hectare and type with chi-square values for Poisson distribution during winters Kenai Moose Research Center, Alaska 1970-74.

Vegetative Type	Hectares	Probability of larger X^2 for Poisson Distribution	Pellet Groups Per Plot			Hectare	Type	% of Total
			X	S^2	N			
1970-71								
Dense Mature Hardwoods	21.1	>0.25	0.45	0.576	20	251.6	5309	7.3
Thin Mature Hardwoods	18.7	>0.25	0.68	0.673	19	379.5	7096	9.8
Spruce Birch Regrowth	36.2	>0.25	0.33	0.319	24	82.7	2995	4.1
Spruce Regrowth	16.1	>0.25	0.20	0.168	20	250.8	4038	5.6
Dense Birch Spruce Regrowth	45.7	0.22	1.28	1.877	25	718.1	32815	45.3
Medium Birch Spruce Regrowth	38.4	>0.25	0.73	0.845	26	409.7	15734	21.8
Thin Birch Spruce Regrowth	28.1	>0.25	0.28	0.293	25	156.0	4383	6.1
Pooled Total	204.3	>0.01	0.58	0.802	159	324.7	66326	-
Stratified Total							72370	100.00
1971-72								
Dense Mature Hardwoods	21.1	>0.25	0.30	0.221	20	167.8	3541	4.4
Thin Mature Hardwoods	18.7	>0.25	0.75	0.145	20	418.6	7827	9.7
Spruce Birch Regrowth	36.2	>0.25	0.50	0.435	24	125.3	4537	5.6
Spruce Regrowth	16.1	>0.25	0.20	0.274	20	250.8	4038	5.0
Dense Birch Spruce Regrowth	45.7	>0.25	1.20	1.000	25	673.2	30764	38.0
Medium Birch Spruce Regrowth	38.4	>0.25	0.88	0.586	26	493.9	18967	23.4
Thin Birch Spruce Regrowth	28.1	>0.25	0.72	0.543	25	401.1	11271	13.9
Pooled Total	204.3	>0.25	0.68	0.686	160	380.7	77767	-
Stratified Total							80945	100.0

Table 2. Pellet-groups deposited by vegetative type per $17.9m^2$ plot, hectare and type with chi-square values for Poisson distribution during winters Kenai Moose Research Center, Alaska 1970-74.

Vegetative Type	Hectares	Probability of larger X^2 for Poisson Distribution	Pellet Groups Per					
			Plot			Hectare	Type	% of Total
			$\bar{X}$	S^2	N			
1972-73								
Dense Mature Hardwoods	21.1	0.25	0.30	0.221	20	167.8	3541	5.5
Thin Mature Hardwoods	18.7	0.25	0.70	1.063	20	390.6	7305	11.4
Spruce Birch Regrowth	36.2	0.25	0.17	0.145	24	42.6	1543	2.4
Spruce Regrowth	16.1	0.25	0.20	0.274	20	250.8	4038	6.3
Dense Birch-Spruce Regrowth	45.7	0.14	0.92	0.910	25	516.1	23586	36.8
Medium Birch-Spruce Regrowth	38.4	0.25	0.77	0.825	26	432.2	16596	25.9
Thin Birch Spruce Regrowth	28.1	0.25	0.48	0.343	25	267.4	7514	11.7
Pooled Total	204.3	0.25	0.52	0.603	160	291.1	59472	-
Stratified Total							64123	100.0
1973-74								
Dense Mature Hardwoods	21.1	0.25	0.35	0.555	20	196.2	4139	9.8
Thin Mature Hardwoods	18.7	0.25	0.20	0.168	20	111.6	2087	4.9
Spruce Birch Regrowth	36.2	0.25	0.13	0.114	24	32.6	1180	2.8
Spruce Regrowth	16.1		0	0	20	0	0	0.0
Dense Birch-Spruce Regrowth	45.7	0.25	0.68	0.727	25	381.5	17433	41.1
Medium Birch-Spruce Regrowth	38.4	0.25	0.35	0.395	26	196.4	7543	17.8
Thin Birch-Spruce Regrowth	28.1	0.25	0.64	0.407	25	356.5	10019	23.6
Pooled Total	204.3	0.25	0.35	0.392	160	195.9	40018	-
Stratified Total							42401	100.0

