file

ALASKA DEPARTMENT OF FISH AND GAME

JUNEAU, ALASKA

STATE OF ALASKA
Jay S. Hammond, Governor

DEPARTMENT OF FISH AND GAME
Ronald O. Skoog, Commissioner

DIVISION OF GAME
Ronald J. Somerville, Director
Donald McKnight, Research Chief

MOOSE RESEARCH CENTER REPORT

By:

Charles C. Schwartz
and
Albert W. Franzmann

Volume XI
Project Progress Report
Federal Aid in Wildlife Restoration
Project W-17-11, Jobs 1.14R and 1.21R

(Printed January 1981)

Job Progress Report (Research)

State: Alaska

Cooperators: Charles C. Schwartz, Albert W. Franzmann, and W. L. Regelin (USFWS)

Project No.: W-21-1 Project Title: Big Game Investigations

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

Period Covered: July 1, 1979 through June 30, 1980

SUMMARY

Several new studies were conducted under this job during this report period. A metabolic chamber to measure resting metabolic rates of tame moose was constructed and successfully tested. Rumen turnover times, total body water, water flux, and percent of total body fat were measured using radio isotope tracers. Results of the introduction of a male moose into Pen 3 following the peak of the rut are discussed. Four new moose calves were brought to the research center to be raised for future calf nutritional studies, but three were killed by a black bear; one was still alive at the end of this report period. The study to test the effects of fertilizing mechanically rehabilitated areas for improving moose browse was completed.

CONTENTS

BACKGROUND

The Kenai Moose Research Center (MRC), 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 1969 through June 1974 was completed (Franzmann et al. 1974). The 1976-1979 progress reports (Franzmann and Arneson 1976, Franzmann and Bailey 1977, and Franzmann and Schwartz 1978, 1979) covering this job were primarily devoted to pellet count census evaluations, the use of immobilizing drugs, biotelemetry, fertilization of moose forage in rehabilitated areas, moose calf mortality assessment, raising moose calves and electronic tissue measurement. Studies which continued through this report period were fertilization of moose forage in rehabilitated areas and raising moose calves.

As outlined in the 1979 progress report, new studies were initiated to determine the nutritional requirements of moose (Franzmann and Schwartz 1979). These studies are part of a broad objective to develop a carrying capacity model for moose on the Kenai National Moose Range. Studies are a cooperative endeavor with assistance from the Denver Wildlife Research Center, U.S. Fish and Wildlife Service; Wayne Regelin is the principal investigator with the Federal Service. The projects described under this job are preliminary attempts to determine if long-term nutritional studies are possible with moose. Rumen turnover, water kinetics, and body fat determinations were covered under the techniques section in this report because we were testing the application of these techniques to studies of moose nutrition. Because the applications were successful, they will be discussed under the digestive physiology section in future reports.

During 1978 a study was initiated (Franzmann and Schwartz 1979) to determine the effects of late breeding on calf production and survival in moose. It was hypothesized that because of an extremely low bull:cow ratio (5-8:100), some female moose may not be bred during their first estrus period. A pilot study was designed to test this hypothesis and to assess the impact of late breeding on calf production and survival. During summer 1978, prior to the breeding season, all the male moose were trapped and removed from Pen 3. Attempts to introduce a bull into the pen after the peak of early October rutting failed. However, in 1979 we were successful in trapping a bull moose on 23 October in Pen 1; he was released into Pen 3 the same day. Results of this study are discussed.

OBJECTIVES

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

PROCEDURES

Metabolic Studies

Several man-days were spent constructing an airtight metabolic chamber (1.2 X 3.7 X 2.4m) to measure the fasting metabolic rates of tame moose. The chamber was constructed of plywood with 2X4 in. supports on the walls and ceiling. The floor was made with 2X8 in. joists covered with plywood. A refrigeration unit was suspended from the ceiling to control humidity. Airflow into the chamber was controlled with a 1.5-inch (3.8-cm) plastic pipe and valve. Air was drawn out of the chamber through a 1.5-inch (3.8-cm) pipe using an Electrolux vacuum cleaner attached to a rheostat to control flow. The total volume of gas passing through the chamber was measured using a conventional gas meter. Subsamples of chamber air were collected and stored in 9 liter spirometers. Gasses were later analyzed for oxygen content with a Beckman Model OM 11 oxygen analyzer, carbon dioxide was measured with a Beckman Model LB 2 CO_2 analyzer, and total methane was measured with a Beckman Model 351 methane analyzer.

During a trial each moose was: (1)placed in the chamber, (2) the door sealed, (3) calibration time of 30 minutes, (4) gas exchange was measured for 2-4 hours, and (5) the moose was released. The calbiration time was recorded to allow for a change in CO_2 and O_2 concentration from atmospheric to a level adequate for measurement. This was generally a concentration of 0.8 percent CO_2 and 19.2 percent O_2, respectively. Measurements were made with moose fasting for 48 hours and receiving *ad libitum* food prior to entering the chamber. Details of the procedure will be described by W. Regelin in his 1980 progress report.

Turnover Studies

Rumen turnover, water kinetics, and total body fat were measured using radio isotope tracers. Drs. R. White and D. Hollaman, University of Alaska, Fairbanks, assisted us with our initial trials. A detailed description of the methods employed is being prepared by R. White, but was not available for this report.

In general, rumen turnover times for both liquid and solid components were measured using CrEDTA (Cr^{51}) and ruthenium chlorine (Ru^{103}), respectively. Fecal samples were collected at 2 hr intervals from time of oral dosage through the first 72 hrs, and then at 6 hr intervals for an additional 24 hrs.

Water kinetics was measured using tritiated water and generally followed the methods described by Wesley et al. (1970).

Pen 3 Introduction

Attempts to trap a bull moose were initiated in early October 1979. We successfully captured an adult male (#5) in Pen 1 on 23 October 1979. This bull was immobilized with etorphine (Franzmann et al. 1976), transported to Pen 3 on a snow machine trailer, given the antagonist of diprenorphine and released.

FINDINGS

Effects of Nitrogen Fertilization Upon Production of Moose Forage

This study was completed and a final paper prepared (Appendix A).

Raising Moose Calves

This study was completed and a final paper prepared (Appendix B).

Metabolic Studies

Preliminary studies using the metabolic chamber were successful. The tame moose readily accepted confinement in the chamber and did not attempt escape. Four trials, using four moose each, were conducted to monitor oxygen consumption and carbon dioxide and methane production. Details of the trials will be presented by W. Regelin in his 1980 progress report.

We did encounter a few problems with the original design of the metabolic chamber. Because there were no windows, the moose were uneasy and paced while in the chamber. This problem was corrected by putting a 0.3X0.8 m plexiglass window at each end of the chamber so the animal could see out. This calmed the moose

considerably. Another problem encountered was that because the chamber was only 1.2 m wide a moose could not comfortably turn around or lie down. All animals stood for the duration of a trial (4 hrs). This problem will be resolved by enlarging the chamber.

Turnover Studies

During this report period two trials were conducted to measure rumen turnover and water kinetics. Analysis was complete for trial one, but unavailable for trial two. Results from trial one indicate a rumen turnover time of 17.0 ± 1.6 and 22.2 ± 1.9 hr for the liquid and particulate portions of the digesta, respectively (Table 1). Rumen turnover studies will be continued to monitor changes in turnover time associated with changes in diet quantity and quality.

Water turnover rates, percent body water and flux were similar in all moose (Table 2). Total body water was higher than values for mule deer (*Odocoileus hemionus*) (Knox et al. 1969) and similar to that of pronghorns (*Antilocapro americana*) (Wesley et al. 1970). Water content of the body varies inversely with fat content (Prentice et al. 1952) and younger animals tend to have a higher percent body water than do older animals (Edelman and Leibman 1959, Phillips et al. 1970). The biological half-life of water ($T_{\frac{1}{2}}$) in moose was higher than that found in sheep (Anand and Parker 1966), mule deer (Knox et al. 1969) and pronghorns (Wesley et al. 1970). Since the $T_{\frac{1}{2}}$ value is a function of body size (Foy 1964) these results are quite reasonable. Additional water kinetics studies are planned for this winter when the tame moose are fed varying levels of crude protein. These studies should add information relating to water flux in moose.

Pen 3 Introduction

Male moose #5 was successfully introduced into Pen 3 on 23 October 1979. Subsequent sightings indicated that he survived the transplant and was alive on 3 July 1980. Several "Super Cub" flights were made over Pen 3 during the normal calving period (late May-early June) in spring 1980 to ascertain if any calves had been born during this period. No calves were sighted, however, we did not see all the female moose known to be in Pen 3. On 1 July, a complete helicopter search of Pen 3 was made in an attempt to determine the status of moose several weeks following the peak of calving. On this flight female 13 was sighted with a calf less than 3 days old. No other calves were sighted. A second helicopter flight was made on 14 July. Female 13 was again sighted with her calf. Four other cows were sighted, none had calves.

Although the results from this pilot study were very preliminary in nature, several important things were learned. First, the potential does exist to test late breeding in moose within the MRC enclosures and it is possible to physically transport a drugged moose from one enclosure to another. Second, the sightability of moose in Pen 3 is very poor and routine "Super Cub" flights do not provide sufficient information to ascertain if and when cows gave birth. Third, and of significance, it appears that late breeding does occur, with the subsequent parturition date delayed by a similar length of time.

From this pilot study it is possible to develop several hypotheses to be tested in the next few years. By placing radio collars on all female moose in Pen 3 we can locate all individuals either on the ground or via aircraft. This should provide the necessary observations to determine calving dates and calf survival. The potential management implications from such studies are very important. If late breeding produces calves born later in the summer, it seems logical that these calves would be smaller at the end of the vegetative growing season. Small calves would have less chance of surviving a long severe winter. Continued studies are requisite to determine the effects of late breeding on moose calf production and survival. Once these effects are understood it will be necessary to determine if late breeding occurs in wild moose populations with low bull:cow ratios.

LITERATURE CITED

Anand, R. S., and H. R. Parker. 1966. Total body water and water turnover in sheep. Am. J. Vet. Res. 27:899-902.

Edelman, I. S., and J. Leigman. 1959. Anatomy of body water and electrolytes. Am. J. Med. 27:256-277.

Foy, J. M. 1964. The biological half-life of tritiated water in the mouse, rat, guinea-pig and rabbit under tropical conditions and the effect of climate and saline drinking on biological half-life of tritiated water in rat. J. Cellular and Comp. Physiol. 64:279-282.

Franzmann, A. W., P. D. Arneson, R. E. LeResche, and J. L. Davis. 1974. Developing and testing of new techniques for moose management. P-R Proj. Final Rep., W-17-2, W-17-3, and W-17-6. 54pp. (multilith).

Franzmann, A. W., R. E. LeResche, P. D. Arneson, and J. L. Davis. 1976. Moose productivity and physiology. Alaska Dept. Fish and Game Fed. Aid in Wildl. Rest. P-R Proj. Final Rep., W-17-2, W-17-3, W-17-4, W-17-5, W-17-6, and W-17-7. 87pp. (multilith).

Franzmann, A. W., and P. D. Arneson. 1976. Moose Research Center Report. Alaska Dept. Fish and Game. Fed. Aid in Wildl. Rest. P-R Proj. W-17-8. 15pp. (multilith).

Franzmann, A. W., and T. N. Bailey. 1977. Moose Research Center Report. Alaska Dept. Fish and Game. Fed. Aid in Wildl. Rest. P-R Proj. W-17-9. 76pp. (multilith).

Franzmann, A. W., and C. C. Schwartz. 1978. Moose Research Center Report. Alaska Dept. Fish and Game. Fed. Aid in Wildl. Rest. P-R Proj. W-17-10. 11pp.

Franzmann, A. W., and C. C. Schwartz. 1979. Moose Research Center Report. Alaska Dept. Fish and Game. Fed. Aid in Wildl. Rest. P-R Proj. W-17-11. 32pp. (multilith).

Knox, K. L., J. G. Nagy, and R. O. Brown. 1969. Water turnover in mule deer. J. Wildl. Manage. 33:389-393.

Phillips, R. W., L. D. Lewis, and K. L. Knox. 1970. Alterations in body water turnover and distribution in neonatal calves with acute diarrhea. Ann. of the New York Acad. Sci. Conf. on Neonatal Enteric Infections Caused by Escherichia coli. May 18, 19, 20.

Prentice, T. C., W. Siri, N. I. Berlin, G. M. Hyde, R. J. Parsons, E. E. Joiner, and J. H. Lawrence. 1952. Studies of total body water with tritium. J. Clin. Invest. 31:412-418.

Wesley, D. E., K. L. Knox, and J. G. Nagy. 1970. Energy flux and water kinetics in young pronghorn antelope. J. Wildl. Manage. 34:908-912.

