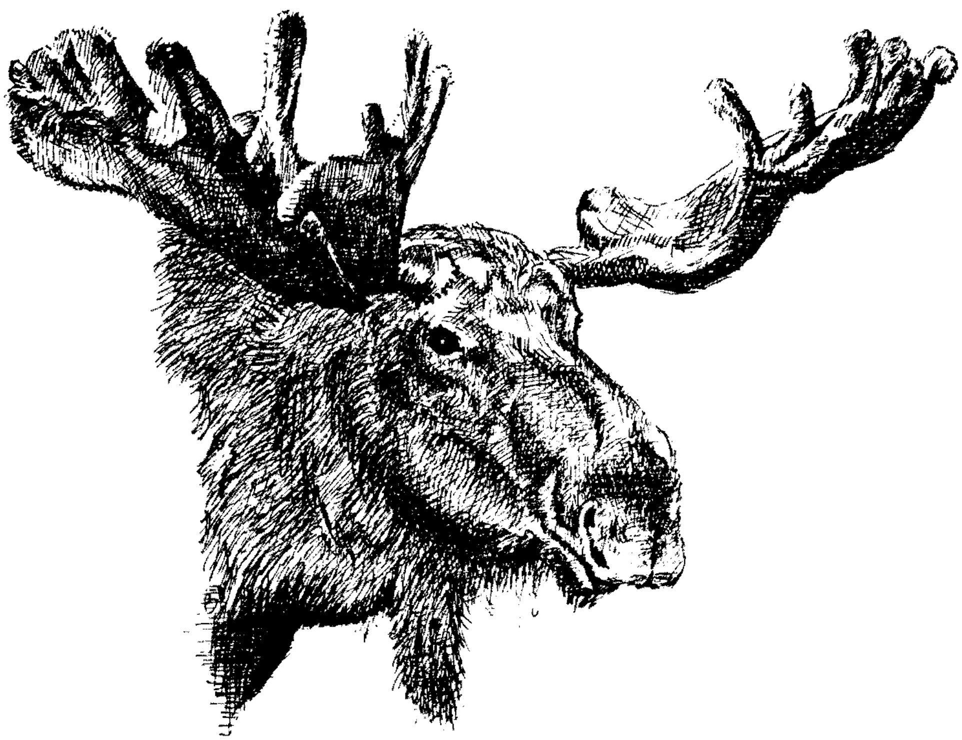
Alaska Department of Fish and Game
Division of Wildlife Conservation
Federal Aid in Wildlife Restoration
Research Progress Report

# Evaluation and Testing of Techniques for Moose Management



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Project W-23-4
Study 1.39
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# PROGRESS REPORT (RESEARCH)

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## SUMMARY

Least squares estimates of urea space ($S_0$) corresponded most closely with an equilibration estimate of 20 min. Total length (TL) measurements accounted for 63% of variation in total body weight (TBW), and the addition of condition class (CC) to the estimate accounted for up to 91% of variation. Heart girth (HG) measurements were not useful for predicting weight. Mean length of the estrous period ($n$=4) was 23.3 (SD 1.0) days. Mean length of gestation for pregnancies resulting in the birth of a healthy calf was 232.5 (5.1) days ($n$=6). Growth from birth-early winter for 1st-estrus calves (1.03 [0.08] kg/day) did not differ from 2nd-estrus calves (0.90 [0.08] kg/day); however, we detected a difference between the 2 groups of calves from birth-late summer (when animals are feeding on natural summer range), with 1st-estrus calves gaining 1.25 (0.08) kg/day and 2nd-estrus calves gaining 1.06 (0.09) kg/day ($P$=0.03). The outcome of pregnancy determinations for 26 moose using fecal progesterone (P4) and estradiol (E2) was correct in 23 and 17 cases, respectively. Unlike P4, E2 data were highly variable and the relative difference between values indicating pregnancy and those indicating no pregnancy was small. However, E2 may be valuable in identifying "false positive" P4 values. Reference values for urinary chemistries of moose on a maintenance diet are presented, along with values for a moose in poor condition. The utility of snow-urine analysis for moose management is discussed. Six of 20 loci from liver and muscle tissue of Kenai Peninsula moose were polymorphic. Average heterozygosity ($H$) for the sample was 7.7%, which represents an unprecedented level of genetic diversity for moose.

Key Words: *Alces*, BIA, bioelectrical impedance analysis, body composition, breeding, estrous cycle, genetic diversity, gestation length, moose, snow-urine, urea dilution, urine.

