ALASKA DEPARTMENT OF FISH AND GAME
DIVISION OF WILDLIFE CONSERVATION
PO Box 115526
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Alaska Department of Fish and Game
Wildlife Restoration Grant

GRANT NUMBER: AKW-23

PROJECT NUMBER : 21.0

PROJECT TITLE: Evaluation and testing of techniques for ungulate management and operation of the Kenai Moose Research Center

PERIOD OF PERFORMANCE: July 1, 2017 – June 30, 2018

REPORT DUE DATE: September 1, 2018

PRINCIPAL INVESTIGATORS: John Crouse and Dan Thompson

COOPERATORS: USFWS Kenai NWR; Dr. Perry Barboza, Texas A&M University; Drs. John and Rachel Cook (National Council of Air and Stream Improvement); Dr. Tom Stephenson (California Department of Fish and Game); Drs. Véronique St-Louis and Michelle Carstensen (Minnesota DNR); Dr. Lisa Shipley, Washington State University; Stephanie Berry (PhD candidate), University of Montana

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Authorities: 2 CFR 200.328
2 CFR 200.301
50 CFR 80.90

I. PROGRESS ON PROJECT OBJECTIVES DURING PERIOD OF PERFORMANCE

OBJECTIVE 1: MRC maintenance and operations.

ACCOMPLISHMENTS: We maintained 14 adult moose during the last reporting period including 3 males and 11 females. Females were held within Pens 2 and 3; separate from the males in Pen 1 throughout the year. One female was killed by a brown bear on 25 April. The males were fed 13% Reindeer Ration (80 kg/animal/week) 1 November – 15 March while they were held in Pen 2-A during replacement of the north perimeter fence of Pen 1. After being returned to Pen 1 in mid-March, the males were fed 13% Reindeer Ration (20 kg/animal/week) through late-April to supplement their intake of native vegetation. The females were fed 13% Reindeer Ration (20 kg/animal/week) February through late-April to supplement their intake of native vegetation.

We weighed and chemically immobilized female moose to measure rump fat and loin muscle thickness and collect blood, urine and feces in September, December and March to monitor resource allocation to fat and lean mass. The males were chemically immobilized concurrently with the females during December when all animals were provided vitamin and mineral supplementation and clostridium vaccination.

The Kenai National Wildlife Refuge (KNWR) obtained funding through their deferred maintenance program and contracted TBI Construction (Wasilla) to replace approximately 1 mile of the Pen 1 perimeter fence. Construction activities began in November once the ground was sufficiently frozen and were completed in early-February. We occasionally observed a few wild moose in Pen 1 following tear down of the original fence, but several ground and aerial surveys once construction was completed verified no moose were in the pen prior to returning our tame males.

OBJECTIVE 2: Determine intake and diet composition of moose.

ACCOMPLISHMENTS: We obtained two video camera collars (Lotek model GPS3300L) through Rachel Cook (NCASI) and fit them on 2 adult female moose at the Kenai Moose Research Center during July 2018. Cameras were programmed to record video from 6:00 – 9:00 AM and 7:00 – 10:00 PM daily. Memory cards within each camera were capable of storing up to 100 h of video footage. We directly observed animals while the cameras were recording during 13 – 26 July (~60h) to record bite rate (bites/minute), diet composition (bites taken per species/total number of bites taken), and instantaneous dry matter intake rates (bite rate * diet composition * bite mass). These data will be used to assess the accuracy of the video collars for sampling foraging ecology, to identify limitations of data collected using the collars, and to identify field and technological modifications that may improve accuracy and reliability.

Anecdotally, we have observed some important limitations of the cameras. There are head positions where the mouth is out of view of the camera. In addition, dense vegetation sometimes obscures the camera view. Environmental factors, such as sun angle and rain, affect the quality of the video footage, and thus may affect how well observers are able to identify what the animals are eating. As well, some technological issues with the collars substantially reduced the total hours cameras were able to collect data (1 camera recorded only 54h of video).

We are collaborating with others to combine our moose observations with similar efforts conducted with elk, caribou and mule deer. A comprehensive analysis across species will help us to better understand how the cameras can be used to study foraging ecology of large ungulates.

OBJECTIVE 3: Determine nutritional intake of moose.