Table 3. Moose days in Pen 1 Kenai Moose Research Center, Alaska during winters 1970 to 1974.*

Moose Number	Winter 1970-71	Winter 1971-72	Winter 1972-73	Winter 1973-74
3	210	210	196	-
Calf of 3	135	61	-	-
6	210	135	-	-
Calf of 6	-	61	-	-
670	210	210	196	-
10	210	210	196	191
Calf of 10	135	61	61	191
35	210	210	196	191
40	210	210	166	-
Calf of 40	135	61	-	-
41	115	-	-	-
4170	115	-	-	-
43	210	210	97	191
53	210	210	-	-
55	210	-	-	-
58	210	210	196	191
61	210	210	-	-
64	210	210	196	-
65	-	-	67	-
6171A	-	61	-	-
69	210	210	196	191
6171B	-	61	-	-
R70-8	210	210	196	191
Calf of R70-8	-	61	-	138
76	-	-	196	-
Calf of 76	-	-	112	-
93	-	-	14	-
96	-	-	22	-
TOTAL	3575	3082	2303	1475

* Based on 210-day pellet-forming winter period (November 1 to June 1)

Biotelemetry

A contract was made with Wildlife Materials Inc., Carbondale, Illinois to provide internal temperature and heart rate transmitters, and the equipment necessary to monitor them, for four moose. In January 1976, Bob Hawkins of Wildlife Materials came to the MRC to assist in setting up transmitters and monitoring equipment.

On January 20, 1976 a semi-tame moose (Paul Jr.) was immobilized with etorphine and xylazine (see Immobilizing Drug section of this report) and temperature and heart rate transmitters were implanted in the moose.

The temperature transmitting device was a sealed glass cylinder (12 cm long x 6 cm diameter) with rounded ends incorporating the transducer, transmitter and one "D" size lithium battery. A laparotomy (Frank 1953) was performed and the apparatus was placed in the abdominal cavity. An FM frequency of 100 mhz was assigned to this transmitter. The transmitted continuous signal was picked up and recorded using a FM receiver with a casette tape recorder. The recorded signal was run through a decoder to provide a temperature reading on the animal, having been correlated with temperature prior to placement utilizing controlled temperature water baths.

The heart rate transmitting device was of similar construction but smaller (8 cm long x 5 cm diameter), with two insulated stainless steel wire leads protruding from the cylinder. The cylinder was placed subcutaneously over the left third and fourth ribs posterior to the point of the left olechrenon. The lead wires were extended subcutaneously and the ends sutured, one over the left side of the heart and the other over the right side of the heart. An FM frequency of 94 mhz was assigned to this transmitter. The actual heartbeat was transmitted by the device and the beats per minute were determined by timing the transmitted signal beats.

A radio-collar (Wildlife Materials Inc.), which had an external or ambient temperature recorder and transmitter (150.947 mhz) and a combination locating and activity transmitter (151.220 mhz), was placed on the moose. The moose was relocated using a model TRX-24 receiver (Wildlife Materials Inc.). If the moose was motionless, the transmitter broadcast a constant pulse, but if moving, a signal of varying pulse (fast and slow) was received. The same receiver was used to obtain ambient temperature signals based on pulse rate of signal and correlated prior to use at various ambient temperatures.

On February 24, 1976 a semi-tame yearling male moose (Rastus) was immobilized and equipped with internal temperature (82 mhz), heart rate (104 mhz), location and activity (151.115 mhz) and ambient temperature (151.000 mhz) transmitters. The only alterations from procedure on Paul Jr. were that the laparotomy was done on the right side, the heart rate unit was made smaller and rectangular (7 x 4 x 2 cm), and the unit was placed subcutaneously in the lower left jugular furrow just anterior to left scapula. On February 26, 1976 Rastus was found dead and the equipment was recovered.

On February 25, 1976 a semi-tame moose calf (Olivia) was immobilized and equipped with internal temperature (96 mhz), location and activity (150.970 mhz) and ambient temperature (151.275 mhz) transmitters. No heart rate transmitter was used.

On March 5, 1976 a free-ranging, adult female moose (No. 79) was immobilized and equipped with transmitters, but she soon died and the transmitters were removed.