## CONTENTS



## BACKGROUND

The Moose Research Center (MRC), with known numbers of confined animals and facilities to handle them, 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 where $S_0$ = the extrapolated specific concentration of SUN, which approximates $S_e$; and $S_t$ = SUN at time t, provided t occurs after equilibration (Holleman et al. 1982). $S_0$ was then compared to $S_{15}$. Total body water space (TBWS) was calculated as

## RESULTS AND DISCUSSION

Job 4. Total Body Fat Estimation

Estimates of urea space were calculated for potential equilibration times of 15 ($S_{15}$), 20 ($S_{20}$), and 30 ($S_{30}$) min post-infusion (Table 1). Estimates of $S_0$ were generated for those animals for which blood samples were collected to at least 50 min post-infusion. $S_0$ corresponded most closely with $S_{20}$ and it is probable that an estimate of equilibration time of 20 min is more appropriate than 15 min (Hundertmark et al. 1990).

Linear least squares estimates ($\underline{n}$=13) of total body weight (TBW) using combinations of TL, HG, and CC (Table 2) yielded significant $R^2$ values. Sixty-three percent of the variation in TBW was explained by TL, which was much less than the 94% reported by Franzmann et al. (1978), but was greater than the 50% reported by Haigh et al. (1980). Contrary to the results of Haigh et al. (1980), adding HG to the equation did not improve $R^2$ and actually increased the standard error of the estimate (SEE). Adding TL and CC as independent variables improved $R^2$ compared

October 1988 and February 1989 with an interval of 140 days or approximately 6 estrous cycles. Angel was bred in 1989 but did not give birth in 1990. Thus, in each of the 3 instances wherein a "false positive" was encountered in mean fecal P4 values the cow had been bred, and in 2 instances the cows exhibited unusual cycling. Fecal E2 values (Fig. 2) did not segregate into 2 groups as well as P4 values but they generally followed a similar pattern with means <20 ng/g

$\underline{P}$ = 15.8% for Scandinavian moose. Smith *et al.* (1990) estimated average $\underline{P}$ for cervids as 17.4%.

One locus (PEP-2) in the present study exhibited 3 alleles, whereas the remaining polymorphic loci exhibited 2 alleles each (Table 7), yielding an estimate of $\underline{A}$ of 1.35 (SE 0.13), which is within the range exhibited by other cervids (Baccus et al. 1983, Smith et al. 1990). Direct-count estimates of heterozygosity for polymorphic loci ($\underline{h}$) ranged from 2.6-47.2% (Table 7). Average heterozygosity ($\underline{H}$), including 14 monomorphic loci, was 7.7% (SE 3.4%), which was also organized the 27th North American Moose Conference which was held in Anchorage and Denali National Park in May 1991.

## RECOMMENDATIONS

We plan to continue to evaluate new drugs and related products as they become available for use. We will investigate the genetic composition of other moose populations in Alaska in order to describe the range of variation present within the state. Investigation of body composition estimation will continue, although it will be documented as a separate project.

