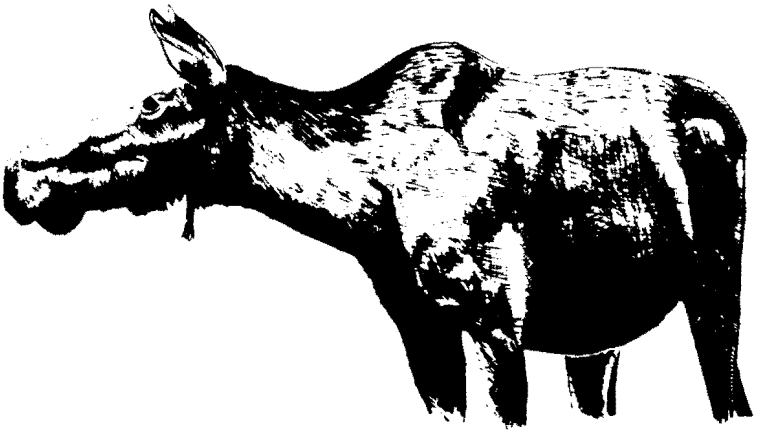
Alaska Department of Fish and Game
Division of Wildlife Conservation
Federal Aid in Wildlife Restoration
Research Progress Report

EVALUATION AND TESTING OF TECHNIQUES FOR MOOSE MANAGEMENT



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Project W-23-2
Study 1.39
December 1989

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PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperator: None

Project No.: W-23-1 Project Title: Wildlife Research and Management

Study. No.: 1.39R Job Title: Evaluation and testing of techniques for moose management

Period Covered: 1 July 1988-30 June 1989

SUMMARY

Several jobs were active during this reporting period. A summary of habitat modifications within the Moose Research Center (MRC) enclosures is presented. The newly synthesized tranquilizer drug R51163 (purine alkyl piperidine, Janssen Pharmaceutic Research Lab, Beerse, Belgium) was determined to cause reduced feed intake for up to 2 weeks following administration in 5 bull moose. In some moose this drug caused metabolic rates to cycle dramatically; however, no difference in median metabolic rates were discerned between treatment and control trials. Telazol (tiletamine hydrochloride and zolazepam hydrochloride, A. H. Robins, Richmond, VA), an effective immobilizing drug for carnivores, was administered to one male calf and was determined to be an ineffective immobilizing agent in this instance. A body composition estimation technique involving urea dilution in blood serum was tested with 4 moose. Infused urea equilibrated with body water within 12.5-15.0 minutes and preliminary results indicate this technique has potential as an in vivo estimator of body composition of moose. Seven cow moose were bred on either their 1st (n = 3) or 2nd (n = 4) estrus. Mean length of gestation (n = 5) was 230.8 $\pm$ 4.6 (SD) days. Calves born in 1988 to cows bred on their 1st or 2nd estrus exhibited identical mean growth rates over the summer (1.24 kg/d), indicating that calves born later in the summer did not exhibit compensatory growth and entered the winter at a lower body weight. Onset of estrus in 3 adult cows corresponded with the nadir point of the concentration of pregnanediol-3-glucuronide (PdG), a progesterone metabolite, in urine. Preliminary data concerning the use of PdG for indication of pregnancy were inconclusive. High-voltage electric fencing was found to be an effective barrier to rutting bull moose; however, the fence design we tested was prone to damage by moose and required a high degree of maintenance. Although peak levels of testosterone in blood serum of 2 bulls coincided with the rut, they were lower than expected.

Key Words: Alces alces, androstenones, body composition, breeding, chemical immobilization, electric fencing, estrous cycle, gestation length, moose, snow-urine, urine.

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BACKGROUND

Because the Moose Research Center (MRC) has known numbers of confined animals and facilities to handle them, it provides unique conditions for developing and testing techniques applicable to moose management. This study has been continuously active since 1969, when the MRC became functional. Three Federal Aid final reports covering the period from 1968 through 30 June 1986 have been published (Franzmann et al. 1974, Franzmann and Schwartz 1982, Franzmann et al. 1987), in addition to more than 30 journal publications (see Schwartz 1987). These publications covered evaluation and testing of drugs; trapping methods; aerial and pellet-count censuses; telemetry; biotelemetry; rumen sampling; marking and collaring; weighing; fertilization of browse; electronic tissue measuring; raising moose calves; and developing a moose ration, feeding trial and digestion crates, a respiratory chamber, radioisotope digestion markers, and a carrying-capacity model. Active jobs include maintenance and

operations (Job 1), drug testing (Job 2), total body fat estimation (Job 4), reproduction studies (Job 5), and miscellaneous techniques (Job 7).

The MRC is located within an area burned by wildfire in 1947. At the time the MRC was constructed (1969), this area was characterized by extremely productive regrowth stands of paper birch (Betula paperifera) and quaking aspen (Populus tremuloides) interspersed with mature stands not affected by fire. Mature and regrowth stands of white spruce (Picea glauca) also were common. Productivity of the habitat has declined since 1969 because of maturation of seral stands and heavy browsing by captive moose. In order to maintain adequate numbers of captive moose within the MRC enclosures a habitat modification program was initiated.

Certain aspects of moose management and research require the use of tranquilizing, immobilizing, antagonist, and adjunct drugs. Testing the efficacy of newly available drugs is an ongoing project at the MRC, wherein effects of drugs can be monitored under controlled conditions.

Body condition is a critical variable within the moose carrying-capacity model (Hubbert 1987, Schwartz et al. 1988a, 1988b), and body fat is a major driver of the moose submodel. This critical parameter (i.e., total body fat) must be accurately measured in moose. A proposal was prepared to test methods for estimating body composition of moose (Schwartz et al. 1988c), focusing primarily on measurements of urea space (Preston and Kock 1973) as an in vivo technique and composition of the peroneus muscle group (M. peroneus tertius, M. extensor digitorum longus, and M. extensor digiti III proprius; Huot and Goodreault 1985) as a technique for use on dead animals.

The need to obtain information for better assessment of "optimum" bull:cow ratios in Alaska moose populations hinges on a thorough understanding of the estrous cycle (i.e., number of days between each estrus). This entails the length of estrus, the receptive period during estrus (i.e., the period of sexual receptivity), the time periods between estruses, and the number of estrous periods during the breeding season. Although, Markgren (1969) identified the time between estruses at 25-30 days, the other needed data have been speculative. At the MRC we conducted late-breeding experiments and were able to demonstrate that gestation lengths for late bred cows were not different from those of early bred cows (Schwartz 1987). The consequences of altered or nonoptimum breeding during the rut has been attributed to low bull:cow ratios, but with no clear supporting evidence. Nevertheless, the issue remains; systematic research is needed to resolve the matter. Past research at the MRC has documented the length of estrus in moose (Schwartz 1987). During the previous reporting period (1987-88), we looked at the effects of 1st and 2nd estrous breeding on growth and development of calves and measured gestation length (Schwartz et al. 1988c).