PREPARED BY:

Charles C. Schwartz
Game Biologist II

Karl Schneider
Regional Research Coordinator

APPROVED BY:

Ronald J. Somerville
Director, Division of Game

Donald E. McKnight
Research Chief,
Division of Game

Appendix A. Proc. 16th N. Am. Moose Conf. and Workshop. Prince Albert, Saskatchewan, 1980 (In Press).

EFFECTS OF NITROGEN FERTILIZATION UPON PRODUCTION OF MOOSE FORAGE IN ALASKA

Wayne L. Regelin - U.S. Fish and Wildlife Service, Denver Wildlife Research Center, Kenai, Alaska 99611

Albert W. Franzmann - Alaska Department of Fish and Game, Kenai Moose Research Center, Soldotna, Alaska 99669

Charles C. Schwartz - Alaska Department of Fish and Game, Kenai Moose Research Center, Soldotna, Alaska 99669

Abstract: Nitrogen fertilizer was applied to small plots in spruce and spruce-birch forest types in southcentral Alaska. The fertilized areas had burned 30 years before and been mechanically crushed 1 year before treatment. Nitrogen (N) was applied as ammonium sulfate or urea at rates of 66 or 133 kg of N per ha. Production of graminoid species increased after fertilization, but growth of forb and shrub species was not changed. N fertilization is not recommended as a method of increasing forage production for moose in this area.

The potential of increasing production of moose forage in the northern boreal forest zone by application of N fertilizer was investigated. Few fertilizer experiments have been conducted in this zone and all have emphasized increasing lumber yields rather than understory vegetation. However, these studies indicated tree growth, seed production and nutrient content of foliage can be increased by N fertilization (Van Cleve 1973, Coyne and Van Cleve 1977, Cayford

and Jarvis 1967, Salonius 1977). Wildlife managers have used N fertilization in attempts to increase nutritional quality and biomass production of shrub species at more southern latitudes (Gibbens et al. 1962, Abell and Gilbert 1974, Anderson et al. 1974, Grenier et al. 1978). Results have been conflicting, lost likely due to differences in soils, climate and plant species. Field experimentation is necessary in each area before management recommendation can be made.

METHODS

The study was conducted at the Moose Research Center (MRC) in southcentral Alaska on the Kenai Peninsula. Vegetation in this area is dominated by black spruce forest (Picea mariana) or white spruce-paper birch mixed forest (Picea glauca - Betula papyrifera). The study areas were located within pen 1 at the MRC in an area which had been burned by wildfire in 1947 and disturbed by Le Tourneau tree crushers in December 1976. Soil in the study area was comprised of well-drained Podzol soil derived from loess overlying glacial till (Stephens 1967). This soil is friable and porous with a low fertility rating. Total N in the soil averaged 1.5% in the O_2, 0.15% in the A_2 and 0.11% in the B_2 horizons (Stephens 1967).

Fourteen experimental plots (Each 30 m on a side) were established; 7 were located in birch - spruce regrowth and 7 in spruce regrowth vegetation types. Six plots in each vegetation type were fertilized and one plot served as an unfertilized control. Ammonium sulfate (28% N) was applied to 2 plots in each type on April 12, 1977, four

plots in each type were treated, half with ammonium sulfate and half with urea (56% N). Rates were the same as the spring application. All fertilizer was applied using a whirlybird backpack fertilizer spreader. Spring application was made during a period of rapid snow melt with a snow cover of about 8 cm. Soil was moist from rain during the autumn application.

Vegetation was measured in each plot in late August, 1978. Five subplots (1x5 m) were randomly located in each plot. All birch, aspen, (Populus tremuloides) and willow (Salix sp.) plants rooted within the subplot were counted, height recorded and current annual growth (CAG) leaders counted and measured for length. Numbers and heights of other shrubs and tree species were recorded. Standing crop biomass was measured by clipping ten randomly located subplots (0.5 m^2) within each plot. All vegetation within or overhanging a subplot was clipped at ground level. Shrub, forb and graminoid species were sacked seperately, dried at 105 C for 48 hours and weighed to the nearest 0.1 g.

RESULTS

Vegetation measurements were made two growing seasons after fertilizer application on plots treated in the spring and one growing season on plots treated in the fall. Shrub density was not altered by fertilized treatments. Only one shrub species (Rosa acicularis) had a significant (P 0.5) increase in height (average of 8 cm) on fertilized plots regardless of rate, type or application date of fertilizer. Height of paper birch plants averaged 35 cm on control plots and 35.2 on fertilized plots.

Paper birch was the only species with sufficient sample size for statistical analysis of length and number of CAG leaders. Fertilization had no significant effect on either measurements. Birch plants in control areas had an average of 8 CAG leaders and leaders averaged 16.0 cm in length. Average values in fertilized plots were 6 CAG leaders with 14.9 cm of length.

Total standing crop biomass was similar in each vegetation type following fertilization, 574 kg/ha in the spruce type and 586 kg/ha in the spruce-birch type. However, the spruce-birch type was dominated by shrub species (67% of total biomass) while the spruce type was comprised of 30% shrubs, 28% forbs and 46% graminoids. These differences were not due to the fertilizer treatment but apparently inherent differences in the vegetation types based on data from control plots. Still, both types responded to the fertilizer in a similar manner. Grass production was increased up to 4-fold while production of forbs and shrubs was not altered (Table 1). Statistical tests between types of fertilizer, rates and season application were all insignificant ($P > 0.5$) due to high variability within plots and treatments. The only trend occurred with grass production. It was greatest at the high rate and two years after treatment.

Table 1. Standing crop biomass of vegetation (kg/ha) on fertilized plots at the Moose Research Center in August, 1978.

Treatment	Grasses	Forbs	Shrubs	Total
Spring Application	204	152	358	714
Fall Application	166	106	242	514
Ammonium sulfate	202	138	270	618
Urea	132	80	298	508
66 kg N per ha	142	142	272	542
133 kg N per ha	232	96	288	622
Control Plots	52	132	266	552

DISCUSSION

This was a small pilot study to determine the potential of N fertilizer to enhance moose habitat and assess the need for further research on this subject. Results indicated N fertilization would not be an effective treatment for short-term improvement of forage production. Long-term effects may be different and the plots will continue to be monitored. Only grass species (mostly Calamagrostis canadensis) increased due to fertilization. This may have a detrimental effect on moose because grasses are seldom eaten and they compete with preferred forbs and shrubs.

Our results are surprising since the soil in this area has a low N level and most plants are stimulated by the addition of N. The absense of a response could be due to a variety of factors which we will not speculate upon. Our results do agree with those of Grenier et al. (1978) in Quebec.

If future studies of this type are conducted, pretreatment data should be collected. This would allow covariance analysis of vari-

ance to be utilized which would better identify treatment effects.

LITERATURE CITED

Abell, D.H., and F.F. Gilbert. 1974. Nutrient content of fertilized deer browse in Maine. J. Wildl. Manage. 38: 517-524.

Anderson, B.L., R.D. Pieper, and V.W. Howard. 1974. Growth response and deer utilization of fertilized browse. J. Wildl. Manage. 38: 525-530.

Cayford, J.H., and J.M. Jarvis. 1967. Fertilizing with ammonium nitrate improves red pine seed production. J. Forestry 65: 402-403.

Coyne, P.I., and K. Van Cleve. 1977. Fertilizer induced morphological and chemical response of a quaking aspen stand in interior Alaska. Forest Sci. 23: 92-102.

Gibbens, R.P., and R.D. Pieper. 1962. The response of browse plants to fertilization. Calif. Fish and Game 48: 268-281.

Grenier, P., B. Bernier and J. Bedard. 1978. The effect of forest fertilization on crude protein content, growth, and use by moose (Alces alces) of paper birch (Betula papyrifera) in Laurentides Park, Quebec. N. Am. Moose Conf. Workshop 13:258-278.

Salonius, P.O. 1977. Nutrient concentration in black spruce foliage immediately following fertilization. J. Soil Sci. 41: 136-139.

Stephens, F.R. 1967. Soils of the Kenai National Moose Range exclosure study area. U.S. Forest Service, Juneau, Alaska. 11 p.

Van Cleve, K. 1973. Short-term growth response to fertilization in young quaking aspen. J. Forestry 71: 758-759.

Appendix B. Trans. XIV Int. Congress of Game Biologists.
Dublin, Ireland, 1979.

Raising, Training and Maintaining Moose (alces alces) for Nutritional Studies

Wayne L. Regelin, U. S. Fish and Wildlife Service, Kenai, Alaska

Charles C. Schwartz and Albert W. Franzmann, Alaska Department Fish and Game, Soldotna, Alaska.

Abstract: Alaska Moose (Alces alces gigas) calves were successfully hand-reared and trained for nutritional studies. Calves were captured 2-5 days after birth and bottle-fed a commercial milk replacer. Calves were trained to accept handling, weighing, and confinement in an energy chamber. As yearlings, they continue to accept close human contact and experimental procedures. The moose are being used to gain knowledge of digestive physiology and energy requirements. This information is being utilized to produce a mathematical model of moose carrying capacity on the Kenai National Moose Range.

Introduction

Collection of physiological data from wild game species often requires tamed, tractable animals. Successful procedures for raising and training several species of wild ungulates have been reported by Trainer (1962), Reichert (1972), Buckland et al. (1976), Schwartz et al. (1976), and Hobbs and Baker (1979). This paper presents techniques used to raise and train moose for use in nutritional and bioenergetics studies at the Moose Research Center (MRC). The MRC, located 30 km northeast of Sotdotna, Alaska, is maintained as a cooperative research area by the Alaska Department of Fish and Game and the U. S. Fish and Wildlife Service, KNMR.

We acknowledge M. Schwartz and D. Johnson for assistance with feeding and training of moose.

Rearing Facilities and Procedures

Six moose calves, 3 males and 3 females, were captured during the last week in May, 1978 when about 3 days old. These calves were obtained from wild, free-ranging cows near the MRC. Two orphan calves, one of each sex, were secured on June 9, 1978, when approximately 3 weeks of age. All calves were initially housed in individual pens constructed of plywood. Each pen was 2.5m^2 with a plastic roof to prevent exposure to rain. Sawdust was provided for bedding and changed every 3 days. Fecal material was removed from pens several times each day. Calves were moved to permanent pens when 6 weeks old. These pens, constructed of woven wire, had no shelter. Individual pens were 3x15m in size and built within a 7 ha holding and exercise area. The holding area was within a 290 ha enclosure.

Bottle feeding began within 2 hours after capture. Milk was offered in 2 liter bottles with a sheep nipple 5 cm long. A commercial milk replacer (Suckle, a Carnation Company product[1]) was fed to all calves until weaned. The milk was mixed according to manufacturer recommendations, 100 g. powder to 1 liter water, and heated to 38c to enhance mixing. The formula contained 24% crude protein, 10% crude fat, 9% ash and 1% crude fiber. The amount of fat and protein was considerably higher than moose milk (Franzmann et al. 197 , Cook et al. 1970) but this did not appear to create any digestive problems. The formula was fortified with vitamins A, D, and E and contained a low level of antibiotic (25 mg/liter milk of neomycin base and 12 mg/liter of milk of oxytetracyclin).

All calves readily accepted bottle feeding after the first feeding. They were fed 5 times per day until 37 days of age. Feedings began at 0600 and were repeated every 4 hours until 2200. Milk consumption was steadily increased from 2.4 to 4.2 liters per day during this time. The number of feedings per day and milk intake was gradually reduced until weaning at 100 days of age (Table 1).

Table 1. Milk feeding schedule for moose calves from birth to weaning.

Age (days)	Intake (liters/day)	Number of feedings/day
1-3	with cow	
4	2.4	5
5	3.0	5
7	3.2	5
11	3.4	5
13	3.5	5
22	3.8	5
25	4.2	5
37	3.3	4
45	2.9	3
67	1.8	2
88	0.9	1
100	weaned	

Calves readily consumed all the milk offered at most feedings. Occasionally one would refuse to drink the entire ration during a single feeding but resumed normal feeding at the next meal.

Water was provided at all times and taken several times per day after about 5 days of age. A commercial pelleted feed (Don's Calf Starter, Alaska Feed Mill)[1] was initially provided ad libitum. Calves consumed little of this feed during the first month. Then consumption steadily increased until restricted. This feed was high in crude protein (24%) and highly digestible. The calves exhibited signs of digestive problems (loose feces) when intake of pellets reached about 1 kg/day at 64 days of age. Intake of these pellets was then limited to 400 gms per day and supplemented ad libitum with less digestible and lower protein (12%) pellets (Don's Horse Feed, Alaska Feed Mill). This change appeared to correct any digestive problems.