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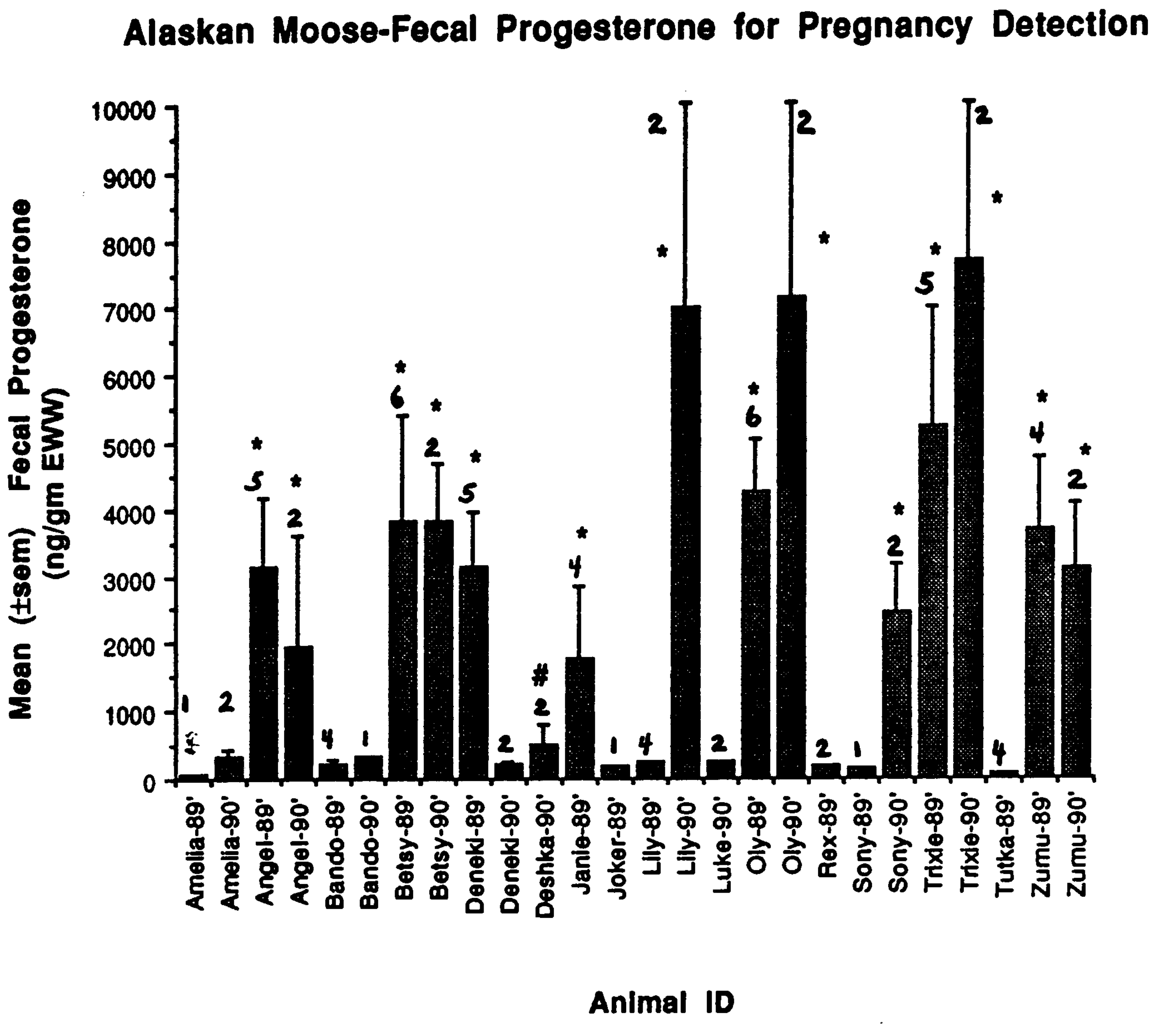


Figure 1. Fecal progesterone (P4) levels for moose housed at the Moose Research Center, Alaska. * denotes a pregnant animal; # denotes an equivocal value (which was associated with a non-pregnant animal).