FINDINGS

Immobilizing, Reversing and Adjunct Drugs

The dosage of etorphine (M-99) for adult moose is about 0.8 mg/45 kg depending upon season and condition (Franzmann and Arneson 1974). The xylazine (Rompun) dosage for adult moose is 2.2 mg/kg (Franzmann and Arneson 1974). When combining these drugs as an immobilizing agent for reindeer and caribou (*Rangifer tarandus*), Robert Dieterich (pers. comm.) cuts the dosage of each in half for administration. We utilized this procedure for 10 moose with generally good success.

Downtime for eight moose (5 adults, 1 yearling and 2 calves) averaged 8 minutes and these animals responded to diprenorphine (M 50-50), the antagonist, in an average of 9 minutes. This recovery period is much longer than for moose immobilized with etorphine alone (1 to 2 minutes). The prolonged recovery time was due, in part, to the effects of xylazine, but primarily to the fact that we underdosed diprenorphine, the antagonist, and should have given it at a rate two times the mg dosage of etorphine rather than at the same rate. Two other moose received inadequate initial doses of the drug combination due to "bleeding out" on one and improper discharge from the dart in the other (the charge blew through the rubber plunger), and both had to be given additional doses for immobilization.

The combination of etorphine and xylazine as an immobilizing agent had several advantages: (1) one-half the etorphine dose was required which cuts cost considerably, since xylazine is relatively inexpensive; (2) salivation, anxiety and occassional overheating associated with etorphine alone was eliminated when combined with xylazine, (3) the antagonist, diprenorphine, may still be used to bring the animal up which was not possible when using xylazine alone and (4) the animal was in a tranquil state after diprenorphine was used and was less likely to suffer injury following use of the antagonist.

We will continue to test the combination immobilizer on moose to obtain substantial background dosage data, particularly in relation to use of diprenorphine, the antagonist.

Pellet Count Census Evaluation

A Poisson distribution was tested with the pellet group data from each vegetation type and against the pooled count each year. In all cases, except for the pooled count in 1971, the Poisson distribution fit the observed distribution (Tables 1 and 2), indicating a random placement of pellet groups. The mean number of pellet groups per type was then compared by analysis of variance using a $\sqrt{x + 1/2}$ transformation of data. In all 4 years, the hypothesis of no difference among habitat types was rejected ($P > 0.01$). On this basis, we summed the number of pellet groups per type to obtain a stratified estimate of the total number of groups deposited in the enclosure. In each of the 4 years, this estimate was uniformly higher than the value obtained by pooling the data.

From stratified total winter pellet groups (Tables 1 and 2) and total moose days (Table 3), pellet groups deposited/moose/day were calculated (Table 4). In winter 1970-71, 3,575 moose days resulted in 72,370 pellet groups for a calculated 20.2 pellet groups/moose/day. In winter 1971-72, 3,082 moose days produced 80,945 pellet groups or 26.3 pellet groups/moose/day. During winter 1972-73, 2,303 moose days produced 64,123 pellet groups or 27.8 pellet groups/moose/day and in winter 1973-74, 1,475 moose days produced 42,401 pellet groups or 28.7 pellet groups/moose/day.

These calculated defecation rate estimates are high in relation to most reported rates. Franzmann et al. (1976) reported significant differences ($P > 0.01$) between adult male (19.6/day) and adult female (14.6/day) moose deposition rates. The combined (male and female) deposition rate was 17.6/day (range = 10 to 25). Timmerman (1974) reviewed the reported average daily deposition rates for moose and the variability was from 9.6 to 32.2 deposits/day/moose with most estimates between 11 and 16. Due to the reported variability in moose deposition rates we decided to utilize a range of deposition rates (10 to 25/day) to assess our estimates of moose in the MRC enclosure.

Using the range of deposition rates and the stratified total pellet groups (Tables 1 and 2) with pellet group days (Table 4) we estimated number of enclosed moose each year of pellet group counts (Table 4). During winter 1970-71 the calculated range of moose numbers was 13.8 to 34.5, when the actual mean number of moose was 17.1. During winter of 1971-72 the calculated range of moose numbers was 15.4 to 38.5, when the actual mean number was 14.7. During the 1972-73, 196 pellet-group day period, the calculated range of moose numbers was 12.2 to 30.5 and the actual mean moose number was 11.8. During the 1973-74, 191 pellet-group day period the calculated range of moose numbers was 8.1 to 20.2 and the actual mean moose number was 7.7. Actual moose numbers fell into the calculated range of moose numbers during winter 1970-71 only. Each other winter period the actual moose number was lower than the extreme low end of the calculated range. We would expect the actual moose numbers to fall near the center of the range of calculated values, assuming the procedure was accurate.