Calves were provided with fresh cut native vegetation on a daily basis. They began to eat vegetation when about 5 days old. Rumination was first noted when 10 days old. By 40 days of age, they were consuming large quantities of freshly cut browse (mostly aspen, Populus tremuloides). Calves also ate many other plant species during daily training periods. Providing large quantities of vegetation became an overwhelming problem. When calves were 80 days old, they were released into the 290 ha enclosure and allowed to forage during the day. They were returned to the individual pens each evening.

Daily injections (1 cc) of Vitamin B complex were made until calves were 40 days old. Vitamin injections were continued every other day until calves were 80 days old and then stopped.

Training

Calves were subjected to close human contact from the day of capture. Trainers spent long hours petting, brushing and just sitting with the calves.

Within a few days the calves readily accepted handling and appeared to be very relaxed in the presence of humans.

Feeding periods were utilized to traincalves for specific purposes. They readily followed a trainer when a feeding bottle was displayed. They were trained to step onto a platform scale at each feeding for 30 days. Calves were trained to follow a trainer and were taken for long walks each day. They were conditioned to return to their pens at the sound of a whistle.

Calves were trained to accept close confinement in a small box simulating a respiration chamber. They were fed in the box at least once per day for 2 months. Confinement in the box was gradually increased to 6 hours per day.

Weight trends and illness

Capture weight of the calves varied from 11.5 to 18.5 kg (Table 2). Six of the eight calves had steady weight gain and maintained good health. The two smallest calves had very slow weight gains and continual health problems. They died when 62 days old. After 60 days these calves had gained only 10 and 17 kg of weight. Healthy calves had gained an average of 34 kg by this time. The calves that died seldom ate vegetation or pellets but did consume their milk ration. Necropsies indicated respiratory failure due to lung congestion. While this was the ultimate cause of death, the reason for their continual poor health is not known.

Occasional scours were treated with oral doses of Kaopectate and injections of 5 cc of sulfadimethexine for 3 consecutive days. This medication was successful in arresting the diarrhea in all calves except the two that died. The only other medical problem encountered was eye infection in 2 calves. These were successfully treated by application of terramycin ointment and injection of 2 cc penecillin for 2 days.

Table 2. Periodic weights of moose calves from capture until weaning.

Moose	Weight in Kg. Capture weight	30 days	60 days	100 days
1	17	29	55	90
2*	12.5	23	29	--
3	16	32	65	112
4*	11.5	17	21	--
5	18.5	26	48	81
6	14	22	31	5
7**	--	38	66	113
8**	--	25	48	84

*died at 62 days of age.

**obtained when three weeks old.

Post-weaning care

All calves continued to gain weight throughout their first year of life. At one year of age, weights varied from 240 to 270 kg. The moose remain tame and tractable. They adjust to daily routines rapidly and without difficulty.

The moose are maintained on an experimental ration with a fiber base of aspen sawdust. The feed formula has not been finalized at this date. The moose do eat native vegetation when available, but the pellet feed ration has constituted the major portion of their diet since 4 months of age. Feeding trials in June revealed feed intake averaged _____kg per day or ____% of body weight per day. The moose have adjusted to a life of captivity very well. They make good experimental animals and are not nearly as nervous as other cervids.

Research Plans

One goal of the research being conducted at the MRC is to produce a mathematical model of moose carrying capacity on the Kenai National Moose Range (KNMR). Our approach is based upon the forage supply available on the range and moose requirements for various nutrients. Quantification of forage supply involves mapping all vegetation types, measuring plant species composition, density and biomass, and analyzing the nutritional value of major forage species. Plants are collected during 6 periods of the year and analyzed for in vitro digestibility, crude protein content, fiber components and mineral content. Vegetation types are being mapped from aerial photographs using computerized techniques. Plant density, composition and standing crop biomass is obtained by measuring and clipping random plots.

The tame moose will be used to collect data on requirements for energy and protein. Fasting metabolic rate of different sex and age classes of moose will be measured during each season in an indirect respiration chamber. Energy requirements for lactation, gestation and activity will also be measured. Protein requirements will be determined by in vivo digestion trials and neutral detergent

techniques. Information on rumen volume, rate of passage, rumen turnover time, and time-energy budgets is necessary to produce a carrying capacity model. These data are being collected in companion studies. Other studies utilizing the tame moose are concerned with digestive physiology and blood and hair physiological values from moose on different nutritional regimes.

Job Progress Report (Research)

State: Alaska

Cooperators: Charles C. Schwartz, Albert W. Franzmann, and Wayne L. Regelin

Project No.: W-21-1 Project Title: Big Game Investigations

Job No.: 1.21R Job Title: Moose Productivity and Physiology

Period Covered: July 1, 1979 through June 30, 1980

SUMMARY

Data collection for outlined studies of moose hair element metabolism, blood chemistry and hematology continued. Results of blood and hair analyses were neither compiled nor analyzed during this report period because of inadequate programming capabilities. Analyses were completed on moose calf blood values and morphometric measurements and a manuscript prepared. Histories of individual moose at the MRC were updated. Research into the development and testing of a formulated ration for moose was continued. Two digestion and balance trials were completed during this report period. Dry matter digestion was 64.3 ± S.D. 2.3 and 68.3± S.D. 2.4 for the two trials. Measurements of dry matter intake indicated seasonal differences in feed consumption with the highest occurring in June and the lowest in March. A reduction in consumption of feed was also noted during the rutting season. Growth, as indicated by weight gain, was measured for six tame moose. Average weight gain from weaning (Aug. 15) until May 31 the following year was 0.62 kg/day. The moose continued to gain weight from June through September with daily gains of 0.74 kg ± S.D. 0.09. Animals lost some weight during the rut and through the winter months. Weight loss per day was 0.04 kg ± S.D. 0.02 from November-April. The captive moose herd appears to be healthy, and one female produced a calf when she was a 2-year-old. She had been inseminated by a yearling male.

CONTENTS

BACKGROUND

Digestive physiology studies with captive moose (*Alces alces*) were initiated last year (Franzmann and Schwartz 1979a) under the moose productivity and physiology studies as outlined by Franzmann et al. (1976). The major goal of these studies is 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 1979a). In general, we are attempting to integrate information on the nutritional requirements of moose with that on the nutrients supplied from the vegetation. The program is two-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 Fish and Wildlife Service personnel.

This report describes ongoing research into the nutrient requirements of moose. Before nutrient requirements could be determined, it was necessary to develop and test a formulated ration capable of meeting the nutrient requirements of moose. This report mostly concerns that aspect of this project.

OBJECTIVES

To establish baselines by sex, age, season, reproductive status, area, drug used, excitability and condition for blood, hair and milk parameters in moose 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 values and digestabilities 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 optimum 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 and contrast the ability of captive moose to digest and assimilate a formulated diet versus four major food items consumed by wild moose either singly or in combination during winter.

The overall objective 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

Blood Chemistry and Hematology

Procedures for collecting, handling and analyzing blood were outlined by Franzmann et al. (1976). During this period, blood was collected from moose immobilized and processed at the MRC.

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 one 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 2-1 cow, 6 tame moose; Pen 3-5 cows and no bull until late in rut; and Pen 4-no moose.

Moose were moved utilizing an etorphine (M-99) and xylazine hydrochloride (Rompun) mixture for initial immobilization of trapped animals. Each animal was routinely processed when immobilized (Franzmann et al.1976).

Digestive Physiology of Moose

Procedures are outlined per the four objectives relating to this aspect of the job.

Objective (1): Hand-reared captive moose calves (Franzmann and Schwartz 1978) were used to meet objectives of this study. Five calves (2 females and 3 males) were the subjects. Studies were conducted at the Moose Research Center. Development and testing of the formulated ration followed recommendations of Ensminger and Olentine (1978:469-493). In general, the diet was evaluated on the basis of (1) physical characteristics, (2) chemical analysis, and (3) biological evaluation.

The diet was analyzed chemically for crude protein (Kjeldahl N x 625), gross energy, ash, and minerals using procedures in A.O.A.C. (1965). Cell wall constituents (CWC), acid-detergent fiber (ADF), and acid-detergent lignin were determined by procedures outlined by Van Soest and Wine (1967), Van Soest (1963), and Goering and Van Soest (1970). Physical characteristics including pelletability, lack of crumbling in prepared pellets, and acceptance of various pellet sizes were evaluated subjectively unless statistical testing seemed justified.

Biological evaluation consisted of two parts. Conventional digestion and balance trials (Ensminger and Olentine 1978, Schneider and Flah 1975, Church 1969) were used to evaluate the animals' ability to process, digest, absorb and assimilate the various nutrients (Part 1, 3 phases). Wooden digestion stalls (3.1 x 2.4 x 3.1 m) designed to permit complete and separate collection of feces and urine were used for digestion studies. Stall floors were fitted with expanded metal sheeting to permit fecal and urine separation. During phase 1, animals were enclosed in 3.1 x 15.2 m enclosures for a minimum of 10 days during which average daily food consumption was measured. During phase 2, moose were fed 90 percent of their phase 1 intake to adjust feed intake, fecal output, and eliminate the analysis of orts. During phase 3, total food consumption, and fecal and urine production were measured daily for 7 days. During phase 3, moose were also offered 90 percent of their phase 1 intake. Food was offered twice daily with water available *ad libitum*. A subsample of the diet, as fed, was collected and frozen. At the end of each digestion trial, a weekly composite sample of the diet was analyzed in duplicate for percent moisture. Orts were subsampled and analyzed in a similar fashion. Excreta were collected once daily, weighed or the volume measured and subsampled. Urine samples were acidified with 6N H_2SO_4 to lower the pH to below 4 to prevent the loss of ammonia nitrogen.

Excreta samples for each moose, 20 percent by weight for feces, and 5 percent volume for urine, were saved daily; feces and urine were frozen (-12°C). Later moisture and nitrogen were determined in undried feces while fiber analysis and gross energy

analysis will be carried out on subsamples dried at 60°C in a convection oven until air-dry. Specific gravity and nitrogen content of wet urine were measured, and gross energy was determined for freeze-dried urine. Moose calves were placed in an indirect respiration calorimeter (Silver et al. 1969) for 2-4 hours to measure rates of oxygen consumption and carbon dioxide and methane production while being fed. After these measurements, moose were fasted for 48 hours and placed back into the respiration chamber. Metabolic rate, as determined by heat production during this fast, was considered the net energy requirement. By following this schedule the energy flow was partitioned into its various components. Nutritional information was collected seasonally to correspond to important periods during the annual cycle of the moose. Periods tested were October, November, March corresponding to: (1) rutting season, (2) early winter stress periods, and (3) late winter season. Due to problems with the moose shedding hair no June trial was attempted.

Blood samples were taken at the beginning of each trial by conventional means and analyzed as described by Franzmann et al. (1976). Hair samples were plucked after each sampling period and analyzed (Franzmann et al. 1976).

The second part of the biological evaluation of the formulated ration involved long-term monitoring of captive moose maintained solely on the diet. Parameters monitored included general growth and development as determined by weight, development of abnormalities either external (i.e., rickets, poor hair coat, etc.) or internal (i.e., rumen dysfunction), general vigor, reproductive maturity and other subtle factors. We feel this part of the evaluation was essential since many deficiencies or dietary problems do not manifest themselves in typical "clinical" symptoms normally described in current ruminant nutrition texts. Rather, if some problem occurs, it more than likely would take some time to develop.

Objectives (2) and (3) were not tested during this report period.

Objective (4): A digestive and balance trial to determine the ability of moose to process quaking aspen (*Populus tremuliodes*), was completed using conventional digestion trials described in objective 1. Hand-clipped samples of aspen twigs less than 8mm in diameter were collected in winter, frozen in plastic bags and fed as required. Because of insufficient quantities of aspen, we fed the moose a 60:40 (dry matter basis) ration of pelleted feed:aspen twigs for the duration of this trial.

FINDINGS

Blood Chemistry and Hematology

Blood samples were collected during this report period from captive tame moose and moose trapped within the four enclosures at the MRC. Because of inadequate programming capabilities these data were not analyzed for this report.

Blood samples and measurements collected from neonatal moose calves (Franzmann et al. 1980, Franzmann and Schwartz 1979b, Ballard et al. 1979) were analyzed and a manuscript was prepared (Appendix A).

Productivity and Mortality of MRC Moose

Histories of individual moose through 30 June 1980 are listed in Tables 1-5. As discussed under the Techniques Section of this report, we successfully introduced a male into Pen 3 after the rut. Efforts to remove all the moose from Pen 4 failed. We successfully removed all but two moose prior to winter 1979-80, and captured two additional moose in spring 1980. However, an unknown number of moose entered the pen from the outside through a break in the fence. The break was repaired, and we are again attempting to remove all remaining individuals.