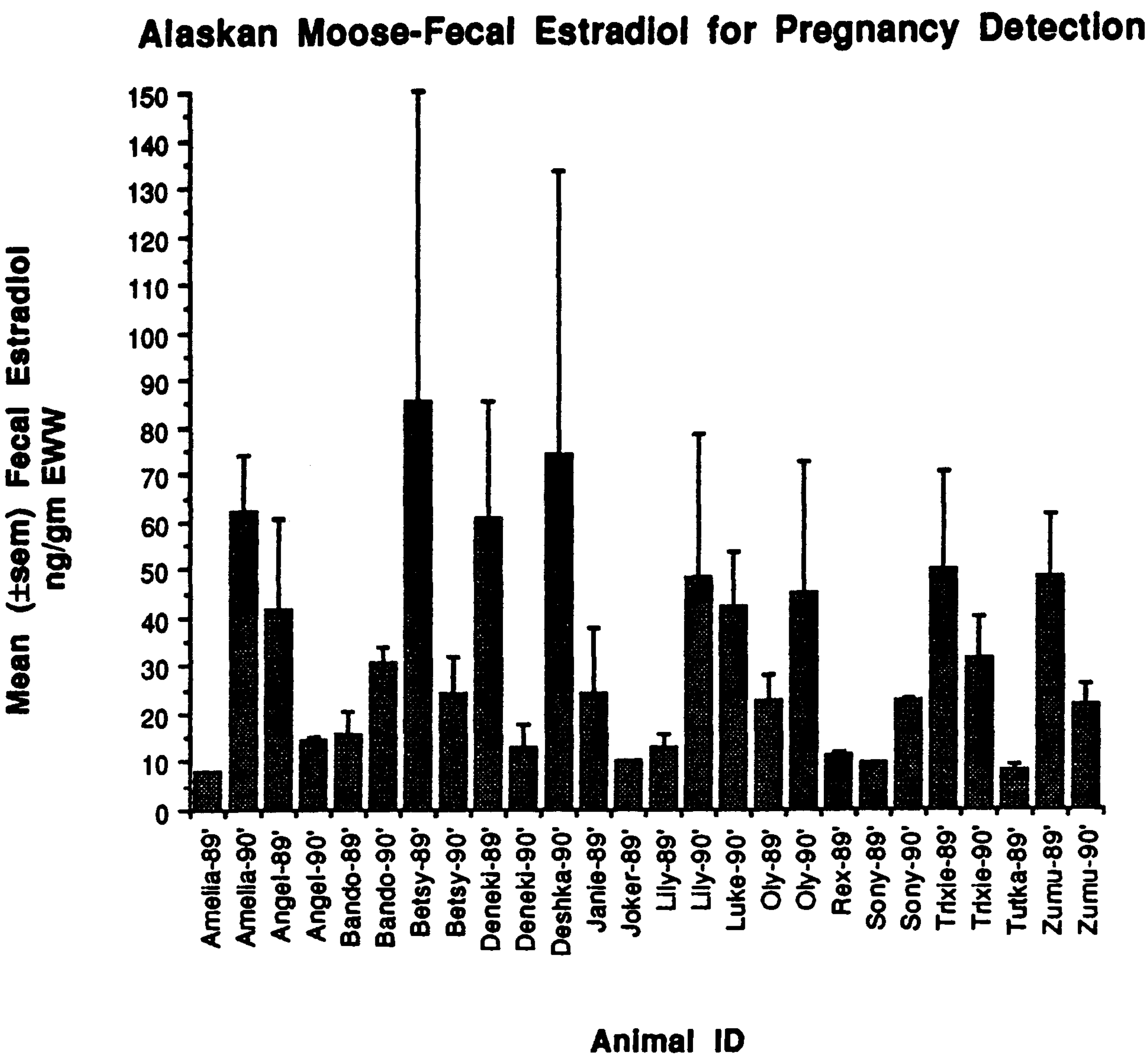


Figure 2. Fecal estradiol (E2) levels for moose housed at the Moose Research Center, Alaska.

Table 1. Dates of sampling, morphometric measurements, BIA measurements, and urea space (US) estimates generated from dilution data collected at 15, 20, and 30 min post-infusion, and US estimates generated by least squares (S(0)) for those animals for which adequate data existed.

| Animal | Date | Weight (kg) | CC | HG (cm) | TL (cm) | R(SD) | $TL^2/R$ | US t=15 | US t=20 | US t=30 | US S(0) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Kobuk | 9/22/90 | 299 | -- | 166 | 266 | 313 | 226.1 | 106.7 | 120.9 | 151.2 | -- |
| | 12/20/90 | 297 | 6 | 184 | 274 | 506 (12.0) | 148.3 | 103.0 | 116.3 | 133.5 | 117.4 |
| | 12/27/90 | 303 | 6 | 164 | 279 | 429 (11.6) | 181.3 | 122.6 | 141.4 | 167.1 | 138.9 |
| | 2/05/91 | 291 | 6 | 158 | 277 | 448 (19.7) | 171.3 | 110.3 | 126.1 | 147.1 | -- |
| Luke | 9/22/90 | 360 | -- | 166 | 266 | 254 (14.8) | 278.2 | 136.5 | 145.6 | 168.0 | -- |
| | 12/20/90 | 367 | 7 | 188 | 294 | 350 (12.9) | 247.0 | 131.0 | 153.6 | 178.1 | -- |
| | 12/27/90 | 366 | 6 | 198 | 289 | 419 (12.2) | 199.3 | --[a] | -- | -- | -- |
| | 1/22/90 | 366 | 6 | 199 | 302 | 425 (9.5) | 214.4 | 98.7 | 177.6[c] | 164.5 | 131.2 |
| Brooks | 11/08/90 | 365 | -- | 188 | 294 | 361 | 239.4 | 157.2 | 185.8 | 227.1 | -- |
| | 1/03/91 | 401 | 7 | 190 | 301 | 409 (12.9) | 221.4 | 143.1 | 162.2 | 187.1 | 152.3 |
| | 1/22/91 | 398 | 7 | 186 | 297 | 382 (17.9) | 230.9 | 142.0 | 172.5 | 201.2 | -- |
| | 2/12/91 | 398 | 6 | 178 | 296 | 391 (10.0) | 223.9 | 130.5 | 161.0 | 201.2 | 159.6 |
| Deneki | 1/16/91 | 451 | 8 | 186 | 311 | 491 | 197.0 | 140.3 | 165.8 | 202.7 | 170.6 |
| | 2/05/91 | 431 | 7 | 180 | 311 | 482 (6.9) | 200.7 | 118.9 | 137.6 | 174.3 | 143.8 |
| Oly | 3/17/91 | 345 | 3 | 162 | 288 | 582 (18.3) | 142.5 | 141.6 | 163.3 | 163.3 | 146.7 |
| Angel | 5/28/91 | 290 | 1 | 194 | 300 | 236 (7.8) | 381.4 | --[b] | -- | -- | -- |