Refinement of the procedure may improve estimations. One potential error source was the estimation of initiation of pellet formation by moose in the fall by observation. This variability could have been eliminated by clearing plots in the fall after pelletization was well under way or after leaf fall. The variability of deposition rates associated with age classes (calves, yearlings and adults) should be better defined as well as the potential individual variability.

Table 4. Pooled and stratified total pellet-groups in Pen 1, Kenai Moose Research Center, Alaska with calculated pellet-groups/moose/day and calculated and actual moose numbers during winters 1970-74.

Winter	% Pen in Plots	Total Pellet-groups		Moose Days	Pellet-groups per moose/day	Pellet group Days	Range of Moose Numbers	
		Pooled	Stratified				Calculated[2]	Actual
1970-71	0.139	66326	72370	3575	20.2	210	13.8 to 34.5	17.1
1971-72	0.140	77767	80945	3082	26.3	210	15.4 to 38.5	14.7
1972-73	0.140	59472	64123	2303	27.8	196	12.2 to 30.5	11.8
1973-74	0.140	40018	42401	1475	28.7	191	8.1 to 20.2	7.7

1 Based on 210-day pellet-forming winter period (November 1 to June 1).

2 Based on range of 10 to 25 pellet-groups/moose/day.

The separation of winter 1971-72 and 1972-73 pellet groups was apparently successful, based upon the calculated pellet groups/moose/day of 26.3 and 27.8, respectively. Any great difference in these figures would have indicated that our criteria for separation were not valid. Aging summer fecal deposits resulted in a total of 11 deposits in 1971 and 22 in 1972 which we believed invalidated our summer aging technique since there were more moose in Pen 1 in summer 1971 than in 1972. Possibly, the older summer fecal deposits had deteriorated.

Winter habitat selection by moose, as indicated by pellet groups per vegetative type (Tables 1 and 2), demonstrates an affinity for birch regrowth (combined dense, medium and thin birch-spruce regrowth) areas. During all 4 winters 73.2 to 82.5 percent of pellet groups were in these areas. Spruce regrowth areas (combined spruce-birch regrowth and spruce regrowth) for the 4 winters contained 2.8 to 10.6 percent of the pellet groups. Mature hardwood areas (combined dense and thin mature hardwoods) contained from 14.1 to 17.1 percent.

Summer habitat selection by moose, as indicated by fecal deposits per vegetative type, was perhaps not useful since aging of summer deposits was not valid and spruce-*Ledum*, grass, sedge and water areas, which were observed to receive increased summer use, were not sampled. However, it should be noted that in all 4 years no summer fecal deposits were counted in thin mature hardwoods and only five were counted in dense mature hardwoods.

Neff (1968) stated, "A major problem requiring future research attention concerns the use of pellet group distribution patterns as an index to habitat preferences." Anderson et al. (1972) could find no significant correlation between indices of mule deer numbers and mean yield or utilization of selected deer browse. We believe that winter habitat selection by moose at the MRC, as reflected by pellet group distribution, corresponded to observed and expected use. LaResche and Davis (1973) reported tame moose on normal range at the MRC consumed 72 percent birch stems in February-May and 21 percent of the remaining material was lowbush cranberry (*Vaccinium vitis-idaea*). Birch-spruce regrowth (73.2 to 82.5 percent of pellet groups) provided the birch for winter browsing. Thin mature hardwood areas contained the greatest proportion of ground cover lowbush cranberry (Oldemeyer and Seemel 1976) and the relative substantial use of these areas, reflected by pellet group distribution, was likely related to its use and importance to moose. However, an undetermined proportion of hardwood use by moose in winter may relate to protection, resting and relief from snow and may partially account for pellet group distribution. The relative nonuse of hardwoods by moose in summer, based on pellet group distribution, was reasonable in this context as LeResche and Davis (1973) reported that lowbush cranberry at the MRC was taken only in trace amounts during the summer. With foliage present on birch in summer, protection and resting areas were more numerous in the regrowth, and mature timber was not necessarily required. Spruce regrowth areas received the least moose use based on pellet group distribution, and this was expected since moose do not browse spruce and these areas contain low densities of birch. The percent of use found (2.8 to 10.6) may relate to these areas being used for protection in addition to the presence of some browse. We found the distribution of pellet groups, in broadly classified vegetation types, corresponded to reported and observed habitat use by moose at the MRC.