Digestive Physiology of Moose

Ingredients (Table 6) used in the formulated moose ration, hereafter referred to as the "MRC Special," were selected to provide one or more of the following: (1) essential nutrients, (2) increased palatability, (3) improved ingredient pelleting, or (4) reduced spoilage. Aspen sawdust was used as a fiber source rather than cultivated hays or crop residues because of its fiber form and woody nature (Franzmann and Schwartz 1979a).

Sawdust was obtained from a local sawmill shortly after milling operations. Initially, we used the sawdust on an "as is" basis when preparing the ration, but because of its high moisture content, several batches of feed molded. This problem was corrected by air drying the sawdust until the moisture content was below 30 percent. We have used sawdust from both summer and winter harvested trees with apparent success. Trees logged during summer contained more sap and, consequently, the sawdust required a longer time to dry.

Aspen was chosen as a sawdust source because it was: (1) eaten by moose, (2) abundant and easy to obtain, (3) lacking in terpenes or resins, and (4) successfully fed to domestic cattle. We are currently experimenting with black cottonwood (*Populus balsamipora*) and white spruce (*Picea glauca*) sawdust, but results are not available at this time.

Table 1. Histories of Pen 1 moose at Kenai Moose Research Center 1 July 1979 through 30 June 1980.

Moose number	Sex	Year of birth	Significant observations			No. times observed	No. times captured
			Date	Event	Remarks		
58	M	1970	24 June 80	Last sighted	Observed	7	0
8[1/]	M	1978	27 June 80	Last sighted	Observed	9	1
R-70-8	F	1968	30 June 80	Last sighted	With calf	7	0
125	F	1966	4 June 80	Last sighted	No calf seen	5	1
UC[2/] (No.5)	M	?	23 Oct. 70	Trapped in 1E	Collared and moved to Pen 3 as No. 5	?	1

[1/] First captured and collared on 11 July 1979. Calf of female No. 125.

[2/] May have been born in Pen 1 or may be moose that broke into Pen on 9 October 1978.

Table 2. Histories of Pen 2 moose at Kenai Moose Research Center 1 July 1979 through 30 June 1980.

Moose number	Sex	Year of birth	Significant observations			No. times observed	No. times captured
			Date	Event	Remarks		
670[1/]	F	1970	- NOT IDENTIFIED IF SEEN THIS YEAR -				
129	F	1976	22 June 80	Last sighted	With UC yearling male	6	1
130	F	1975	2 Aug. 79	Died	Overheated after being drugged	3	1
31	F	?	15 June 80	Last sighted	Trapped in Pen 4 on 10 June 80, collared, moved to Pen 2	2	1
UC[1/]	F	?		Sighted	Had metal ear tags	1	0
UC[2/]	F	?	27 June 80	Sighted	Observed	?	0
UC	F	?	2 May 80	Sighted	Released outside pens	?	0
UC[3/]	?	1979	22 June 80	Last sighted	With No. 129 female	?	0

1/ Female with metal ear tags may be No. 670.

2/ Pen 2 fence was broken down twice and a gate pushed open once so several moose may have broken into pen during winter and spring.

3/ 1979 calf of dead cow No. 130 was thought to be female and to have been seen with No. 129. However, a male yearling was seen with No. 129 on 22 June 1980. Possibly there are two yearlings.

Table 3. Histories of Pen 3 moose at Kenai Moose Research Center 1 July 1979 through 30 June 1980.

Moose number	Sex	Year of birth	Significant observations			No. times observed	No. times captured
			Date	Event	Remarks		
2870(14)	F	1970	27 Sep. 79	Trapped in 3W	Not processed	1	1
13	F	1970-72	10 Oct. 79	Trapped in 3S with No. 17	Not processed	2	2
17	F	?	10 Oct. 70	Trapped in 3S with No. 13	First captured and collared on 17 July 1979. History unknown	2	2
75(15)[1/]	F	1969	NOT IDENTIFIED IF SEEN THIS YEAR				
20	F	?	21 June 80	Sighted with calf	Trapped in 4NE on 8 June 1980. Collared & moved to Pen 3 with calf	4	1
5	M	?	14 June 80	Last sighted	Trapped in 1E on 23 Oct. 1979. Collared and moved to Pen 3.	3	1
UC[1/]	F	?	28 May 80	Sighted	Observed	1	0

[1/] Only one observation of an uncollared moose in Pen 3 this year. No known break-ins through fence. Possibly the UC female is No. 75(15).

Table 4. Histories of Pen 4 moose at Kenai Moose Research Center 1 July 1979 through 30 June 1980.

Moose number	Sex	Year of birth	Significant observations			No. times observed	No. times captured
			Date	Event	Remarks		
7	M	1969	NOT OBSERVED THIS YEAR		ASSUMED DEAD		
140(73)	M	1969	26 Sept 79	Found dead	Assumed winter mortality	1	0
80	M	1969	NOT OBSERVED THIS YEAR		ASSUMED DEAD		
81[1/]	F	1969	17 July 79	Trapped in 4SE	Released outside	1	1
Unid., Collared[1/]	F	?	8 June 80	Sighted	Collar and ear tag colors same as No. 81 female	1	0
UC (No. 20)	F	?	8 June 80	Trapped in 4NE with calf	Collared and moved to Pen 3 as No. 20	?	1
UC (No. 31)	F	?	10 June 80	Trapped in 4NW	Collared and moved to Pen 2 as No. 31	?	1
UC	F	?	14 June 80	Sighted near another UC female	UC female with calf was seen on 29 July 79	?	0
UC	F	?	14 June 80	Sighted near another UC female	Observed	?	0

[1/] Unidentified, collared moose may be No. 81 female. She and some UC moose may have entered Pen 4 through hole that was discovered in SE fence line.

Table 5. Mortality within enclosures at Kenai Moose Research Center 1 July 1979 through 30 June 1980.

Pen No.	Moose No.	Sex	Year of birth	Date	Remarks
2	130	F	1975	2 Aug 1979	Died from overheating after being drugged
4	7	M	1969	19 Sep 1978	Trapped and released; not sighted again. Assumed dead
4	140(73)	M	1969	26 Sep 1979	Found dead; assumed winter mortality
4	80	M	1969	22 Dec 1978	Last sighting; assumed dead

Table 6. Composition of the "MRC Special" diet formulated for captive moose[1/].

Ingredient	Percent
Corn, ground yellow	28.7
Sawdust[2/]	25.9
Oats, rolled	17.2
Soybean meal, powdered	7.2
Cane molasses, dry	5.7
Barley, ground	5.7
Beet pulp, ground	5.7
Vitamin premix[3/]	0.3
Trace mineral salt[4/]	0.7
Dicalcium phosphate[5/]	1.3
Pelaid[6/]	1.4
Mycoban[7/]	T

1/ The diet was formed in 4.8 mm pellets.

2/ Aspen sawdust from sawmill.

3/ Each kg contained 5004.4 USP units vitamin A, 13228 IC units viatmin D_3, and 44 I units vitamin E.

4/ Guaranteed analysis: NaCl 95-98%, Zn 0.35%, Mn 0.28%, Fe 0.175%, Cu 0.035%, I 0.007%, Co 0.007%.

5/ Guaranteed analysis: P 18.0%, Ca 31.0-34.0%.

6/ Pelaid, Rhodeia Inc., Ashland Ohio, is a wood byproduct used to enhance pelleting.

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

Although spruce sawdust was more readily available than aspen sawdust, we were reluctant to use it initially because of the terpenes it contained. Work by Nagy et al. (1964) with sagebrush (*Artemesia tridentata*), Oh et al. (1967) with Douglas-fir (*Pseudotsuga menziesii*), and Schwartz et al. (1980a,b) with *Juniperus* spp. has indicated that volatile oils and terpenes inhibited mule deer (*Odocoileus hemionus*) rumen bacteria and reduced palatability of feed.

The MRC Special was mixed and pelleted by the Alaska Mill and Feed Company in Anchorage. Through this reporting period, 11 different batches of feed have been made and fed to the captive moose. Subsamples have been collected, but chemical analyses are not available at this time. These samples are currently being analyzed by personnel at the nutrition lab of the U.S. Fish and Wildlife Service, in Kenai, Alaska.

Protein and energy levels of the MRC Special (Table 7) were based on dietary requirements for dairy cattle. The 11.75 percent crude protein level and associated digestible energy appeared adequate for moose calf growth from weaning to 1 year of age. Growth, as measured by weight gain, (Table 10, Figs. 1 and 2) for six moose fed the MRC Special, was similar to that for wild moose calves on the Kenai Peninsula through October (Franzmann et al. 1978). After November, the moose receiving MRC Special continued to gain weight throughout the winter, while the wild moose calves lost weight. The average daily gain from weaning (August 15) until May 31 the following year was 0.62 kg ± S.D. 0.02. These moose continued to gain weight throughout their second summer until early October when rutting activity began. Average daily weight gains from May 31 until October 1 were 0.74 kg ± S.D. 0.09. Animals experienced slight weight loss during the rutting period and throughout the winter. Weight loss per day was minimal and only amounted to 0.04 kg ± S.D. 0.02 from November 1 through March 25. Weight loss was a result of reduced feed intake and consequent fat metabolism. Similar weight loss has been observed in black-tailed (*O. hemionus columbianus*) and white-tailed (*O. virginianus*) deer offered *ad libitum* feed throughout winter.

We are continuing to weigh the tame moose biweekly. Since these animals will not attain maximum body weight until 3-4 years of age, no mathematical equations to describe their growth have been fitted to the weight-age relationship at this time.

Consumption of the MRC Special (Table 9) varied seasonally, with the highest dry matter intake occurring in June and the lowest intakes in March. Caloric values for the feed consumed were not available for this report, so gross energy intake determinations were not available for all seasons. Daily consumption of gross energy has been calculated for the two digestion trials conducted in November and March (Table 10). Gross energy intake was much higher in November and decreased significantly in March. The percent of total energy lost in the

Table 7. Chemical composition and apparent digestibility of the "MRC Special" diet formulated for captive moose.

Analysis	Amount and units
Dry matter	80.0%
Crude protein	11.75%
Cell wall constituents	47.2%
Acid-detergent fiber	26.5%
Gross energy	4.45 Kcal/gram
Calcium	9750 ppm
Potasium	7140 ppm
Sodium	2910 ppm
Phosphorus	2106 ppm
Magnesium	205 ppm
Iron	62 ppm
Zinc	23 ppm
Copper	6 ppm
Selenium	0.22 ppm
Cobalt	0.1 ppm
Chromium	0.1 ppm
Dry matter digestion (in vivo)	64.3%

Table 8. Daily weight in kilograms of 5 captive moose hand-reared at the Moose Research Center, 1979-80.

	Animal Name (sex)					
Date	Lucile (F)	Rodney (M)	Chester (M)	Chief (M)	Angel (F)	Jezebel (F)
7-01-79	253	284.5	263	293	273	
7-02-79	264	294	270	305	281	
7-04-79	258	291	272	301	268	
7-06-79	266	293	274	300.5	273	
7-08-79	266	297	278	301	275	
7-09-79	272	309	283	306	285	
7-10-79	268	299	281	298	277	
7-11-79	265	306	276	303	274	
7-13-79	261	296	276	295	282	
7-17-79	272	311	290			
7-18-79		310	288	309	289	
7-19-79	269	312	292	311	286	
7-20-79	275	317	298	313	298	48
7-23-79	271	316	298	316	285	
7-26-79	282	317	301	318	289	
7-27-79	276	318	296	323	286	59
7-28-79	284	329	398	324	295	62
7-29-79	277	323	301		300	64
7-30-79		316		317	292	65
8-02-79		321	301		298	
8-03-79	284	323	304	325	297	
8-06-79	287		315	326	304	70
8-07-79	290	330	319	328	300	
8-08-79		326	311	329	302	
8-11-79	291			335	315	77
8-13-80			324	330	306	
8-14-79	292	343	326	339	314	79.5
8-17-79	294	343	337	339	311	82
8-25-79		353				
8-26-79		357				

Table 8 (Cont.).