[a] Urea dilution was not performed on this animal
[b] These data have not yet been analyzed
[c] This value is suspect and will be re-analyzed.

Table 2. Regression equations, coefficients of determination ($R^2$), standard errors of the estimate (SEE), and error degrees of freedom (DF) for prediction of moose total body weight (TBW) from total length (TL), heart girth (HG), and condition class (CC), Moose Research Center, 1991.

| Regression equation | $R^2$ | SEE | DF |
|---|---|---|---|
| TBW = 3.29(TL)-604 | 0.63[a] | 34.0 | 11 |
| = 3.22(TL)-0.18(HG)-618 | 0.63[a] | 35.6 | 10 |
| = 2.91(TL)+13.7(CC)-573 | 0.85[a] | 22.7 | 10 |
| = 2.85(TL)+0.16(HG)+13.7(CC)-585 | 0.85[a] | 23.9 | 9 |
| = 3.60(TL)-105(1/CC)-626 | 0.91[a] | 18.9 | 10 |
| = 3.57(TL)-106($1/CC^2$)-675 | 0.91[a] | 17.4 | 10 |

[a] $P<0.01$

Table 3. Reproductive observations of 10 captive female moose at the Kenai Moose Research Center from September to November 1990, and subsequent parturition data.

| Moose | Date of Estrus | Type of Data[a] | Time Between Estrous Period (Days)[b] | Date of Parturition | Length of Gestation (days) | Calf or Calves Sex | Calf or Calves Wt.(Kgs.) |
|---|---|---|---|---|---|---|---|
| Trixie | 12 Oct | O | | 1 Jun | 232 | M | 16.8 |
| Betsy | 25 Oct | O | | 22 Jun | 240 | F | 15.9 |
| Oly | 8 Oct | O | | | | | |
| | 31 Oct | O | 23 | | | | |
| Amelia | 12 Oct | N | | | | | |
| | 2 Nov | O | 24 | 15 Jun | 225 | M | 13.9 |
| | | | | | | F | 11.8 |
| Zumu | 3 Oct | O | | | | | |
| | 27 Oct | O | 24 | 18 Jun[f] | 235 | M | -- |
| | 18 Nov | O | 22 | | | | |
| Sony | 2 Oct | O | | 22 May | 232 | M | 25.9[d] |
| Lily | 7 Oct | O | | 25 May | 230 | M | 13.6 |
| | | | | | | F | 13.2 |
| Deshka[c] | 10 Oct | O | | 3 Jun | 236 | F | 12.3 |
| Lara[c] | --[e] | N | | 22 May | -- | M | 18.6 |
| Sinuk[c] | 9 Oct | N | | | | | |

[a] O = Observed breeding, N = not observed, estrus assumed based on vaginal discharge, rumpled rump hair (from being mounted) and other circumstantial evidence.
[b] Time between first observed mounting of each estrus period.
[c] Yearling
[d] Data collected on 15 June 1991.
[e] Bred sometime before 10 October 1990.
[f] A dead, partially eaten calf was discovered on 19 June.