Our reproduction studies would benefit from techniques that would indicate the onset of estrus and whether or not a female was pregnant; such techniques would also have management applications. Brundige et al. (1988) were able to detect pregnancy in bighorn sheep (Ovis canadensis) from serum progesterone levels. Although blood is difficult to collect from free-ranging animals, it may be possible to detect onset of estrus and pregnancy from progesterone metabolites in urine and feces. We are cooperating with Steve Monfort (National Zoological Park, Smithsonian Institution, Front Royal, Virginia) to determine if moose urine and feces can be assayed for progesterone and estrogen metabolites. Monfort (unpubl. data) determined that the urinary concentration of the progesterone metabolite pregnanediol-3-glucuronide (PdG) undergoes cyclic fluctuations corresponding to the estrous cycle and remains elevated during pregnancy in Eld's deer (Cervus eldi). Similarly, estrogen concentration peaked 4-5 weeks prior to parturition and declined dramatically immediately prior to birth. It may be possible to detect these metabolites in urine deposited in snow (snow-urine) and feces (S. Monfort, pers. commun.; Safar-Hermann et al. 1987), allowing data to be collected from free-ranging moose. We plan to test the hypothesis that progesterone and estrogen metabolites in urine and feces can be used to detect estrus and pregnancy and predict parturition dates in moose.

The Alaska Department of Fish and Game has been working with the Alaska Railroad to evaluate ways of reducing moose-train collisions and high rates of moose mortality on the railroad right-of-way during the winter. The potential of electric fencing to accomplish this objective is being evaluated at the MRC.

Rutting behavior of moose involves many complex social interactions between the bull and cow (Bubenik 1987). Moose, like many other ruminants are spontaneous ovulators. The annually recurrent puberty for prime animals of both sexes begins earlier in males than in females, generally just before the autumn equinox. One of the attributes of the individual way of life of cow moose is also the individual timing of her estrus. This timing can be advantageous when the sex ratio is skewed and the bull moose needs a recuperation period after each mating (Bubenik and Timmermann 1982). Because individual timing can cause protracted rutting and calving (Bubenik 1987), the disposition to induced estrus may have an advantage in northern latitudes, where short breeding periods are necessary for survival of rutting bulls and calves born too late in the season.

In order to induce and synchronize the rut, which spares the semen reserves of the male (Bubenik 1987), many stimulating cues have evolved among northern cervids, one of which is the use of sex pheromones of the urine and saliva. The former are carried on the tarsal glands tufts on which both sexes urinate (Bubenik et al. 1979), and the latter are dropped by the salivating bull and/or smeared from the bull's chin and bell by the female.

Based on the pilot studies of red deer (Cervus elaphus) by Bubenik and Claus (unpubl. data) it can be shown that the timing of secretion and the concentration of both powerful sex pheromones of the androstenone group (discovered first in the wild boar [Sus scrofa]) correlate with age and sexual performance of the stag. Based on these results, Bubenik (pers. commun.) suggested similar studies with moose.

Urine is a medium that contains metabolic by-products, and it has been used to assess nutritional status of captive animals (Warren et al. 1981, 1982; Waid and Warren 1984, DelGiudice et al. 1987, DelGiudice and Seal 1988). However, obtaining urine from live free-ranging animals is as difficult as obtaining blood, if not more so. Recent reports indicate that assays of snow-urine for urea, sodium, potassium, and phosphorus (expressed as ratios to creatinine) are potential indicators of nutritional status of populations (Mech et al. 1987, DelGiudice et al. 1989). As snow-urine is easily sampled and assays are relatively inexpensive, this technique can potentially become an effective management tool for moose as well as other species. A proposal was written during this reporting period describing our intentions to examine this technique (Appendix A).

OBJECTIVES

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

To operate and maintain the MRC to facilitate studies of captive moose (Job 1).

To test and evaluate immobilizing, tranquilizing, adjunct, and reversing drugs (Job 2).

To investigate physiological parameters that may provide an index to total body fat in moose (Job 4).

To investigate the basic parameters of moose reproduction (Job 5).

To test miscellaneous techniques (Job 7).

METHODS

Job 1. MRC Maintenance and Operations

A LeTourneau tree crusher (Oldemeyer 1977) was used to modify habitat within the MRC enclosures. This machine operates by pushing over trees and crushing them with cleated wheels as it moves over them. In 1977 a portion of Pen No. 1 was rehabilitated, and in 1986 an ongoing crushing program was

initiated with the objective of returning the habitat in all 4 pens to a more productive seral stage. We operated the crusher during the winter months of 1986-87, 1987-88, and 1988-89 after the ground had frozen to a sufficient depth such that trees would be broken at ground level, leaving the root system intact to facilitate shoot growth in the following years. Although some spruce stands were crushed, we concentrated our efforts on the birch-aspen cover type, particularly areas of regrowth, leaving mature stands available for security and thermal cover. Where possible, habitat was rehabilitated in large blocks to reduce the impact of black bear (Ursus americanus) predation on captive moose calves (Schwartz and Franzmann 1983). The areas rehabilitated in each year (prior to this reporting period) were digitized to allow for calculation of area size and map generation.

Job 2. Drug Testing

We tested the new tranquilizer drug R51163 on moose during the previous reporting period (Schwartz et al. 1988c). We evaluated the drug's effectiveness to calm moose, and to relax animals to the point that we could safely draw a blood sample. We also evaluated the drug's effects on dry matter intake and resting metabolism to determine if there were latent effects on these physiological parameters. Specific methodology is discussed in Schwartz et al. (1988c) and in a manuscript submitted for publication to Journal of Wildlife Diseases (Appendix B).

We tested the efficacy of Telazol, an immobilizing drug that works well with carnivores, as an immobilizing agent for moose. Powdered Telazol was diluted with physiological saline to a concentration of 300 mg/ml. The recommended dosage of 6 mg/kg (B. Taylor pers. commun.) was administered to a 238-kg male calf, and the degree of immobilization was recorded.

Job 4. Total Body Fat Estimation

Four bulls (3 calves and one 3.5-yr-old) were confined separately in 3.1- x 15.2-m enclosures at the MRC beginning 9 January 1989. These animals were provided a formulated ration (Schwartz et al. 1985), water, and a mineral lick ad libitum. Beginning 7 March, 3 bulls were put on limited feed rations, based on ad libitum consumption: the 3.5-year-old bull was put on a diet of 85% ad libitum, one of the calves was given 85%, and another calf was given 75%. Dry matter of food consumed was calculated to determine actual intake.

Animals were sampled biweekly for body composition beginning in January. Animals were weighed and immobilized with xylazine hydrochloride (Rompun, Haver-Lockhart, Shawnee, KS). Two blood samples were obtained via jugular venipuncture for serum analysis and whole blood analysis. A 20% urea solution was prepared and administered via a catheter at a rate of 66 ml/kg live weight (130 mg U/kg) following the technique first described by Preston

and Kock (1973). Blood samples were collected at 5, 7.5, 10, 12.5, 15, 22.5, 30, and 60 minutes after infusion. These samples were centrifuged at the MRC and the serum was extracted, placed in vials, and frozen prior to analysis. Whole blood was analyzed at the MRC for Hb and packed cell volume (PCV). Serum was analyzed by a contracted vendor for blood urea nitrogen (BUN) and electrolytes; BUN concentration for each animal was plotted against time collected to determine the time at which the infused urea equilibrated in the blood, and BUN values were used to calculate urea space (US) with the following equation:

$$US(\%)_t = \frac{100\% \times \text{solution infused (ml)} \times \text{mg UN/ml}}{\text{live weight (kg)} \times 1000 \text{ mg/kg} \times \Delta \text{BUN (mg/dl)}}$$

where Δ BUN is the change in BUN concentration between the pre-infusion blood sample and the sample taken at time t (equilibration time).