Date	Animal Name (sex)					
	Lucile (F)	Rodney (M)	Chester (M)	Chief (M)	Angel (F)	Jezebel (F)
9-05-79	312			357	333	96
9-07-79	298			346	314	94
9-10-79	305				321	94
9-11-79	310			352	321	93
9-11-79						96
9-18-79	309			362		93
9-25-79						102
9-26-79	315		344	359.5	328	102
10-01-79	306	342	337		326	100
10-04-79	304	327	328		322	101
10-06-79						99.5(a.m.); 108(p.m.)
10-08-79	319	318	312	334	328	
10-18-79						98
10-23-79	329	301	299	323	323	89
11-05-79	330	326	323	343	330	
11-09-79	334	332	321	344	330	102
11-16-79	335	335	324	341	336	
12-05-79	348	330	323	344	343	
12-10-79	334	334	320	337	343	134
12-26-79	357	344	344	350	356	145
1-08-80	363	358	341	356	371	154
1-16-80		356	351	357		159
1-24-80	363	358	346	352	355	167
1-28-80	363	352	341	350	360	165
2-04-80		358	347	359	348	
2-07-80	370	358	351	365	361	172
2-15-80	356	356	345	360	341	168
2-21-80	357	354	342	354	333	
2-23-80		350	341	356		
2-24-80	364	354	346	359	337	
2-25-80						179

Table 8 (Cont.).

Date	Animal Name (sex)					
	Lucile (F)	Rodney (M)	Chester (M)	Chief (M)	Angel (F)	Jezebel (F)
2-29-80	362	358	343	360	339	177
3-05-80	362	361	334	358	334	
3-07-80						183
3-12-80	359	352	336	355	324	
3-15-80	359 In digest. stall	350 In digest. stall	339 In digest. stall	351 In digest. stall	324	
3-18-80						183
3-22-80	352 Out digest. stall	349 Out digest. stall	343 Out digest. stall	349 Out digest. stall	325	181
3-24-80	351 After fast	350 After fast	337 Fasted	349 After fast	332	
4-02-80	339	332	319	338	304	183
4-08-80	339	344	322	344	310	
4-13-80						186
4-16-80	346	349	328	345	307	190
4-23-80	351	344	336	347	313	194
4-25-80	357	356	336	355	311	203
4-28-80	Moose panicked while being held in pre-trial pens	Moose panicked while in pre-trial pens	Moose panicked while in pre-trial pens	Moose panicked while in pre-trail pens	Moose panick while in pre-trial pens. Angel injured her foot. She was not used in actual trial	
4-29-80	354	347	335	350	306	203
5-03-80	362	348	332	356	297	
5-07-80	359 Pre-trial	344 Pre-trial	336 Pre-trial	355 Pre-trial		
5-13-80						217
5-14-80	366 Post-trial	338 Post-trial	333 Post trial	345 Post trial	291	
5-19-80	355	333	329	338	292	218
5-24or25 -80	Lucy gave birth to Kap 1					

Table 8 (Cont.).

Date	Animal Name (sex)					
	Lucile (F)	Rodney (M)	Chester (M)	Chief (M)	Angel (F)	Jezebel (F)
5-26-80		331				214
5-29-80		348	336	333	293	219
6-08-80		337	337	335	294	
6-09-80	292					
6-14-80	305					
6-16-80		356	350	356	314	234
6-19-80	Calf (Kap i) taken away	343 Fasted 48 hrs.	343 Fasted 48 hrs.	339 Fasted 48 hrs.		236
6-25-80	316	369	357	357	317	243

Table 9. Seasonal intake of dry matter for moose fed a pelleted ration.

Animal	Date: 1-10 June	9-25 October	10-19 November	5-11 March	25-April-5 May
	animal weight (kg)	(intake $g/W^{0.75kg}/day$)			
Angel	249(97.2)	326(54.7)	323(94.9)	329(51.2)	-
Lucy	243(86.2)	-	-	360(49.7)	358(75.8)
Chief	271(94.4)	328(68.3)	333(80.2)	355(53.6)	356(91.7)
Rodney	273(96.9)	310(72.6)	333(84.4)	356(59.6)	350(65.1)
Chester	247(102.3)	306(72.6)	325(85.6)	336(54.3)	334(85.2)
Mean intake ±S.D.	95.4±5.9	67.1±8.5	86.3±6.2	53.7±3.8	79.5±11.6

Table 10 . Gross energy intake and fecal energy loss for moose fed a pelleted ration during November and March.

Date and animal	Body wt. (kg)	Daily GE intake/ kg $W^{0.75}$/day kcal	Fecal energy %GE
November			
Angel	323	409.4	35.7
Chester	325	360.3	34.3
Rodney	333	363.2	34.5
Chief	333	313.8	38.2
March			
Chester	336	171.0	32.7
Rodney	356	207.8	28.6
Chief	355	194.9	31.4
Lucy	360	188.9	29.2

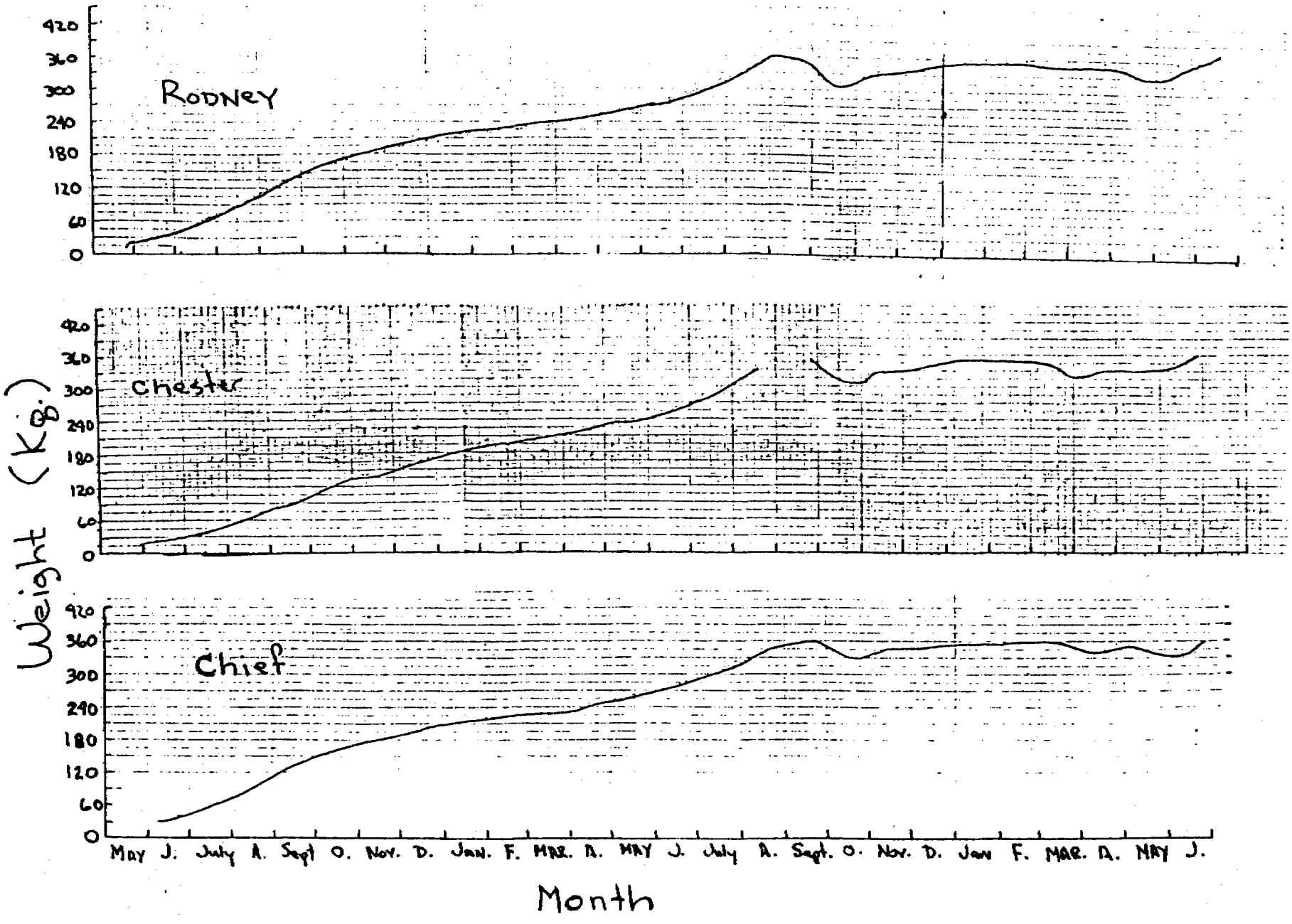

Fig. 1. Weight gain for 3 male moose May 1978 through June 1980.

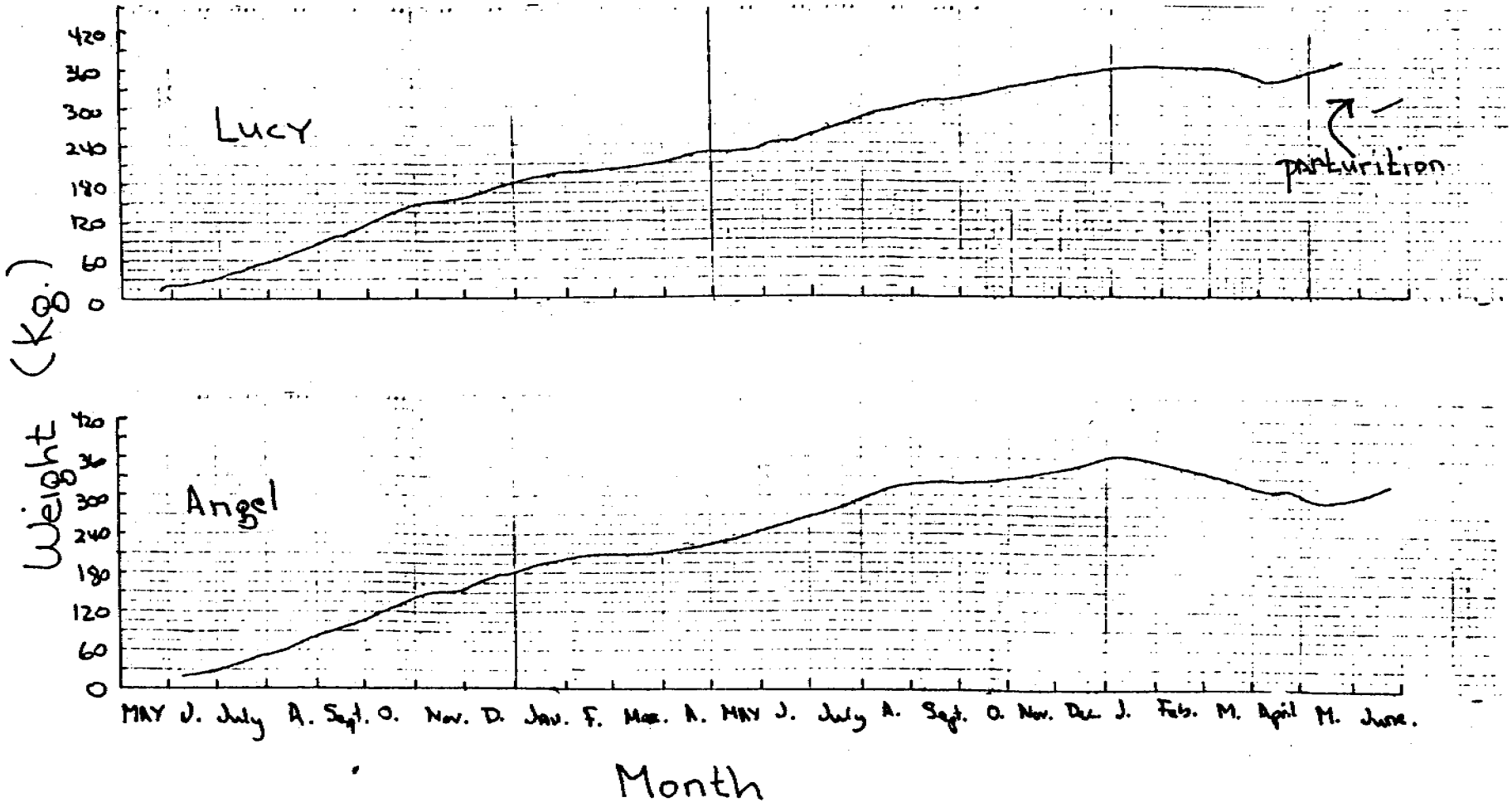

Fig. 2. Weight gain for 2 female moose May 1978 through June 1980.

feces was fairly consistent between the two seasons. This consistency reflects the similarity between apparent digestion of dry matter which was 64.3 percent ± S.D. 2.3 percent and 68.3 percent ± S.D. 2.4 percent in November and March, respectively. The slight difference in digestion coefficients between November and March was probably associated with differences between batches of MRC Special rather than animal differences. No chemical analyses were available to support this claim. Data on energy partitioning and fiber and protein digestion were not available for this report. However, digestibility appears adequate in light of weight gains and general health and vigor of the moose receiving the diet.