Table 4. Birth weights and selected subsequent weights of moose calves born at the Moose Research Center in 1990, and their corresponding rates or increase. Means are reported with SD in parentheses.

| | Birth | | Late summer | | Early winter | | Rate of increase (kg/d) | | |
|---|---|---|---|---|---|---|---|---|---|
| Animal name | Weight (kg) | Date | Weight (kg) | Date | Weight (kg) | Date | Birth - late summer | Late summer - early winter | Birth - early winter |
| First estrus calves | | | | | | | | | |
| Sol | 15.6 | 23 May | 203 | 9 Oct | 230 | 1 Dec | 1.34 | 0.51 | 1.11 |
| Luna | 12.9 | 23 May | 177 | 9 Oct | 197 | 1 Dec | 1.18 | 0.38 | 0.95 |
| Terra | 17.9 | 24 May | 188 | 8 Oct | 215 | 2 Dec | 1.24 | 0.49 | 1.03 |
| Mean | 15.4 (2.5) | | 189 (13.1) | | 214 (16.5) | | 1.25 (0.08) | 0.46 (0.07) | 1.03 (0.08) |
| Mean 1988-89 (n = 4) | 14.9 (1.3) | | 178 (9.1) | | 220 (9.6) | | 1.28 (0.06) | 0.59 (0.11) | 1.04 (0.04) |
| Second estrus calves | | | | | | | | | |
| Hydro | 15.6 | 8 Jun | 148 | 8 Oct | 185 | 28 Nov | 1.08 | 0.72 | 0.98 |
| Satorene | 14.3 | 8 Jun | 142 | 8 Oct | 167 | 28 Nov | 1.05 | 0.49 | 0.88 |
| Vickie | 15.4 | 29 Jun | 106 | 8 Oct | 139 | 5 Dec | 0.90 | 0.57 | 0.78 |
| Stripes | 31.5[a] | 24 Jul | 116 | 8 Oct | 151 | 5 Dec | 1.11 | 0.60 | 0.89 |
| Stars | 27.5[a] | 24 Jul | 115 | 8 Oct | 155 | 5 Dec | 1.14 | 0.69 | 0.95 |
| Mean | 15.1 (0.7) | | 125 (18.4) | | 159 (17.5) | | 1.06 (0.09) | 0.61 (0.09) | 0.90 (0.08) |
| Mean 1988-89 (n = 7) | 14.0 (1.4) | | 150 (12.4) | | 187 (9.4) | | 1.24 (0.10) | 0.54 (0.13) | 0.98 (0.04) |

[a] First recorded weight for this calf, which was born 4 July 1990. This weight not used in calculation of mean birth weight.

Table 5. Sex and age of study animals, outcome of pregnancy predictions based upon fecal P4 and E2 concentrations, and ultimate reproductive fate of those animals, Moose Research Center, 1989-90.

| Animal/ Year of Parturition | Sex | Age | Prediction[a] P4 (ng/g EWW) | E2 (ng/g EWW) | Reproductive fate |
|---|---|---|---|---|---|
| Amelia 1989 | F | C | N | N | did not breed |
| 1990 | | Y | N | Y | bred/no calf |
| Angel 1989 | F | A | Y | Y | viable calf |
| 1990 | | | Y | N | bred/no calf |
| Bando 1989 | M | A | N | N | -- |
| 1990 | | | N | E | -- |
| Betsy 1989 | F | A | Y | Y | viable calf |
| 1990 | | | Y | E | viable calf |
| Deneki 1989 | F | A | Y | Y | bred/no calf |
| 1990 | | | N | N | did not breed |
| Deshka 1990 | F | Y | N | Y | did not breed |
| Janie 1989 | F | A | Y | E | bred[b] |
| Joker 1989 | M | A | N | N | -- |
| Lily 1989 | F | C | N | N | did not breed |
| 1990 | | Y | Y | Y | viable calf |
| Luke 1990 | M | Y | N | Y | -- |
| Oly 1989 | F | A | Y | Y | viable calf |
| 1990 | | | Y | Y | viable calf |
| Rex 1989 | M | C | N | N | -- |
| Sony 1989 | F | C | N | N | did not breed |
| 1990 | | Y | Y | E | viable calf |
| Trixie 1989 | F | A | Y | Y | viable calf |
| 1990 | | | Y | Y | viable calf |
| Tutka 1989 | M | C | N | N | -- |
| Zumu 1989 | F | A | Y | Y | viable calf |
| 1990 | | | Y | E | abortion[c] |

[a] Y=pregnant, N=not pregnant, E=equivocal
[b] This animal died during the trial and her pregnancy status could not be ascertained
[c] This animal aborted after samples were collected

Table 6. Mean urinary metabolite values for moose fed various levels of a controlled ration, Moose Research Center, 1990.