On 12 April 1989 the calf on the 85% feed ration was sampled for urea space, euthanized, skinned, and eviscerated. The empty carcass was weighed and cut longitudinally along the centerline of the body. Six patches of skin measuring approximately 10 x 10 cm were cut from the hide, and the peroneus muscle group was dissected from one leg. The viscera was weighed, emptied of gastrointestinal contents, weighed again, and frozen along with both halves of the carcass, the skin, and peroneus samples. The frozen items, excepting the skin and peroneus muscle, were cut into 2.54-cm slices on a commercial band saw; the sawdust accumulated at the base of the saw blade was collected separately for each carcass half and viscera and refrozen (Huot and Picard 1988). This procedure was repeated for the calf on the 75% feed ration on 1 June. The other 2 animals were removed from limited rations on 1 June and released into the large enclosures at the MRC to gain weight over the summer. These animals will be sampled and euthanized in the fall.

The frozen sawdust, skin, and peroneus muscle samples will be analyzed for percent fat, water, protein, and ash by an independent lab. Percent body fat estimates will be correlated with urea space measurements to determine the accuracy of the urea space technique.

Job 5. Reproduction Studies

Seven female and 2 male moose (aged >2.5 years) were used in studies to determine the length of estrus the length of the estrous cycle and gestation length. All animals were semitame and maintained at the MRC. Animals were held in two 4-ha enclosures during the study and fed a pelleted ration (Schwartz et al. 1985). In 1987 we randomly divided the 7 cow moose into 2 treatments. Four cows in the control group were maintained in one of the holding pens with an intact (i.e., not vasectomized) mature bull. The 2nd group of 3 cows was maintained in the 2nd pen with a surgically vasectomized bull. All animals were

observed daily beginning in the first week of September and continuing through mid-November. Dates of breeding (determined by a cow being mounted by the bull) were noted for each female.

Females that had initially mated with the vasectomized bull were put with the intact bull about 2 weeks later. These cows were again observed to determine the date of breeding with the intact bull. In 1988 the treatment order was reversed for each female; cows bred on their 1st estrus in 1987 were placed initially with the vasectomized bull in 1988, and cows bred on their 2nd estrus in 1987 were placed initially with the intact bull in 1988.

Following breeding (i.e., 19-26 days after 1st estrus) each female (both groups) was observed to determine if they had recycled (indicating they were not pregnant) or were not exhibiting signs of a subsequent estrus (indicating they were pregnant). Following the breeding season, all moose were maintained together and fed a pelleted ration throughout the winter.

During the calving season, each cow was checked several times daily to record time and date of calving. Calves were weighed the day of birth using a spring scale (Salter No. 235, London, England), ear tagged, and fitted with a calf mortality transmitter (Telonics Inc., Mesa Arizona). When the calves were approximately 2 weeks of age, they were released with their cow into the large enclosures of the MRC. Each cow had access to pens Nos. 2 and 3, which contained regrowth vegetation from the 1947 burn and recently crushed vegetation from our crushing program in 1986-87 and 1987-88. Radio signals from each calf were checked daily for mortality mode, and the calf were visually observed every 3-5 days during the summer. Once calves returned to the holding facility in the fall they were weighed weekly. Growth and development were measured as weight gain/day from time of birth to fall.

Job 7. Miscellaneous Projects

Monitoring Estrus and Pregnancy

Urine was collected from adult cows housed at the MRC by maneuvering a 10-cc vial attached to the end of a pole into the urine stream. Samples from 3 cows (Janie, Oly, and Betsy) were collected daily from mid-October through mid-November, periodically through February, weekly through March and April, and daily in May and June. Urine samples from other adult females, calves, and bulls were collected periodically. Samples were frozen and shipped to the National Zoological Park for spectrophometric analysis. Concentration of PdG was expressed as ng/ml C.

Electric Fence Testing

Three adjoining enclosures were constructed in the NW corner of Pen No. 2 to test the effectiveness of electric fencing as a barrier to moose (Fig. 2). The existing northern fence of Pen No. 2 and the western fence of Pen No. 2A, constructed of woven-wire livestock fencing to a height of 2.4 m (8 ft), were used as boundaries of the enclosures to minimize material and labor costs and to provide us with a fenced corridor between Pen Nos. 1 and 2A so that movement of moose between these pens could be facilitated. For the purposes of this test, most fencing material and labor were provided by Alaska Power Fence (Homer, AK).

A 12-wire electrified (2.4 m in height) fence was constructed; alternating ground and electrified wires were equally spaced. Fencing was attached via porcelain insulators to hollow steel posts (10.2 cm outside diameter) spaced approximately 30.5 m apart. Fiberglass spacers were placed every 7.6 m to preclude sagging of wires. Gates were constructed with welded steel framing with the same wire spacing as the fence, except that all wires on the gate were electrified. The system was controlled by a Gallagher-Snell "Super Battery Energizer" powered by a standard 12-volt automobile battery. The energizer was configured to provide a maximum output pulse energy of 4.9 Joules and 8000 volts.

Bulls were placed in the pens prior to the onset of rut. One mature bull was placed in each of the eastern and western enclosures, and two 3.5-year-old bulls were placed in the central pen. A mature bull was housed in Pen No. 2A, which was separated from the eastern enclosure by woven wire fencing (Fig. 2). This arrangement provided 2 electrified barriers and 1 woven wire barrier between bulls. The bulls were observed periodically during the rut to determine their response to the fence, and the fence was inspected periodically to identify and repair damage caused by the moose.

Hormone and Pheromone Production in Bulls

From July 1988 through January 1989, we collected saliva, blood, and urine from 2 bulls for determinations of 16-androstenes and testosterone. Analyses for androstenes were carried out by C. R. Claus (Institute for Animal Behavior and Animal Rearing, University of Hohenheim, Stuttgart, Federal Republic of Germany [FRG]), following procedures described by Claus (1974). Serum testosterone levels were determined by D. Schams (Institute fur Physiologie, Technische Universitat Munchen, FRG). In general, 16-androstene determinations were carried out by an enzyme-immunoassay. Sample preparation included extraction with hexane, followed by a solvent distribution against 90% methanol. Aliquot portions of the methanol (containing the steroid) were dried down and measured in the assay system. Alternatively, for more specific determinations of the corresponding androstenols (musk

odor), the extracts were transferred on thin-layer plates and chromatographed. The radioimmunoassay was carried out after individual elution. The values were corrected for procedural losses. Description of methods for testosterone determinations have not yet been transmitted by D. Schams.

Indirect Indices of Body Composition

Urine samples were collected from the 4 bulls used in the body composition study every 2-3 days. These samples were frozen and shipped to G. DelGiudice (Veterans Administration Hospital, Minneapolis, MN) for analysis of urea nitrogen, sodium, potassium, phosphorus, and creatinine content.