One of two yearling females receiving the MRC Special from time of weaning produced a calf this spring as a 2-year-old. Simkin (1974), in a review of reproduction and production of moose, inferred that yearling moose on a high plane of nutrition ovulate and breed more frequently than yearling moose on a low plane of nutrition. Reid et al. (1957) and Sorensen et al. (1959), working with domestic cattle, selected trios of female calves at an early age and placed them on either a high, medium or low nutritive diet for at least 80 weeks. Heifers on the high quality diet came into heat at 37.4 weeks, those on medium diet at 49.1 weeks and those on low diet at 71 weeks. Of further significance is the fact that this yearling female was successfully inseminated by a yearling bull; this has not been documented previously. Appendix B contains a manuscript documenting this event.

Although our preliminary research into formulating a moose ration suggests the MRC Special is useful for maintaining moose, its composition should not be considered final. Continuing research into nutritional requirements of moose, particularly calves and reproductive females, will doubtless indicate modifications which will improve the ration.

A manuscript was prepared and presented on the preliminary results of our studies of the MRC Special. An abstract of this paper is presented as Appendix C.

LITERATURE CITED

A.O.A.C. 1965. Official methods of analysis. 10th edition. Association of official Agricultural Chemists, Washington D.C. 957p.

Ballard, W. B., A. W. Franzmann, K. P. Taylor, T. Spraker, C. C. Schwartz and R. O. Peterson. 1979. Comparison of techniques utilized to determine moose calf mortality in Alaska. Proc. 15th N. Am. Moose Conf. and Workshop. Kenai-Soldotna, AK.

Church, D. C. 1969. Digestive Physiology and nutrition of ruminants. Vol. 1, Digestive physiology. Dept. Animal Sci., Oregon St. Univ. Corvallis. 316pp.

Ensminger, M. E., and C. G. Olentine. 1978. Feeds and nutrition complete. Ensminger Publishing Co. Calif. 1417pp.

Franzmann, A. W., R. E. LeResche, P. D. Arneson, and J. L. Davis. 1976. Moose productivity and physiology. Alaska Dept. Fish and Game Fed. Aid in Wildl. Rest. P-R Proj. Final Rep., w-17-2, W-17-3, W-17-4, W-17-5, W-17-6, and W-17-7. 87pp.

Franzmann, A. W., and C. C. Schwartz. 1978. Moose Research Center Report. Alaska Dept. Fish and Game. Fed. Aid in Wildl. Rest. P-R Proj. W-17-10. 11pp.

Franzmann, A. W., R. E. LeResche, R. A. Rausch, and J. L. Oldemeyer. 1978. Alaskan moose measurement and weights and measurement-weight relationships. Can. J. Zool. 56(2):298-306.

Franzmann, A. W. and C. C. Schwartz. 1979a. Moose Research Center Report. Alaska Dept. Fish and Game. Fed. Aid in Wildl. Rest. P-R Proj. W-17-11. 23pp.

Franzmann, A. W., and C. C. Schwartz. 1979b. Kenai Peninsula moose calf mortality study. Alaska Dept. Fish and Game. Fed. Aid in Wildl. Rest. P-R Final Rep. W-17-10 and 11. 18pp.

Franzmann, A. W., C. C. Schwartz, and R. O. Peterson. 1980. Causes of summer moose calf mortality on the Kenai Peninsula, Alaska. J. Wildl. Manage. 44:764-768.

Goering, H. K. and P. J. VanSoest. 1970. Forage fibre analyses. Agricultural Research Service. USDA Agric. Handbook No. 379.

Nagy, J. C., H. W. Steinfhoo, and G. M. Ward. 1964. Effects of essential oils of sagebrush on deer rumen microbial function. J. Wildl. Manage. 28:785-790.

Oh, H. K., T. Sakai, M. B. Jones, and W. M. Longhurst. 1967. Effects of various essential oils isolated from Douglas fir needles upon sheep and deer rumen microbial activity. Appl. Microbiol. 15:777-784.

Reid, J. T., J. K. Loosli, K. L. Turk, G. W. Trimberger, S. A. Asdell, and S. E. Smith. 1957. Effect of nutrition during early life upon the performance of dairy cows. Paper presented at 1957 Cornell Nutr. Conf. for Feed Manufactures, 65-71.

Schneider, B. H. and W. P. Flah. 1975. The evaluaton of feeds through digestibility experiments. Univ. Georgia Press, Athens. 423pp.

Schwartz, C. C., J. C. Nagy, and W. L. Regelin. 1980a. Juniper oil yield, terpenoid concentration, and antimicrobial effects on deer. J. Wildl. Manage. 44:107-113.

Schwartz, C. C., W. L. Regelin, and J. C. Nagy. 1980b. Deer preference for juniper forage and volatile oil treated foods. J. Wildl. Manage. 44:114-120.

Silver, H., N. F. Colovos, J. B. Holter, and H. H. Hates. 1969. Fasting metabolism of white-tailed deer. J. Wildl. Manage. 33:490-498.

Simkin, D. W. 1974. Reproduction and productivity of moose. Naturaliste Can. 101:517-526.

Sorensen, A. M., W. Hansel, W. H. Hough, D. T. Armstrong, K McEntee, and R. W. Bralton. 1959. Causes and prevention of reproductive failures in dairy cattle. 1. Influence of underfeeding and overfeeding on growth and development of Holstein heifers. Bull. 936. Cornell Univ. Agri. Expt. Stn., 51pp.

Van Soest, P. J. and R. H. Wine. 1967. Use of detergents in the analysis of fibrous feeds. IV. Determination of plant cell wall constituents. J. Assoc. Off. Anal. Chem. 50:50-55.

Van Soest, P. J. 1963. Use of detergents in the analysis of fibrous feeds. II. A rapid method for the determination of fiber and lignin. J. Assoc. Off. Agric. Chem. 46:829-835.

PREPARED BY:

Charles C. Schwartz
Game Biologist

APPROVED BY:

Donald J. Somerville
Director, Division of Game

SUBMITTED BY:

Karl B. Schneider
Regional Res. Coord.

Donald E. McKnight
Research Chief, Div. of Game

Appendix A. Proc. 16th N. Am. Moose Conf. and Workshop Prince Albert, Saskatchewa. (In Press).

NEONATAL ALASKAN MOOSE CALF PHYSIOLOGIC AND MORPHOMETRIC MEASUREMENTS AND VARIABILITY

Albert W. Franzmann, Kenai Moose Research Center, Alaska Department of Fish and Game, Soldotna 99669

Warren B. Ballard, Alaska Department of Fish and Game, Glennallen 99588

Charles C. Schwartz, Kenai Moose Research Center, Alaska Department of Fish and Game, Soldotna 99669

Ted H. Spraker, Alaska Department of Fish and Game, Soldotna 99669

Abstract: Blood chemistry and hematologic values and morphometric measurements were obtained from neonatal Alaskan moose (*Alces alces gigas*) calves (1-to-3 days old) during calf mortality studies on the Kenai Peninsula, the Nelchina Basin, and the Sustina Basin. Differences between the populations and between years were assessed in relation to relative condition and/or nutritive status of the calves and their mothers. Comparisons of measurements to other ungulate neonates were made. The physiologic and morphometric measurements provided base-line data for application and assessment of the relative wellbeing of a population. The implications of the low physiologic status of neonatal calves and post-parturient cows is discussed.

Blood chemical and hematological values have been published for all North American ungulates. Assessment and application of these data were lacking until adequate sampling of a species over time and under various conditions was accomplished. Blood studies of Alaskan moose (*Alces alces gigas*) were the first studies of ungulates to incorporate most classes and ages of moose to allow applying these values to assess condition of moose (Franzmann and LeResche 1978). Nevertheless, certain classifications of moose were lacking in these data, namely neonatal moose calves and post-parturient cows.

Weights and measurements of North American moose (*Alces alces*) have been reported (Blood et al 1967, Breckenridge 1946, Denniston 1956, Franzmann et al. 1978, Karns 1976, Kellum 1941, Murie 1934, Peek 1962, Peterson 1955, Timmermann 1972). However, lacking in these reports are substantial data for neonatal moose.

Moose calf mortality studies in Alaska (Ballard et al. 1980, Franzmann et al. 1980) were designed to collect physiologic and morphometric data from neonatal calves and their post-parturient mothers. This paper reports the results of these collections from different areas of Alaska from 1977 through 1979. Comparisons and assessment of differences were made primarily using the blood parameters which best reflected condition of moose (Franzmann and LeResche 1978).

METHODS

Moose calves were sampled from the Kenai Peninsula, Nelchina Basin, and Susitna Basin during late May and early June in 1977, 1978, and 1979. The Kenai Peninsula studies were conducted from the Kenai Moose Research Center (MRC) which is on the Kenai National Moose Range in the northwestern Kenai Peninsula lowlands. A detailed description of the study area was presented by Oldemeyer et al. (1977). The Nelchina and Susitna Basin studies were conducted from Glennallen and detailed description of the study areas appears in Ballard and Taylor (1978).

Calf capturing methods were described by Ballard et al. (1979). Blood collecting and analysis were done as outlined by Franzmann and LeResche (1978) and measurements were obtained as defined by Franzmann et al. (1978).

The data were sorted by location and year and means and standard deviations calculated. Comparison and evaluation of data were by *t*-test program with paired samples. All differences referred to hereafter were at $P<0.01$ unless otherwise indicated. The 1977 Kenai Peninsual sample was again sorted by separating the June from May sampled calves. The June calves were approximately 1 week old at capture. All other calves were from 1-to-3 days old. The parameters selected for primary sorting were those outlined by Franzmann and LeResche (1978) as most useful for condition evaluation.

The parameters were; packed cell volume (PCV), hemoglobin (Hb), calcium (Ca), phosphorus (P), glucose, total protein (TP), albumin, and beta globulin. The remaining blood parameters were combined and presented as base-line data and include; cholesterol, triglyceride, lactic dehydrogenase (LDH), glutamic oxalacetic transaminase (GOT), alkaline phosphotase, sodium (Na^+), potassium (K^+), chloride (Cl^-), carbon dioxide (CO_2), iron, blood urea nitrogen (BUN), creatanine, bilirubin, uric acid, globulin, alpha 1 globulin, alpha 2 globulin, and gamma globulin. The calf measurement data were sorted by year and population.

Limited data were collected from post-parturient cows due to restrictions imposed by the primary objective of the calf mortality studies (Ballard et al. 1980, Franzmann et al. 1980). Nevertheless, during the 2 years of the Kenai Peninsula study, blood samples were obtained from 24 post-parturient cows, but none were obtained from the Nelchina and Susitna studies.

RESULTS

Table 1 lists the combined data means, standard deviations and sample sizes of all blood and measurement parameters obtained from neonatal calves and are presented as base-line data for neonatal Alaskan moose calves. The calf blood data were sorted by location and year (also month for Kenai 1977) for condition related blood parameters (PCV, HB, Ca, P, glucose, TP, albumin, and beta globulin--

Franzmann and LeResche 1978) and are presented in Table 2 with mean condition related blood parameters from post-parturient Kenai cows and late winter adult moose (Franzmann and LeResche 1978).

Some differences ($P<0.01$) were detected between calf populations for condition related parameters. The Nelchina 1977 calves mean PCV (35.4%) was higher than all other calf populations except Susitna 1977 (34.0%) and Kenai 1977 June (32.8%). No other differences were detected. Hemoglobin differences were limited to the Kenai 1977 May mean (10.6 g/dL) being lower than the Nelchina 1978 (11.7 g/dL), and Susitna 1977 (12.4 g/dL) means. No differences were detected among Ca levels, but P differences were detected with the Nelchina 1977 P mean (7.1 gm/dL) less than the Susitna 1978 (9.7 gm/dL), Sustina 1979 (9.8 gm/dL) and Kenai 1977 May (8.6 gm/dL) means. The Nelchina 1978 P level (7.9 gm/dL) was also significantly lower than the Susitna 1979 mean (9.8 gm/dL). Glucose differences were characterized by Susitna 1978 mean (78 mg/dL) being lower than all but the Nelchina 1978 mean (128 mg/dL) and Kenai 1977 June mean (207 mg/dL) being higher than all but the Kenai 1978 (154 mg/dL), Susitna 1977 (161 mg/dL) and Kenai 1977 May (154 mg/dL). The only differences among TP means were that the Nelchina 1978 mean (5.01 g/dL) was significantly lower than the Kenai 1978 (5.78 g/dL) and Nelchina 1977 (5.58 g/dL) means. Albumin differences were characterized by Nelchina 1977 (2.32 g/dL) and the Nelchina 1978 (2.24 g/dL) means being lower than most Susitna and Kenai populations except the Kenai 1977 May (2.62 g/dL) and Susitna 1977 (2.40 g/dL) populations.