We believe the MRC provided an ideal testing situation to evaluate the pellet group technique in estimating moose numbers. The tendency to overestimate moose numbers, moose days and a range of daily pellet group deposition rates utilizing pellet counts was disturbing. If we assume the technique was accurately conducted as outlined, we must conclude that winter pellet group counts were not precise estimators of moose numbers at the MRC.

It is possible we could refine our technique, but it is doubtful whether we could greatly improve our accuracy due to the many variables involved in this procedure. Because from winters 1971-72 through 1973-74 the actual population declined as did the range of calculated estimates it appears annual population trend assessments may be enhanced by utilizing pellet group counts. The downward trend from 1970-71 to 1971-72 was not reflected by this technique, however.

Biotelemetry

Internal temperature transmissions from Paul Jr. were taped from January 22 to March 10, 1976. He was found dead on March 15, 1976. An autopsy indicated death was due to peritonitis resulting from a puncture wound (probably from a limb) which opened the incision and penetrated the rumen.

Because of a temperature decoder malfunction we were not able to get actual temperature readings, but we were able to establish that his temperature varied 1.39°C over the recording time. Due to the deteriorating condition of the moose and the influence of peritionitis on his body temperature, we made no attempt to correlate temperature with activities. The transmitter did provide a signal that was recordable up to 30 m with a hand-held FM antenna and up to 100 m with a FM antenna mounted on a 10 m tower.

The heart rate transmitter unit placed over the lower rib cage of this animal was too large and it caused pressure necrosis of the skin over the unit. The unit eventually sloughed out. The unit was then modified and made smaller and it was concluded that placement should be changed. We were not able to detect heartbeat transmissions except immediately after placing the transmitting unit in place while the moose was still immobilized. Once on his feet and free to move, we could only receive a rubbing sound. This indicated to us that the wire leads had not remained in place and were moving, creating the friction sound. Therefore, the leads must be firmly sutured down their entire length.

The locating and activity transmitter was useful in finding the moose, and the activity transmitter was particularly useful in that we could determine if the moose was moving or still while tracking. The activity transmitter was particularly helpful for locating free-ranging moose in heavy cover.

Ambient temperature recordings from the collar were influenced by their proximity to the animal and were higher than adjacently recorded ambient temperatures. Variability associated with an ambient temperature transmitter on the collar, due to gradual wearing of hair from under the collar and resultant loss of body heat into the area, precludes its use for our studies. The unit would be useful if it recorded actual surface temperatures, but it does not since it is separated from the body surface by the collar.

Internal temperature transmissions from Olivia were taped from February 26 to March 22, 1976. The temperature recordings ranged from 38.04C (100.47F) to 40.23C (104.41F) and averaged 39.36C (102.85F). There was no opportunity to correlate specific activities with body temperature. On May 17, 1976 Olivia was located by utilizing the location transmitter, however, the internal temperature transmitter was not working. Olivia was doing well as of June 29, 1976. It was postualted that the lithium battery was faulty or the unit seal was defective and leaked allowing the unit to malfunction.

We experienced many disappointments in these attempts to utilize biotelemetric devices to obtain physiologic data, but obtained several important results for future applications. The injury to Paul Jr. appeared unavoidable and must be considered an inherent risk. Both Rastus and moose 79 were in extremely poor condition at time of immobilization. The extended stress of immobilization nearly three hours at this critical time was apparently more than they could overcome. We discountinued attempts to apply the units to other moose at this critical time of year, but will attempt the procedure again in late fall. Hopefully, the short transmission time of the body temperature unit in Olivia was an individual unit problem. Further in vivo application will determine this. In vitro tests of units on hand showed they were functioning up to report time (June 30, 1976), but how long they will continue functioning remains to be seen.

With some of the procedural, mechanical, and electronic "bugs" worked out during this trial, we anticipate obtaining useful physiologic data in our next attempt.

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