RESULTS AND DISCUSSION

Job 1. MRC Maintenance and Operations

Habitat was rehabilitated in portions of Pen Nos. 1, 2, and 3 prior to the winter of 1988-89 (Fig. 1, Table 1). A small portion of Pen No. 3 was rehabilitated in 1988-89 and is not included with these data. Our plan calls for further rehabilitation in Pen Nos. 1 and 3 and extensive rehabilitation of Pen No. 4; however, the 3 tree crushers owned by ADF&G, including the machine being used at the MRC, were sold as surplus equipment in July 1989.

Job 2. Drug Testing

Data analysis was completed during this reporting period for our evaluation of R51163 as a tranquilizer in moose. A manuscript was prepared for publication and submitted to Journal of Wildlife Diseases (Appendix B).

The effect of Telazol on moose was tested on a 238-kg male calf that had been immobilized for urea infusion and blood sampling. The calf was injected with 1,428 mg (6 mg/kg) Telazol diluted in saline (300 mg/ml) IM at 0826 hours on 12 April 1989. By 0828 hours the animal was ataxic and exhibiting muscle quivering in the shoulders and flanks; however, it attempted to stand upon our approach. The degree of immobilization had not improved by 0840 hours, therefore the calf was injected with an additional 477 mg IM at 0844 hour. After this injection, the animal still attempted to stand upon our approach; therefore, we administered another 477 mg IM at 0903 hours. We proceeded with the body composition measurements, but the animal began to struggle during the process and was given another injection of 477 mg IM at 0934 hours. After we completed our body composition measurements, the animal was euthanized.

Telazol was unsatisfactory as an immobilizing agent in this instance. The test animal never exhibited a tranquil state, such as we have come to expect with xylazine hydrochloride or

carfentanil (Wildnil, Wildlife Laboratories, Fort Collins, CO), and it remained alert throughout the procedure. This moose required 2,859 mg Telazol (12 mg/kg) administered over a period of 68 minutes to achieve a state of immobilization sufficient to allow completion of the body composition technique.

Job 4. Total Body Fat Estimation

Infused urea equilibrated with BUN within 12.5-15.0 minutes in the 4 moose sampled (Fig. 3), which is similar to 12.5 minutes equilibration time reported for cattle (Preston and Kock 1973). All subsequent sampling consisted of blood samples drawn at these times, and the sample exhibiting the highest correlation with body fat will be used in the future. Percent body fat was calculated from 15-minute urea space estimates with an equation derived for domestic cattle (Preston and Kock 1973). Two distinct body fat estimates were generated for each calf, based on sampling from 2 different dates, and 1 estimate was generated for the adult bull. Estimates for two of the calves ranged from 4.9% to 7.1%, and the single estimate for the adult bull was 10.4%; these estimates are within the range expected for animals of these ages during the winter. Estimates for the 3rd calf were 0.45% and -20.35%. This calf was subjected to the most severe feed restriction (75% ad libitum), and these unrealistic values may be indicative of a failure of the technique in extremely lean animals or the unsuitability of the cattle regression model. Analysis of additional samples from these animals are in progress. Composition of the sawdust, skin, and peroneus muscle groups collected from the 2 euthanized animals has not been determined yet.

Job 5. Reproduction Studies

Two cows that were bred on their 2nd estrus in 1988 exhibited typical estrous cycles, cycling at 24 and 25 days between estruses (Table 2). These intervals are consistent with normal intervals observed in the 2 prior breeding seasons (Schwartz 1987, Schwartz et al. 1988c). Two cows exhibited unusual cycling, skipping one or more estruses. Janie entered her 2nd estrus 52 days after her first, and entered a 3rd estrus 47 days after the second. These intervals are equivalent to 2 cycles each. Deneki cycled on 12 October and was bred by the intact bull, but she was observed breeding with a vasectomized bull on 27 February, yielding an interval of 140 days between estruses. Because, Deneki was not observed daily beyond the period of her predicted 2nd estrus, we cannot state with certainty that she did not cycle during the interim.

Mean gestation length for the 5 cows that gave birth in 1989 was 230.4 $\pm$ 4.6 (SD) days (Table 2). Mean gestation length for 5 cows from 1987-88 and one from 1984-85 was 230.8 $\pm$ 5.2 days (SD) (Schwartz et al. 1988c). This gestation length is longer than that reported by Stewart et al. (1987) of 216-218 days for moose in Saskatchewan, within the range reported by Markgren (1969) of

226-244 days for moose in Sweden and the Soviet Union, but shorter than that reported for North America by Peterson (1974) of 240-246 days.

Weight gain per day was identical for 1st and 2nd estrus calves (Table 3) from birth through September, when calves were free-ranging with their mothers in Pen Nos. 2 and 3. All calves and their mothers were held in the small enclosures (Pen Nos. 2A and 2B) after September, and weight gain per day among calves decreased from that observed over the summer, with 2nd estrus calves exhibiting a lower rate of increase (Table 3). However, our sample size is small, and once moose are housed in the small enclosures they are provided with supplemental feed. Dominance hierarchies among cows and among calves likely influence individual feed intake.

This apparent lack of compensatory growth by 2nd estrus calves resulted in lower winter weights among this cohort. Mean weight of 1st estrus calves entering October was 15% greater than that of 2nd estrus calves (Table 3). Such a weight difference among moose coming off summer range may result in differential winter mortality.

Job 7. Miscellaneous Projects

Monitoring Estrus and Pregnancy

Concentrations of PdG in urine collected through 13 January 1989 could not be interpreted definitively as indicating pregnancy; PdG profiles for Janie, Betsy, and Oly were inconclusive (Fig. 4). All 3 cows were observed breeding on or about the day on which their urinary PdG concentrations were at the nadir (lowest) point. Betsy and Oly exhibited increased concentrations after estrus, but their final samples unexpectedly indicated that PdG levels had decreased again. None of these cows entered estrus subsequent to being bred by the intact bull, and each gave birth as expected, given their dates of breeding. Although Janie's profile exhibited increasing PdG concentration following estrus, it did not decline; however, we did not collect any samples from her between 16 November and 13 January. Considering that she had bred on 30 November (Table 2), it was likely that her PdG profile decreased to baseline after 16 November whereupon she recycled (S. Monfort, pers. commun.). Janie bred again on 16 and 17 January, which indicated that she had not concieved in November. Her PdG profile, although high, was not indicative of pregnancy and may have been caused by extension of the luteal phase of the estrous cycle (S. Monfort, pers. commun.) in which the corpus luteum did not degenerate following a failed conception. This may explain Janie's unusual cycling described previously (i.e., twice the normal duration). Apparently, her luteolytic mechanism was suppressed following ovulation, indicating a hormonal imbalance. This is consistent with her reproductive performance last year; although she had bred with an intact bull, she did not give birth. She died in early March 1989, and when examined her

body was too badly decomposed to determine whether or not she was pregnant.