| Animal | Diet level (% ad libitum) | Ratio[a] | Jan | Feb | Mar | Apr | May |
|---|---|---|---|---|---|---|---|
| Yogi | 75 | U:C | 4 | 5(1) | 6(1) | 5(2) | 7(5) |
| | | P:Cx1000 | 49 | 23(7) | 29(15) | 37(43) | 45(31) |
| | | Na:Cx100 | 269 | 95(92) | 90(116) | 55(84) | 149(84) |
| | | K:Cx100 | 198 | 110(40) | 116(43) | 93(32) | 143(84) |
| | | Ca:Cx1000 | 23 | 707(421) | 275(233) | 296(193) | 418(272) |
| | | n | 1 | 7 | 11 | 5 | 5 |
| Chief | 100 | U:C | -- | -- | 5 | 5(2) | 6(2) |
| | | P:Cx1000 | -- | -- | 148 | 24(12) | 38(19) |
| | | Na:Cx100 | -- | -- | 0 | 54(64) | 93(92) |
| | | K:Cx100 | -- | -- | 29 | 59(30) | 130(47) |
| | | Ca:Cx1000 | -- | -- | 28 | 68(41) | 516(764) |
| | | n | -- | -- | 1 | 5 | 6 |
| Rex | 85 | U:C | 7 | 5(3) | 6(1) | 6(0.2) | -- |
| | | P:Cx1000 | 24 | 250(365) | 216(215) | 18(4) | -- |
| | | Na:Cx100 | 149 | 133(120) | 28(24) | 27(30) | -- |
| | | K:Cx100 | 165 | 118(45) | 108(41) | 71(94) | -- |
| | | Ca:Cx1000 | 13 | 244(176) | 155(87) | 477(395) | -- |
| | | n | 1 | 8 | 11 | 2 | -- |
| Butch | 100 | U:C | 5(1) | 5(1) | 6(1) | 5(1) | -- |
| | | P:Cx1000 | 196(247) | 59(104) | 33(51) | 18(2) | -- |
| | | Na:Cx100 | 55(49) | 108(133) | 144(120) | 109(87) | -- |
| | | K:Cx100 | 65(48) | 83(43) | 94(61) | 141(49) | -- |
| | | Ca:Cx1000 | 505(258) | 731(543) | 550(466) | 860(438) | -- |
| | | n | 2 | 9 | 10 | 4 | -- |
| Bill | 85 | U:C | 5(2) | 6(2) | 6(1) | 5(1) | -- |
| | | P:Cx1000 | 10(4) | 11(5) | 9(2) | 15(4) | -- |
| | | Na:Cx100 | 129(150) | 130(125) | 29(27) | 49(27) | -- |
| | | K:Cx100 | 55(16) | 103(58) | 75(33) | 63(27) | -- |
| | | Ca:Cx1000 | 157(18) | 490(278) | 817(230) | 812(208) | -- |
| | | n | 2 | 9 | 10 | 4 | -- |

[a] Units of measure are mg/dl for U, P, Ca, and C; mEq/l for Na and K

Table 7. Allele (A, B, and C) frequencies and a measure of heterozygosity (h) for 6 polymorphic loci from a Kenai Peninsula, Alaska moose population.

| Allele | Locus | | | | | |
|---|---|---|---|---|---|---|
| | MDH-1 | PGM-1 | MPI | PEP-2 | PGM-2 | MOD-2 |
| n | 38 | 38 | 38 | 38 | 32 | 38 |
| A | 0.000 | 0.000 | 0.368 | 0.250 | 0.031 | 0.263 |
| B | 0.987 | 0.895 | 0.632 | 0.737 | 0.969 | 0.737 |
| C | 0.013 | 0.105 | 0.000 | 0.013 | 0.000 | 0.000 |
| h | 0.026 | 0.211 | 0.368 | 0.395 | 0.063 | 0.472 |

APPENDIX A.

## Winter Habitat Use by Moose in Southeastern Alaska: Implications for Forest Management

**Kris J. Hundertmark[1], Wayne L. Eberhardt[2], and Ronald E. Ball[3]**

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ABSTRACT: Habitat use by moose (*Alces alces*) was monitored via radio telemetry from November 1981 through April 1983, a period that included a low-snow and a high-snow winter. In the low-snow winter, moose used coniferous, mixed hardwood/conifer, and cut areas in proportion to availability, preferred deciduous stands, and avoided open areas. In the high-snow winter, moose altered their habitat use by utilizing coniferous and mixed stands significantly more, and deciduous and cut areas significantly less, than in the low-snow winter. Moose avoided snow >80 cm deep. Implications for forest management are discussed.