The beta-globulins showed sporadic differences among populations, but there was no pattern. The Kenai 1977 June beta globulin mean (1.17 g/dL) was highest and the Kenai 1978 mean (0.61 g/dL) was lowest.

Of particular interest were the differences noted between the neonatal calves and post-parturient cows (Table 2). Since the post-parturient cows were all from the Kenai Peninsula, we combined the Kenai neonatal calf samples (Kenai 1977 May, Kenai 1977 June, and Kenai 1978) and compared all both condition related and other blood parameters between the cows and their calves (Table 3). Neonatal calves blood chemistry levels were significantly higher than the cows for cholesterol, LDH, alkaline phosphotase, P, Ca, BUN, bilirubin, globulin, alpha 1 globulin, and beta globulin. Post-parturient cows had higher CO_2, creatanine, TP, albumin, hemoglobin and PCV valves than their calves.

Comparing the condition related parameters of post-parturient cows with adult moose sampled during late winter (Table 2), we detected significant differences. Late winter adult moose had significantly higher blood levels of PCV, Hb, and T.P. and lower levels of glucose than post-parturient cows.

Barrett and Chalmers (1979) analyzed blood from neonatal pronghorns (*Antilocapra americana*) and we listed the values with neonatal

moose calves (Table 4). Glucose, Hb, and PCV data were available from white-tailed deer (*Odocoileus virginianus*) (Johnson et al. 1978) and black-tailed deer (*Odocoileus hemionus columbianus*) (Bandy et al. 1957, Cowan and Bandy 1969) and were included in Table 4.

Differences in weights and measurements between neonatal moose calf sampled were detected only in comparisons between the Kenai 1977 June population and others. This population (n=6) was 1 week old, and all others were generally 1-to-3 days old. The mean weights and measurements listed in Table 1 exclude the weights and measurements from the Kenai 1977 June group and thereby represent calves 1-to-3 days old.

DISCUSSION

Difference in blood parameters between neonatal moose calf populations lacked a pattern that could be used to quantify relative condition of the populations based on criteria established for adult moose (Franzmann and LeResche 1978). Blood values from the calves generally indicates a uniformity among the populations, particularly when the Kenai 1977 June population which was older is excluded. The differences detected may be a function of differences in excitability and stress associated with collecting the calves (Franzmann and LeResche 1978, Franzmann et al. 1975). We had no valid assessment for the stress influence. The blood parameters obtained from the calves

when combined (Table 1) represent base-line data from a diverse cross section of neonatal Alaskan moose calves and may be used to compare against future sampling. As more samples become available refinement of condition assessment may be accomplished.

The differences between Kenai Peninsula post-parturient cows and their calves (Table 3) do reflect a pattern. The calves blood chemistry levels were significantly higher or the same as the cows for all parameters except PCV, HB, TP, albumin, CO_2 and creatanine. Both hematologic values (PCV and Hb) were higher in cows and this reflects their more developed hemopoietic system. Barrett and Chalmers (1979) when compairing neonate and adult pronghorns reported that Ca, P cholesteral, and alkaline phosphotase, were significantly higher in neonates than adults. This pattern was the same for moose (Table 3). Pronghorn adults had significantly higher PCV, Hb, TP, and albumin levels than neonates, which was the pattern for moose in this study (Table 3). The only differences in comparisons of pronghorn and moose neonates and adults noted was that pronghorn fawns had higher magnesium, sodium and glucose values than adults, and in moose there were no differences between sodium and glucose in neonates and adults. Magnesium values were not determined for moose and CO_2 and creatanine were not determined for pronghorn.

The adult moose sampled in this study had all given birth to calves within 1-to-3 days prior to sampling. The cows were in poor condition as graded at capture (Franzmann et al. 1976). Ten cows graded 6, 7

cows graded 5, 3 cows graded 4, and 4 cows were not graded. The physiological stress of pregnancy, calving, and lactation were shown in physical condition. The blood values of post-parturient cows reflected the poor condition when compared to adult moose samples reported by Franzmann and LeResche (1978) collected in late winter and early spring (February to May). Blood levels of PCV, Hb, and TP (all condition related parameters) were significantly higher in adult moose than post-parturient cows. Glucose was higher in post-parturient cows which likely reflected the stress of capture (Franzmann and LeResche 1978, Franzmann et al. 1975). Packed cell volume, Hb, and TP were determined to not be unfluenced by excitability (Franzmann and LeResche 1978). Franzmann and LeResche (1978) listed condition related blood levels that represented adult moose in average or better condition and the post-parturient moose were lower for all (PCV, Hb, P, TP, and albumin) except Ca and glucose. Calcium appears to be least influenced of the parameters, and glucose has limited value due to its response to excitability and stress. In this study, sampling the post-parturient cows created greater than usual excitement and stress (Franzmann et al. 1980). The post-parturient cows condition related parameters were lower than or equal to the MRC (Feb., Mar., Apr.) samples (Franzmann and LeResche 1978) which were the lowest levels for a population in the report.

It is apparent that the Kenai Peninsula post-parturient cows are at a definate physiological low. There were no other moose data from

post-parturient cows to use for comparison, and the values determined may be normal for moose that have experienced the stress of pregnancy, parturition, and lactation at a critical time of year. What is of equal concern and interest is the low status of some critical neonatal blood values in relation to the already depressed post-parturient cows (PCV, Hb, TP, and albumin). The pattern of low blood values in neonates was also detected in pronghorn fawns (Barrett and Chalmers 1979) and in general closely resembles moose neonates (Table 4). Moose neonates have lower PCV, Hb, Ca, and P levels, but higher protein fractions except gamma globulin. Alkaline phosphotase moose mean (622.2 U/L) was extremely higher than for pronghorns (296.4 U/L). Alkaline phosphatase levels are associated with active skeletal development (Coles 1974), and perhaps the larger skeletal structure of the moose calf results in higher levels. Values from other neonate ungulates are limited, but glucose, Hb, and PCV values from white-tailed deer and black-tailed deer (Table 4) are also relatively low and generally similar to pronghorns and moose.

Managers should be aware of the low physiologic state of neonatal moose calves and post-parturient cows as reflected by blood parameters. This period in the life history of moose is most critical and disturbance of the cow and calf should be avoided. Traditional calving areas were likely selected because they provided the quality and quantity of nutrients and protection needed through the parturition period. Protection of these areas should retain a high priority in the managers program.

ACKNOWLEDGEMENTS

We are grateful for the assistance provided by L. Aumiller, T. Balland, S. Eide, Kenai Air Service, L. Mech, L. Metz, R. Peterson, K. Taylor, and J. Wollington. D. McKnight and K. Schneider read the manuscript and provided helpful suggestions. This work was supported, in part, by Federal Aid in Widllfie Restoration Project W-17-R, by the U.S. Fish and Wildlife Service, and by the Alaska Department of Fish and Game.

LITERATURE CITED

Ballard, W. B., and K. P. Taylor. 1978. Moose calf mortality study, Game Management Unit 13. Alaska Dept. Fish and Game P-R Proj. Prog. Rep., W-17-9, W-17-10. 43pp.

Ballard, W. B., T. H. Spraker, and K. P. Taylor. 1980. Causes of neonatal moose calf mortality in southcentral Alaska J. Wildl. Manage. (in review).

Ballard, W. B., A. W. Franzmann, K. P. Taylor, T. H. Spraker, C. C. Schwartz, and R. O. Peterson. 1979. Comparison of techniques utilized for determining moose calf mortality in Alaska. Proc. 15th N. Am. Moose Conf. and Workshop. Soldotna-Kenai, AK.

Bandy, P. J., W. D. Kitts, A. J. Wood, and I. McT. Cowan. 1957. The effect of age and the plane of nutrition on the blood chemistry of Columbian black-tailed deer (*Odocoileus hemionus columbianus*). Blood glucose, non-protein nitrogen, total plasma protein, plasma albumin, globulin, and fibrinogen. Can. J. Zool. 35:283-289.

Barrett, M. W., and G. A. Chalmers. 1979. Hematological and clinochemical values for free-ranging pronghorn fawns. Can. J. Zool. 57:1757-1766.

Blood, D. A., J. R. McGillis, and A. Lovaas. 1967. Weights and measurements of moose in Elk Island National Park, Alberta. Can. Field-Nat. 81:263-269.

Breckenridge, W. J. 1946. Weights of Minnesota moose. J. Mammal. 27:90-91.

Coles, E. H. 1974. Veterinary clinical pathology. 2nd ed. W. B. Saunders Co., Philadelphia 455pp.

Cowan, I. McT., and P. J. Bandy. 1969. Observations on the haematology of several races of black-tailed deer (*Odocoileus hemionus*). Can. J. Zool. 47:1021-1024.

Denniston, R. H. 1956. Ecology, behavior, and population dynamics of the Wyoming or Rocky Mountain moose, *Alces alces shirasi*. Zoologica 41:105-118.

Franzmann, A. W., and R. E. LeResche. 1978. Alaskan moose blood studies with emphasis on condition evaluation. J. Wildl. Manage. 42:334-351.

Franzmann, A. W., A. Flynn, and P. D. Arneson. 1975. Serum corticoid levels relative to handling stress in Alaskan moose. Can. J. Zool. 53:1424-1426.

Franzmann, A. W., C. C. Schwartz, and R. O. Peterson. 1980. Causes of summer moose calf mortality on the Kenai Peninsula, Alaska. J. Wildl. Manage. 44(3) (in press).

Franzmann, A. W., R. E. LeResche, P. D. Arneson, and J. L. Davis. 1976. Moose productivity and physiology. Alaska Dept. Fish and Game, P-R Proj. Final Rep. 87pp.

Franzmann, A. W., R. E. LeResche, R. A. Rausch, and J. L. Oldemeyer. 1978. Alaskan moose measurements and weights and measurement-weight relationships. Can. J. Zool. 56:298-306.

Johnson, H. E., W. G. Youatt, L. D. Fay, H. D. Harte, and D. E. Ullrey. 1968. Hematological values of Michigan white-tailed deer. J. Mammal. 49:749-754.

Karns, P. D. 1976. Relationships of age and body measurements to moose weight in Minnesota. Proc. 12th N. Am. Moose Conf. and Workshop. 12:274-284.

Kellum, F. 1941. Cusino's captive moose. Mich. Cons. 10:4-5.

Murie, A. 1934. The moose of Isle Royale. Misc. Pub. No. 25, Mus. Zool. Univ. Mich. p. 1-44.

Oldemeyer, J. L., A. W. Franzmann, A. L. Brundage, P. D. Arneson, A. Flynn. 1977. Browse quality and the Kenai moose population. J. Wildl. Manage. 41:533-542.

Peek, J. M. 1962. Studies of moose in the Gravelly and Snowcrest Mountains, Montana. J. Wildl. Manage. 26:360-365.

Peterson, R. L. 1955. North American moose. Univ. Toronto Press, Toronto. 280pp.

Timmermann, H. R. 1972. Some observations of the moose hunt in the Black Sturgeon area of northwestern Ontario. Proc. 8th N. Am. Moose Conf. and Workshop. 8:223-239.

Table 1. Neonatal Alaskan moose calf unsorted blood values and measurements from 1977, 1978, and 1979 on the Kenai Peninsula, Nelchina Basin and Susitna Basin.

Parameters measured	Unit	Sample size	Mean	Standard deviation
Glucose	mg/dL	97	141.7	41.2
Cholesterol	mg/dL	97	96.9	20.8
Triglyceride	mg/dL	84	132.8	102.8
LDH	U/L	96	604.0	172.6
SGOT	U/L	97	90.1	87.0
SGPT	U/L	86	82.6	98.0
Alkaline phosphotase	U/L	97	622.2	201.0
Phosphorus	mg/dL	97	8.5	1.9
Calcium	mg/dL	97	11.6	0.9
Ca/P	ratio	97	1.4	
Sodium	mEg/L	86	136.1	5.5
Potassium	mEg/L	86	5.8	1.0
Chloride	mEg/L	86	92.3	4.7
Carbondioxide	mEg/L	85	14.4	4.9
BUN	mg/dL	97	15.4	5.9
Creatanine	mg/dL	87	1.1	0.4
Bilirubin	mg/dL	95	0.5	0.3
Uric acid	mg/dL	93	0.5	0.3
Total protein	g/dL	97	5.28	0.62
Albumin	g/dL	97	2.54	0.40
Globulin	g/dL	97	2.74	0.32
Alpha 1 globulin	g/dL	97	0.47	0.16
Alpha 2 globulin	g/dL	97	0.46	0.18
Beta globulin	g/dL	97	0.91	0.43
Gamma globulin	g/dL	97	0.90	0.52
A/G	ratio	97	0.93	
Iron	mg/dL	47	199.8	158.0
Menoglobin	g/dL	104	11.4	1.6
Packed cell volume	%	103	30.7	4.6
Total Body Length	Cm	102	99.2	8.3
Hind Foot Length	Cm	106	45.0	2.2
Chest Girth	Cm	106	61.2	5.8
Neck Circumference	Cm	103	29.7	3.0
Weight	kg	109	18.0	4.5

Table 2. Condition related blood parameters from Alaskan neonatal moose calves, post-parturient Kenai cows, and adult moose sampled in late winter (Feb.-May).