Generally, concentrations of PdG in urine collected from moose were in agreement with our hypothesis; an exception was Zumu (Table 4). Angel and Trixie exhibited low concentrations of PdG during estrus and subsequent high values, possibly indicating pregnancy. Zumu exhibited relatively low PdG values, despite being sampled 40 days after being bred. All of these cows gave birth in 1989. Deneki exhibited a low PdG value 43 days after being bred. She was observed in estrus on 27 February 1989, indicating that she had not conceived on her initial estrus. Low PdG values were obtained from 2 calves (1 male, 1 female) and an adult bull.

The concentration of PdG in urine was a reliable indicator of the onset of estrus in the 3 cows studied; however, our data were inconclusive concerning pregnancy detection. It is apparent that serial urine samples throughout gestation from specific cows are necessary to examine the relationships between hormone concentrations and reproductive performance. Such samples were collected from Betsy and Oly, but those collected in 1989 have not been analyzed yet.

Electric Fence Testing

The electric fencing was successful in keeping rutting bulls separated. Moose responded to electric shock by flinching and running a short distance. Although it seemed that the moose learned not to touch the fence, we observed a response to the shock only when a moose touched the fence with its nose or lips. After observing instances of moose brushing the fence with shoulders, hips, or hardened antlers and exhibiting no indication of shock, we attributed it to (1) hardened antlers and winter guard hairs of moose are not adequate conductors, (2) moose did not touch a ground wire at the same moment that they touched an electrified wire, and (3) moose standing in snow were not adequately grounded to complete a circuit when touching only an electrified wire.

We observed moose sparring through the woven wire barrier but not through the electric portions. Bulls at the MRC routinely engaged portions of the woven wire fence with their antlers, pushing and lifting it as a means of displaying to other bulls and MRC personnel. We did not observe this behavior directed toward the electric fencing.

Despite its apparent effectiveness, we experienced problems with this fencing design associated with the insulative quality of antlers. One large bull damaged the fence by inadvertently hooking the top wire with his antlers, pulling it out of the spacers, and separating and/or breaking insulators from the corner posts. When wires came in contact with each other as a result of this damage the system voltage dropped significantly

(e.g., on at least one occasion the voltage dropped to zero), reducing the effectiveness of the fence. However, we used steel posts to support the fencing, whereas the manufacturer had recommended wood. Damaged wires that came in contact with steel posts may have been responsible for grounding the system. Maintaining the integrity of the fence in light of frequent moose damage required many man-hours.

Electric fencing seems to be effective in deterring moose from crossing fencelines; however, a sturdier fence configuration is advisable, as is testing with wild moose. Our moose were accustomed to fences, and any results from this study should be interpreted with this in mind. The potential for wild moose to become entangled and subsequently injured or killed in any type of fencing must be addressed. Also, the apparent failure of moose antlers and guard hairs to conduct electricity needs to be investigated. One alternative that may reduce damage is to place an electrified wire in an outrigger configuration 0.9 m (3 ft) from the vertical fence at a height of approximately 1.2 m (4 ft) above ground level (this would have to be modified in deep-snow areas). If this arrangement is effective, it may eliminate the need to electrify the main fence.

Hormone and Pheromone Production in Bulls

Blood serum testosterone concentrations for Wild Bill and Sockeye (3-year-old bulls) peaked in September (Table 5). Those for Wild Bill increased from July through early September and declined thereafter. Concentrations for Sockeye peaked in late September, but they did not exhibit the smooth increase and decline phases evident in Wild Bill. The peaks corresponded with the beginning of the rut. Overall, these testosterone concentrations were somewhat lower than expected (D. Schams, pers. commun.); Sempere and Boissin (1983) reported peak serum testosterone levels in roe deer (Capreolus capreolus) of greater than 7 ng/ml. Neither of these bulls was in an enclosure with cows during the rut, and we can only speculate as to whether this influenced the rapid decline of testosterone following the peak concentrations in September. Analyses for 16-androstenes were not completed during this reporting period.

Indirect Indices of Body Condition

Analysis of urine for urea, creatinine, and electrolytes has not been performed.

RECOMMENDATIONS

We plan to continue to evaluate new drugs and related products as they become available for use. We plan to acquire and test a body composition analyzer that works on the principle of bioelectrical impedance analysis. Testing of the electric fence will continue. Analyses for 16-androstenes and testosterone will

continue in an attempt to better understand the hormonal mechanisms of moose reproduction. Collection and analysis of urine will continue to determine if analysis of snow-urine is feasible in moose.

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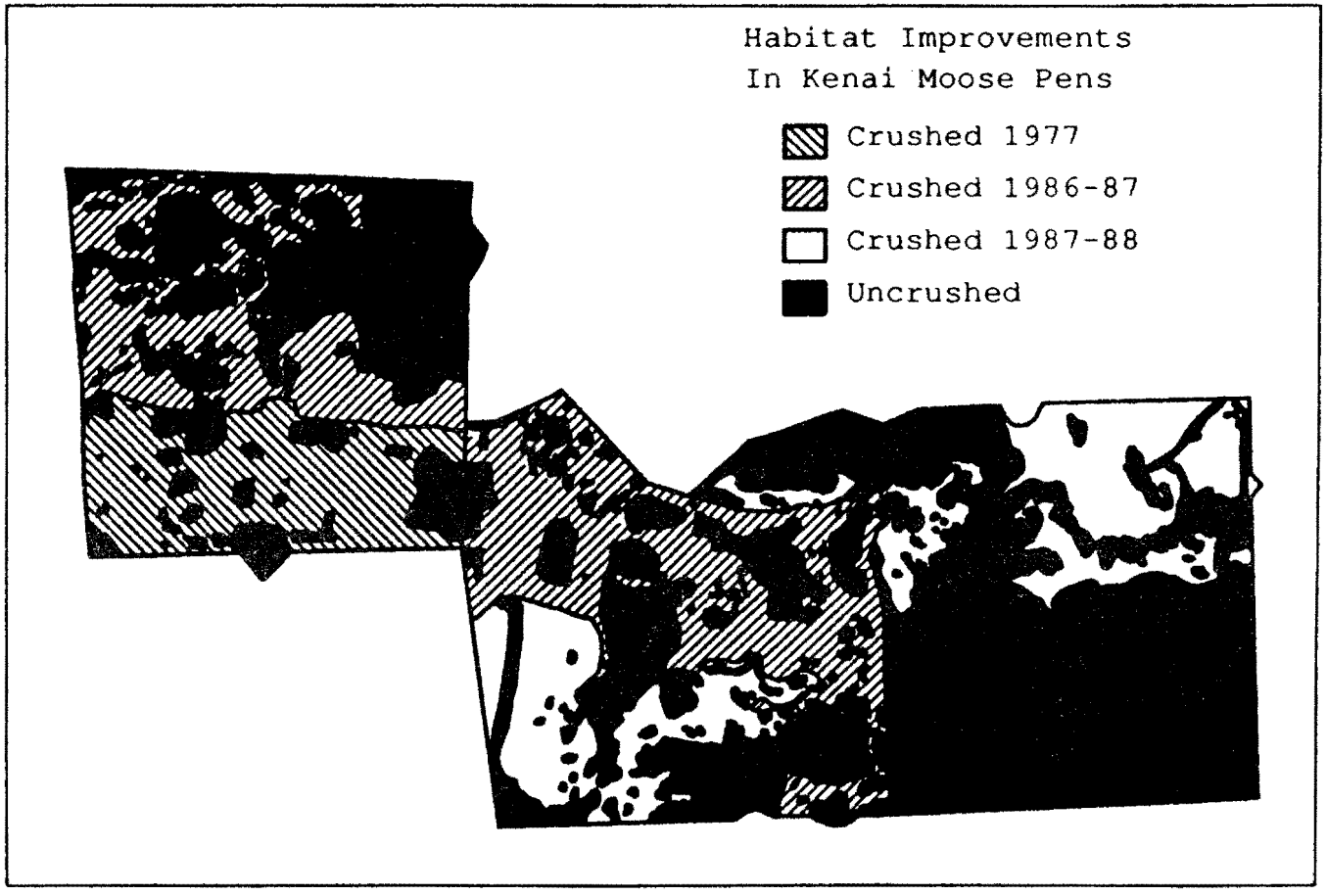