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APPENDIX B.

**Are Sex-pheromones Involved in Moose Breeding Behavior?**

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ABSTRACT: Evidence is presented that saliva of bull moose (*Alces alces gigas*) contain 16-unsaturated $C_{19}$ steroids. These pheromones have been identified in red deer (*Cervus elaphus hippelaphus*) and wild boar (*Sus scrofa*) and operate in the latter as a potent primer stimulating estrus and copulation readiness in the sow. Saliva samples collected from mature bull moose contained a mean concentration 0.48 ng/ml ($\underline{n}$=15, SD=0.17) of 5androst-16-en-3-one. Using thinlayer-chromatography, the musk-scent components were identified as 5a-androst-16-en-3a-ol (3.5 ng/ml) and 5a-androst-16-en-3b-ol (3.5 ng/ml). Bull moose produced signalling pheromones in concentrations 10-20 times lower than those of the boar. Additional research is required to determine the role of the compounds in rut synchronization and induced estrus.

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APPENDIX C.

## Seasonal Activity Patterns of Moose on the Kenai Peninsula, Aalaska

**John S. Bevins[1], Charles C. Schwartz[2], and Albert W. Franzmann[2]**

[1]Deceased, John was lost at sea north of Barrow, Alaska on a polar bear survey flight on October 11, 1990. This paper was prepared by him before his death. John was associated with the Alaska Coop. Wildl. Res. Unit, University of Alaska, Fairbanks; [2]Alaska Department Fish and Game, Moose Research Center, Soldotna, AK 99669.

ABSTRACT: We obtained monthly estimates of 24-hour activity patterns of moose (*Alces alces*) on the Kenai Peninsula, Alaska, during winter and summer. Activity levels of moose during winter ovelapped between areas of high and low deciduous browse availability. Shorter resting periods occurred during summer months ($\underline{x}$=105 min), than during winter months ($\underline{x}$=171 min), resulting in increased activity levels from winter ($\underline{x}$=486 min) to summer ($\underline{x}$=622 min). No consistent pattern was found in the difference in active period length between summer ($\underline{x}$=80 min) and winter ($\underline{x}$=81 min). Estimates are useful for predicting total energy expenditure of moose. Large variations in activity levels among moose points out the importance of obtaining unbiased samples from populations.

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APPENDIX D.

## Moose Husbandry in North America

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ABSTRACT: Moose (*Alces alces*) have been maintained in captive and semi-captive conditions since the time of fur traders in North America for 3 general purposes: display in zoological gardens, scientific research, and commercial production. Husbandry techniques summarized are from a survey of the major zoos and game farms in North America. Additional data from the Moose Research Center, of the Alaska Department of Fish and Game are presented. Techniques for care, rearing, maintenance, feeding, and housing of moose are reviewed and discussed. Adequately designed facilities are constructed with a minimum of 7 ft (2.13 m) woven wire fence and contain a shelter. Moose are fed fresh cut browse and other green plant material, but the development of a formulated ration which meets the nutrient requirements has simplified feeding and reduced labor costs. With adequate shelter, moose can tolerate extreme cold, but warm temperatures impose stress; adequate shelter and cooling areas are essential. Disease and other illness, particularly in calves, can result in high mortality.

APPENDIX E.

**Physiological and nutritional adaptations of moose to northern environments**

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ABSTRACT: Moose (*Alces alces*) exploit the boreal forest where food resources have high quality and availability during long winters. To accommodate this fluctuating environment, moose store large quantities of fat during summer and fall which helps to offset their winter energy deficit. Annual rhythms are keyed to this cycle. Intake rates vary seasonally and correspond with nutrient quality and forage availability. Moose are hyperphagic in summer and reduce food intake during winter. Activity budgets vary among environments and seasons with foraging and resting/ruminating occupying most of their time. Metabolism follows a circannual cycle that peaks in mid-summer with a nadir in late-winter; peak metabolism corresponds to maximum energy intake and storage. Moose are classified as seasonally adaptable concentrate selectors that choose a diet primarily of browse forage and twigs. This diet is high in lignin as well as readily digestible nutrients. Energy and protein requirements are similar to other cervidae. Body composition, like metabolism and intake, is dynamic seasonally. Nutritional adaptations stabilize energy balance and allow moose to withstand energy shortages in a fluctuating environment.

WILDLIFE RESTORATION

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