Population and year	Blood parameters																							
	PCV			Hb			Ca			P			Glucose			TP			Albumin			Beta Globulin		
	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N
Nelchina 1977	35.4	4.5	14	11.6	1.3	14	12.4	0.6	13	7.1	1.6	13	136	40	13	5.58	0.6	13	2.32	0.27	13	1.12	0.35	13
Nelchina 1978	30.0	3.0	25	11.7	1.2	24	11.1	0.5	19	7.9	1.6	19	128	35	19	5.01	0.51	19	2.24	0.39	19	0.69	0.18	19
Susitna 1977	34.0	4.9	8	12.4	1.6	8	12.0	0.8	8	7.3	2.8	8	161	30	8	5.47	0.82	9	2.40	0.36	9	1.2	1.0	9
Susitna 1978	30.1	2.9	8	10.3	1.4	8	11.6	0.7	7	9.7	0.7	7	78	39	7	5.11	0.43	7	2.71	0.24	7	0.75	0.17	7
Susitna 1979	28.2	5.8	13	11.9	2.5	14	11.5	1.0	14	9.8	1.9	14	144	31	14	5.23	0.61	14	2.78	0.39	14	0.69	0.15	14
Kenai 1977 May	29.2	4.2	19	10.6	1.2	19	11.7	0.8	21	8.6	1.4	21	154	42	21	5.17	0.55	21	2.62	0.53	21	0.89	0.29	21
Kenai 1977 June	32.8	3.3	6	11.5	0.8	6	11.4	2.0	6	10.2	3.0	6	207	43	6	5.15	0.87	6	2.91	0.53	6	1.17	0.21	6
Kenai 1978	29.8	4.1	10	10.5	1.7	10	11.6	0.4	10	8.7	1.5	10	154	30	10	5.78	0.74	10	2.76	0.28	10	0.61	0.21	10
Post-parturient 1977-78 cows (Kenai)	38.3	5.6	23	14.2	2.3	23	10.6	0.9	24	4.2	1.5	24	141	31	24	6.60	0.81	23	4.25	0.63	23	0.63	0.16	23
Adult moose 1977-78[a] late winter	45.6	5.7	184	18.2	1.8	187	10.4	0.8	273	4.5	1.2	273	120	29	273	7.01	0.61	277	4.12	0.68	277	0.69	0.27	277

a From Franzmann and LeResche (1978).

Table 3. Physiologic and morphometric measurements from neonatal moose calves and post-parturient cows, sampled during springs of 1977 and 1978 on the Kenai Peninsula, Alaska.

Parameter measured	Unit	Neonatal calves			Post-parturient cows		
		N	$\bar{x}$	SD	N	$\bar{x}$	SD
Glucose	mg/dL	36	163.4	42.3	24	140.6	31.3
Cholesterol	mg/dL	36	101.1*	13.7	24	74.5	16.4
Triglycerides	mg/dL	23	108.6	86.9	--	--	--
LDH	U/L	36	544.1*	143.2	24	319.0	93.3
SGOT	U/L	36	71.8	22.5	24	75.3	29.2
SGPT	U/L	26	45.0	32.9	14	38.7	11.2
Alkaline phosphotase	U/L	36	479.9*	133.8	24	112.0	137.0
Phosphorous	mg/dL	36	8.9*	1.8	24	4.2	1.5
Calcium	mg/dL	36	11.5*	0.9	24	10.6	0.9
Ca/P	ratio	36	1.3		24	2.5	
Sodium	mEq/L	26	135.6	8.4	15	133.5	3.4
Potassium	mEq/L	26	5.3	0.7	15	5.0	0.6
Chloride	mEq/L	25	92.2	6.6	14	95.2	6.4
Carbon dioxide	mEq/L	26	10.3*	4.7	14	18.8	4.3
BUN	mg/dL	36	16.5*	5.2	24	10.3	6.8
Creataine	mg/dL	26	1.03*	0.41	15	1.93	0.46
Bilirubin	mg/dL	36	0.47*	0.29	24	0.26	0.17
Uric acid	mg/dL	34	0.32	0.18	23	0.42	0.22
Total protein	g/dL	36	5.38*	0.67	23	6.60	0.81
Albumin	g/dL	36	2.67*	0.54	23	4.25	0.63
Globulin	g/dL	36	2.71*	0.33	23	2.35	0.60
Alpha 1 globulin	g/dL	36	0.48*	0.17	23	0.27	0.15
Alpha 2 globulin	g/dL	36	0.34	0.16	23	0.45	0.20
Beta globulin	g/dL	36	1.10*	0.26	23	0.63	0.16

Continued

Table 3 (cont.)

Parameter measured	Unit	Neonatal calves N	$\bar{x}$	SD	Post-parturient cows N	$\bar{x}$	SD
Gamma globulin	g/dL	36	0.79	0.40	23	1.03	0.35
A/G	ratio	36	0.99		23	1.81	
Iron	mg/dL	26	233.8*	212.4	14	131.5	67.3
Hemoglobin	g/dL	35	10.7*	1.3	23	14.2	2.3
Packed cell volume	%	35	29.9*	4.2	23	38.3	5.6
MCHC	%	35	35.8	4.0	23	37.1	3.9

* Significantly ($P<0.01$) different than mean for post-parturient cows.

Table 4. Comparisons of blood parameter means of neonatal moose, pronghorns, white-tailed deer, and black-tailed deer.

Parameter measured	Unit	Moose[a]	Pronghorn[b]	White-tailed deer[c]	Black-tailed deer
Glucose	mg/dL	141.7(97)	203.5(60)	119.7(5)	90.2(7)[d]
Cholesterol	mg/dL	96.9(97)	67.4(89)		
SGOT	U/dL	90.1(97)	106.5(92)		
Alkaline phosphotase	U/dL	622.2(97)	296.4(74)		
Phosphorus	mg/dL	8.5(97)	10.0(83)		
Calcium	mg/dL	11.6(97)	12.4(85)		
Ca/P	ratio	1.40	1.24		
Sodium	mEq/L	136.1(86)	145.2(85)		
Potassium	mEq/L	5.8(86)	6.2(85)		
BUN	mg/dL	15.4(97)	21.3(63)		
Creatanine	mg/dL	1.1(87)	2.4(11)		
Total protein	g/dL	5.28(97)	4.78(46)		
Albumin	g/dL	2.54(97)	2.36(46)		
Globulin	g/dL	2.74(97)	2.42(46)		
Alpha globulin	g/dL	0.93(97)	0.59(46)		
Beta globulin	g/dL	0.91(97)	0.70(46)		
Gamma globulin	g/dL	0.90(97)	1.13(46)		
A/G	ratio	0.93(97)	1.01(46)		
Hemoglobin	g/dL	11.4(104)	14.6(116)	8.4(5)	10.3(26)[e]
Packed cell volume	%	30.7(103)	39.7(110)	30.9(5)	33.8(26)[e]

a This study
b Barrett and Chalmers (1979)
c Johnson et al. (1978)
d Bandy et al. (1957)
e Cowan and Bandy (1969)

Appendix B. MALE MOOSE SUCCESSFULLY BRED AS YEARLINGS.

An important parameter in population dynamics of ungulate species is a measure of the reproductive rates and production; age at first breeding is one of these variables. Numerous studies document the successful breeding and calf production of yearling female moose (Alces alces). Estimates of ovulation in yearling females range from 0 in Montana (Simkin 1965) to a high of 82 percent in Finland (Rajakoski and Koivisto (1966). Wildhagen (1962, cited in Markgren, 1969) in Norway, Huston (1968) in Montana and Markgren (1969) in Sweden documented spermatogensis in the testicles of male yearling moose. Because field observations of breeding in yearling moose are difficult to obtain, and successful insemination almost impossible to prove, the literature contains no reference to a yearling male moose successfully inseminating a female with subsequent calf production. This paper describes such a happening.

Methods and Materials

Because of experiments into the nutritional requirements of moose at the Moose Research Center (MRC) Kenai Peninsula, Alaska it was necessary to maintain a herd of tame moose. Five moose calves born in spring, 1978 were

hand-raised as outlined by Regelin et al. (1979). The five moose were kept in a 7 ha enclosure and fed a pelleted ration (Schwartz et al. 1980) ad libitum.

Results and Discussion

During the normal breeding season in 1979 (late September-early October) the three yearling males displayed expected behavioral attributes associated with breeding (Altmann 1959, Lent 1974). A dominance hierarch was formed between individuals and considerable agonistic behavior was observed. Actual breeding was not observed.

Sometime between 28 May and 1 June 1980, one of the two yearling females gave birth to a healthy male calf. This female was bred by at least one of the three yearling males since no other adult bulls were present.

The birth of this calf documents the fact that yearling males are capable of breeding females in the absence of more dominant older bulls. Moose in this study receiving the pelleted ration were on a high nutritional plane. Pimlott (1959) explained a great variation in breeding of yearling female moose in Newfoundland based on differences in range quality (67% and 29% of yearlings on good and poor range, ovulated, respectively). Although our work demonstrates that yearling bull moose are capable of breeding under

controlled conditions additional information is needed to determine the extent of such breeding in wild populations.

ACKNOWLEDGEMENTS

We are grateful to M. Schwartz, D. Johnson, and D. C. Johnson for care and maintenance of the tame moose. This work was supported in part by Federal Aid in Wildlife Restoration, Project W-17-11.

LITERATURE CITED

Altmann, M. 1959. Group dynamics of Wyoming moose during the rutting season. J. Mamm. 40:420-424.

Houston, D. O. 1968. The Shiras moose in Jackson Hole, Wyoming. Tech. Bull. Nat. Parks Serv., U.S. Dept. Interior, No. 1, 110pp.

Lent,P. C. 1974. A review of rutting behavior in moose. Naturaliste Can., 101:307-323.

Markgren, G. 1969. Reproduction of moose in Sweden. Viltrevy, 6:127-299.

Pimlott, D. H. 1959. Reproduction and productivity of Newfoundland moose. J. Wildl. Manage. 24:381-401.

Rajakoski, E., and D. Koivisto. 1966. Puberty of the female moose (Alces alces) in Finland. Suom. Riista, 18:157-162.

Regelin, W. L., C. C. Schwartz, and A. W. Franzmann. 1979.

Schwartz, C. C., W. L. Regelin, and A. W. Franzmann. 1980. A formulated ration for captive moose. Proc. N. Am. Moose Conf. Workshop, 16:(in press).

Simkin, D. W. 1974. Reproduction and productivity of moose. Naturaliste Can., 101:517-526.

Charles C. Schwartz,

Kenai Moose Research Center, Alaska Department of Fish and Game,Soldotna, AK 99669; Wayne L. Regelin, U.S. Fish and Wildlife Service, Denver Wildlife Research Center, Kenai, AK 99611; Albert W. Franzmann,Kenai Moose Research Center, Alaska Department of Fish and Game, Soldotna, AK 99669.

Appendix C. Proc. 16th N. Am. Moose Conf. and Workshop Prince Albert, Saskatchewa. (In Press).

A FORMULATED RATION FOR CAPTIVE MOOSE

Charles C. Schwartz, Kenai Moose Research Center, Alaska Department of Fish and Game, Soldotna, Alaska 99669

Wayne L. Regelin, U. S. Fish and Wildlife Service, Denver Wildlife Research Center, Kenai, Alaska 99611

Albert W. Franzmann, Kenai Moose Research Center, Alaska Department of Fish and Game, Soldotna, Alaska 99669

Abstract: A formulated ration suitable for animal maintenance or experimental purposes has been developed for moose (*Alces alces*). It contains 11.8 percent crude protein and has an apparent dry matter digestibility of 64 percent. Performance was measured over 1.5 years with data from six moose. Daily gain from weaning to 1 year of age was 0.62 ± S.D. 0.4 kg. Possible diet problems and improvements are presented. Aspen (*Populus tremuloides*) sawdust the primary constituent, is believed to be the major reason for the diet's success. A discussion based on extensive literature review is presented concerning fiber types, and their effects on animal welfare.

1/ Research funded in part by Federal Aid in Wildlife Restoration, Projects W-17 and W-21.