Fig. 1. Areas within Pens 1-3 at the Moose Research Center modified by a LeTourneau tree crusher, 1977-1988.

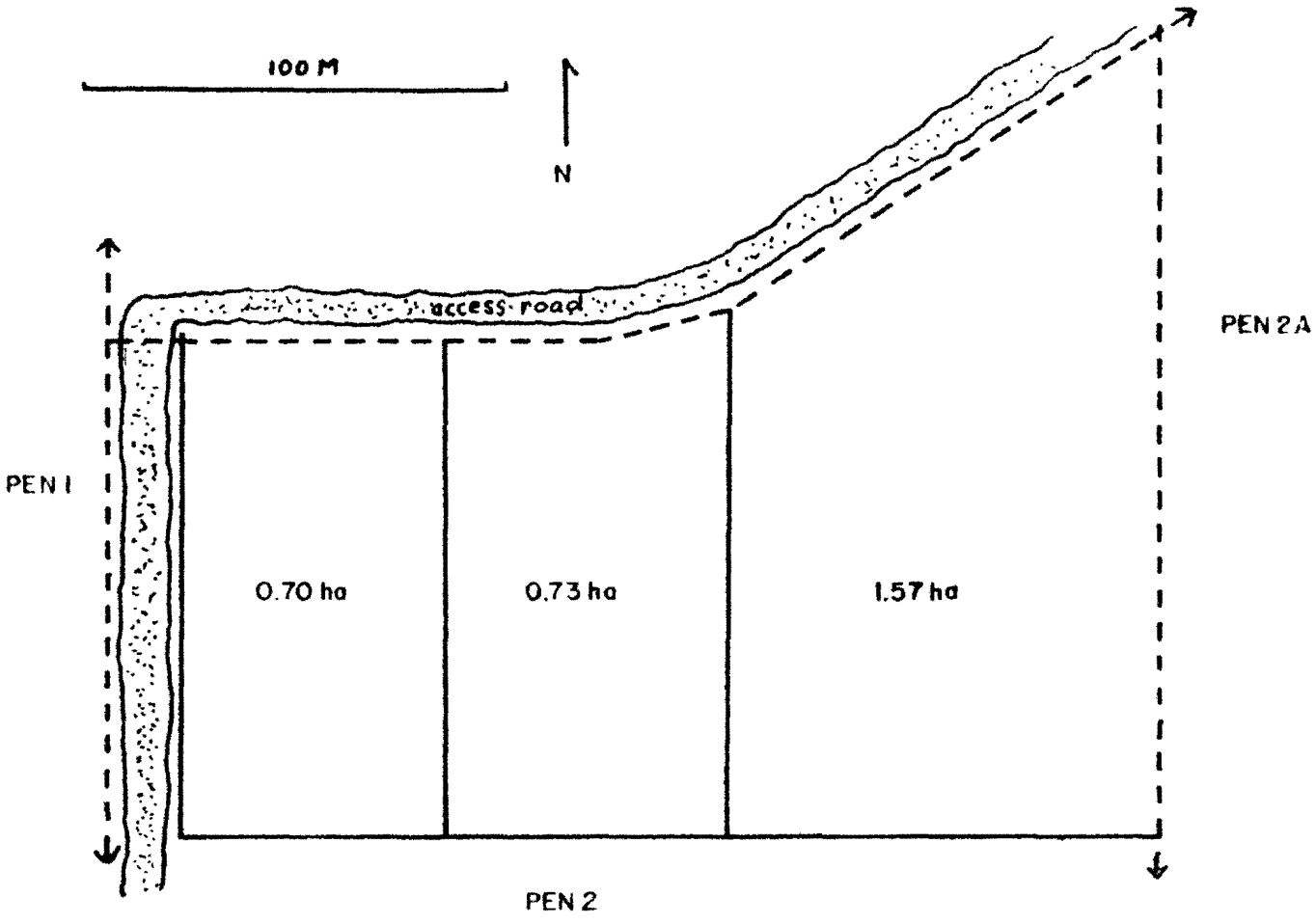

Fig. 2. Configuration of enclosures within Pen 2 at the Moose Research Center used to test electrified fence as a barrier to bull moose. Solid lines indicate electrified fencelines, broken lines indicate woven wire fencing.

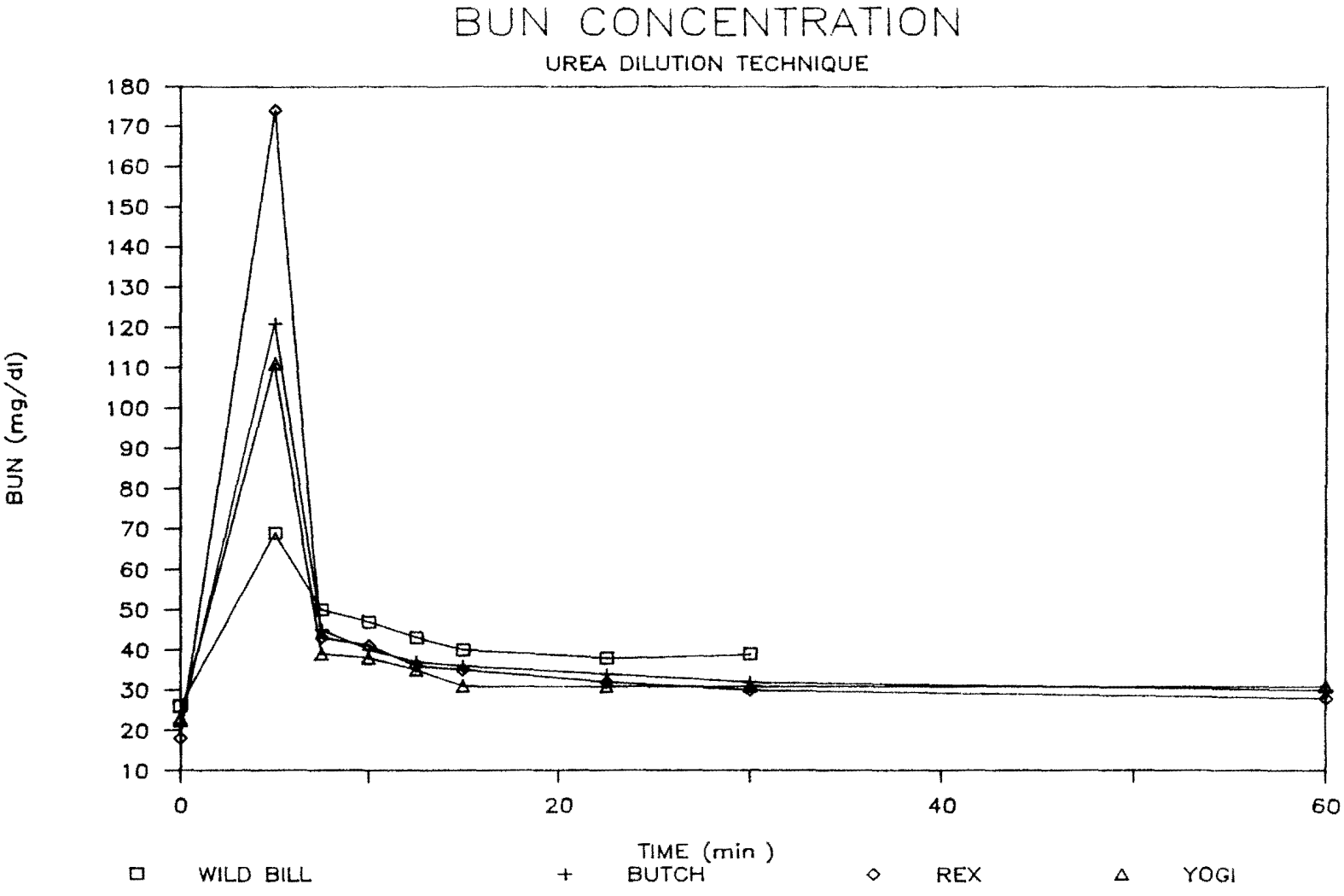

Fig. 3. Concentration of BUN in 4 male moose indicating equilibration time of a 20% urea solution infused into the blood subsequent to the sample collected at time = 0 min, Moose Research Center, 1989.

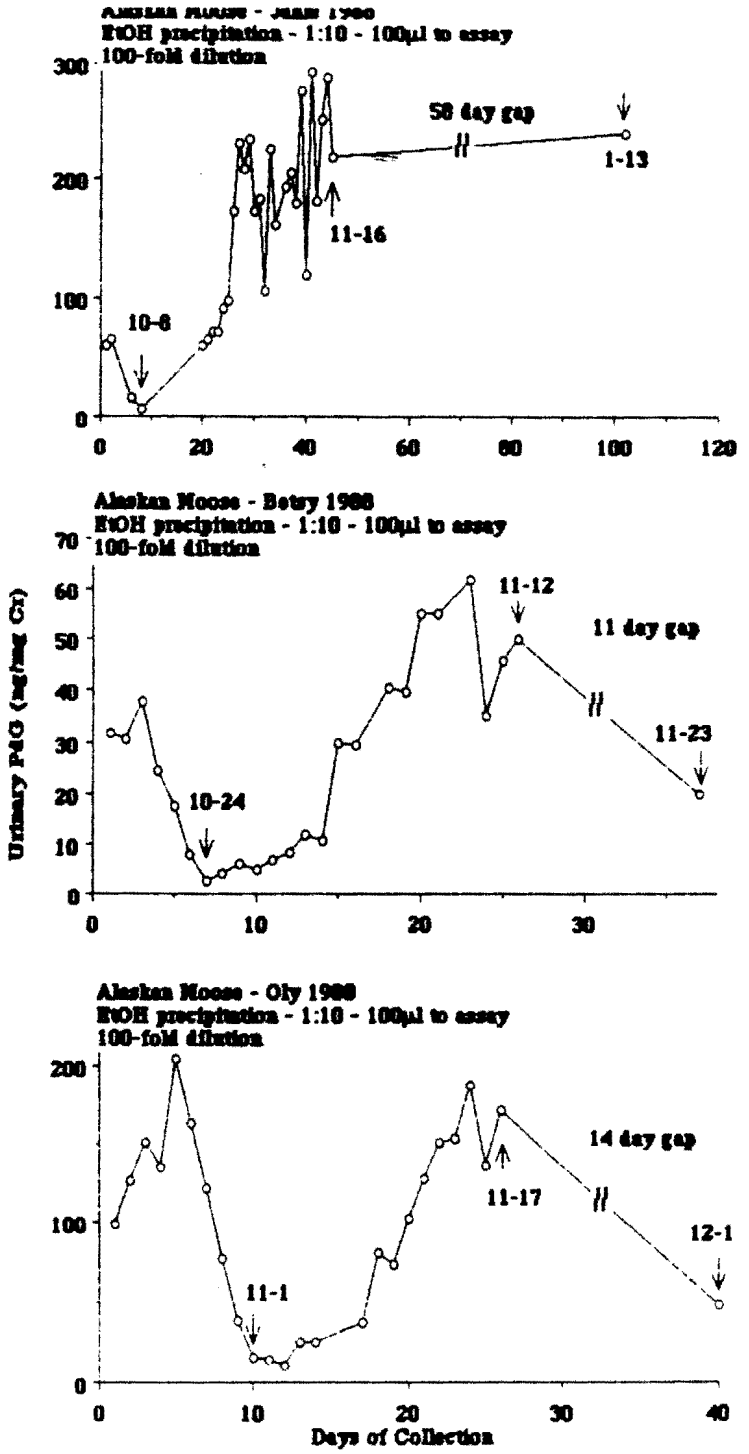

Fig. 4. Concentration of PdG in urine samples from 3 female moose housed at the Moose Research Center.

Table 1. Area rehabilitated within Pens 1-3 at the Moose Research Center by Letourneau tree crusher, 1977-1988.

	Pen size (km^2)	Area rehabilitated (km^2)			
		1977	1986-87	1987-88	Total
Pen 1	2.386	0.640	0.671	--	1.311
Pen 2	2.541	--	0.912	0.544	1.456
Pen 3[a]	2.388	--	--	0.585	0.585
Total	7.315	0.640	1.583	1.129	3.352

[a] Does not include area rehabilitated in 1988-89.

Table 2. Reproductive observations of seven captive female moose at the Kenai Moose Research Center from September, 1987 to January, 1988.

Moose	Date of Estrus	Type of Data[a]	Time Between Estrus Periods (Days)[b]	Date of Parturition	Length of Gestation (days)	Calf or Calves Sex	Wt.(Kgs.)
Oly	6 Oct	O				F	14.7
Oly	31 Oct	O	25	13 June	225	F	14.5
Zumu	2 Oct	O		23 May	233	F	17.7
						F	15.4
Angel	1 Oct	O		24 May	235	M	13.2
						F	5.9
Janie	8,9 Oct	O					
Janie	30 Nov	O	52	Died Mar 1989			
Janie	16,17 Jan	O	47	Not pregnant			
Betsy	30 Sep	O				M	13.8
Betsy	24 Oct	O	24	14 June	233	F	14.1
Trixie	12 Oct	O		26 May	226	M	15.0
						M	11.8
Deneki	12 Oct	O					
Deneki	27 Feb	O	140	Not pregnant			

[a] O = Observed breeding.

[b] Time between first observed mounting of each estrus period.

Table 3. Birth weights and selected subsequent weights of moose calves born at the Moose Research Center in 1988, and their corresponding rates of increase.

Animal name	Birth Weight (kg)	Birth Date	Late summer Weight (kg)	Late summer Date	Early winter Weight (kg)	Early winter Date	Rate of increase (kg/d) Birth - late summer	Late summer - early winter	Birth- early winter
First estrus calves									
Lily	16	24 May	179	6 Oct	226	16 Dec	1.22	0.66	1.02
Butch	13	25 May	166	24 Sep	222	14 Dec	1.26	0.69	1.03
Mean	14.5						1.24	0.68	1.03
Second estrus calves									
Sony	13	7 Jun	147	26 Sep	199	14 Dec	1.22	0.66	0.98
Rex	13	7 Jun	134	26 Sep	194	14 Dec	1.10	0.76	0.96
Amelia	17	18 Jun	146	27 Sep	175	1 Dec	1.29	0.45	0.96
Yogi	13	14 Jun	166	2 Oct	192	19 Dec	1.36	0.38	0.96
Mean	14.0						1.24	0.56	0.97

Table 4. Concentration of pregnanediol-3-glucuronide (PdG), expressed as a ratio to creatinine (C), in the urine of moose of various sex and age classes, Moose Research Center, 1988.

Animal	Sex	Age	Date of collection	PdG (ng/ml C)
Lily	F	Calf	14 Nov 1988	11.54
Zumu[a]	F	Adult	11 Nov 1988	18.18
			12 Nov 1988	13.65
Angel[a]	F	Adult	28 Sep 1988	14.88
			2 Oct 1988	4.30
			23 Nov 1988	129.07
Trixie[a]	F	Adult	11 Oct 1988	15.90
			23 Nov 1988	392.15
Deneki	F	Adult	21 Nov 1988	16.03
Tutka	M	Calf	10 Nov 1988	3.92
Bando	M	Adult	10 Nov 1988	6.96

[a] Indicates an animal that was pregnant.

Table 5. Concentrations of testosterone in blood serum collected from 2 bull moose at the Moose Research Center, 1988-89.

Date of collection	Wild Bill	Sockeye
14 Jul	0.34	0.46
29 Jul	0.38	<0.3
16 Aug	0.62	0.32
6 Sep	1.25	<0.3
27 Sep	0.46	4.18
17 Oct	0.39	<0.3
9 Nov	<0.3	0.36
25 Jan	<0.3	--

Appendix A.

ASSESSMENT OF MOOSE CONDITION VIA BIOCHEMICAL ANALYSIS OF URINE IN SNOW, A PROPOSAL

BACKGROUND

The relative quality of wildlife habitat is ultimately expressed through the physical condition of resident animals (Franzmann 1985). Thus, habitat quality can be measured indirectly by measuring animal condition. By continuously monitoring animal condition, managers could identify and address habitat changes that could lead to population declines. A technique that would allow managers to serially monitor animal condition would be a valuable management tool.

Blood is an ideal medium from which to collect information relative to the condition of an animal (Franzmann et al. 1987), and has been used extensively with ungulates (Seal 1978, Seal and Hoskinson 1978, Seal et al. 1978, Bahnak et al. 1979, Warren et al. 1981, 1982, Kie et al. 1983, DelGiudice et al. 1987a, Franzmann et al. 1987). However, acquiring blood samples requires handling animals, which often is prohibitively expensive and subjects the animals to potential stress and trauma. Urine is also a medium which contains metabolic by-products and has been used to assess animal condition (Warren et al. 1981, 1982, Waid and Warren 1984, DelGiudice et al. 1987b, DelGiudice and Seal 1988). However, obtaining urine from live free-ranging animals is as difficult, if not more so, as obtaining blood.

Mech et al. (1987) and DelGiudice et al. (In Press a) successfully monitored wolf (Canis lupus) nutritional status by sampling urine deposited in clean, fresh snow. However, their data were useful only in demonstrating short-term changes in urinary metabolites that indicated that wolves had recently fed. DelGiudice et al. (1988) documented a relationship between levels of urinary urea nitrogen and electrolytes, expressed as ratios to creatinine, and nutrient availability for wild populations of white-tailed deer (Odocoileus virginianus). However, published data are not consistent with this statement. Warren et al. (1981) found no significant differences in urinary urea:creatinine (U:C) ratios between adult male white-tailed deer fed ad libitum and those fed a restricted diet. DelGiudice et al. (1987) detected no differences in urinary U:C ratios among adult female white-tailed deer fed diets differing in energy and protein content. Waid and Warren (1984) observed seasonal differences in U:C ratios of free-ranging adult female white-tailed deer but could not attribute the variation to nutrition. Warren et al. (1982) observed

differences in urinary U:C ratios in fawn white-tailed deer fed diets differing in protein and energy content, with highest ratios attributable to low energy and high protein intake. However, Warren et al. (1982) suggested the use of additional indices to differentiate among the factors affecting serum and urinary urea concentrations: protein intake, energy intake, tissue catabolism, and urea recycling. Further testing of this technique is indicated to determine its potential as an indicator of nutritioanl status of free-ranging animals.

METHODS

This study will be conducted concurrent with a test of a body fat estimation technique. At least three male calves and a 3.5-year-old bull will be used as test animals. Test animals will be fed different amounts of a pelleted ration (Schwartz et al. 1980) to produce animals on different nutritional planes. Animals will be weighed monthly. Urine samples will be collected monthly in conjunction with weighing and with estimates of body fat. Urine will be divided into two equal portions: one portion will be analysed as is, and the other portion will be mixed with an equal portion of distilled water before analysis to approximate dilution in snow. Urine and urine/water will be assayed for urea N, Ca, P, Na, K, and creatinine (C). Nitrogen, Ca, P, Na, and K will be expressed as ratios with C (eg N:C, Ca:C) to correct for urine dilution in water (Mech et al. 1987). Results of assays will be compared to body fat estimates to determine their accuracy and precision in determining nutritional status.

SCHEDULE

Report due: July 1 (with techniques report)

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Appendix B.

AN EVALUATION OF R51163 AS A TRANQUILIZER IN MOOSE

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ABSTRACT: R51163, a newly synthesized purine alkyl piperidine, that produces reliable sedation in cattle was tested in 6 adult bull moose (Alces alces). A single animal dosed at 0.2 mg/kg body weight (BW) responded with violent kicking when handled, and was less manageable than when not sedated. We noted various responses from animals dosed with 0.4 mg/kg BW, with some were sedated sufficiently to draw a venus blood sample, while others responded by kicking. All animals dosed with 0.4 mg/kg BW ate significantly ($P < 0.05$) less dry matter for at least one week post-treatment when compared to controls. Mean estimates of resting metabolism, measured the day of injection, did not differ between treatment and control groups, although the variation about each measurement was almost 2 times larger for drugged (C.V. = 14.5%) vs. control (C.V. = 8.2%) individuals.

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