ACCOMPLISHMENTS: Analyses of Cr marker concentrations, plant nutrients, plant fibers, and plant phenolics were completed for all samples collected in 2014, 2015 and 2016 (CT 160001994, Texas A&M AgriLife Research). Pellets from each individual fecal sample were pooled to make composite diets for each moose which spanned a period of approximately 2 weeks. Microhistological analyses of composite diets (n=208) were completed (PO 11 170017665-1, Washington State University Wildlife Habitat and Nutrition Laboratory). Initial analyses suggest shrubs comprised the majority of the diet, however, graminoid intake was significant early in the summer and forb consumption increased towards late June and averaged about one-third of the overall diet. In general, digestible energy intake, digestible nitrogen intake and fecal phenol concentrations decreased through the summer, but further analyses are required before any robust conclusions can be made.

OBJECTIVE 4: Determine how summer food intake relates to condition of the female and the growth of her calf.

ACCOMPLISHMENTS: We estimated intakes using fecal output estimates (based on marker concentration in feces) and the microhistology results corrected for digestibility. Mean summer food intake was high and variable ($\bar{X}$ = 21.4 kg dry matter (± 10.8). A large portion of the variation in estimates was likely due to differences in the marker concentration among pelletized food batches, a small daily Cr marker dose relative to total ingesta volume, and perhaps daily variations in fecal Cr concentrations. Reproductive effort influenced early winter body weight and fat reserves. Adult females averaged 14% heavier and had 6% more body fat in years when they did not lactate.

OBJECTIVE 5: Vegetation management.

ACCOMPLISHMENTS: KNWR Fire Management Staff, with MRC staff assisting, continued pile burning in Pen 4. Forty acres were accomplished during January – March. Fifty acres were scheduled for burning, but snow loads on top of the piles and insufficient wind during burn days hampered efforts. The remaining unburned 10 acres of piles will dry out over summer of 2018 and burned during the fall, or early winter.

OBJECTIVE 6: Preparation of study plans, reports and publications.

ACCOMPLISHMENTS:

Cook, R. C., **J. A. Crouse**, J. G. Cook, and T. R. Stephenson. 2019. Nutritional condition indices for caribou: evaluating accuracy, precision and sensitivity. **<u>In Prep.</u>**

Cook, R. C., L. Shipley, S. Berry, and **J. A. Crouse** (and others). 2019. Evaluation of Video Collars for Use in Foraging Ecology Studies of Large Ungulates. **<u>In Prep.</u>**

Shively, R. D., **J. A. Crouse**, **D. P. Thompson**, and P. S. Barboza. 2019. Food intake and food selection of female moose in summer: lactation and the window of plant growth for moose in late successional habitats. **<u>In Prep.</u>**

Thompson, D. P., P. S. Barboza , **J. A. Crouse**, T. J. McDonough, O. H. Badajos, and A. M. Herberg. 2018. Body temperature patterns vary with pregnancy and condition in moose (Alces alces). **In Review.**

Thompson, D. P., J. A. Crouse, T. J. McDonough, P. S. Barboza, and S. Jaques. 2019. Acute Thermal and Stress Response to Chemical Immobilization in Moose. **<u>In Prep.</u>**

Thompson, D. P., S. Jaques, **J. A. Crouse**, T. J. McDonough, and P. S. Barboza. 2019. Comparing assays and blood mediums for measuring cortisol in moose. **<u>In Prep.</u>**

Thompson, D. P., P. S. Barboza, **J. A. Crouse,** and S. Farley. 2019. Redefining the thermal response in moose. **In Prep.**

Thompson, D. P., J. A. Crouse, P. S. Barboza, T. J. McDonough, and O. H. Badajos. 2019. Thermal environments for moose productivity. **In Prep.**

II. SUMMARY OF WORK COMPLETED ON PROJECT TO DATE.

We designed and tested two supplemental formulations to administer the indigestible marker Cr to moose in winter 2014. Moose were remarkably sensitive to small changes in the ingredients of the formulation. We therefore used a familiar "Reindeer" ration to convey the marker at 0.22% of dry mass (Alaska Pet and Garden, Anchorage AK). Moose were gradually accustomed to consuming a daily dose of approximately 500g ration with the marker in spring 2014. We subsequently fed the marker ration daily from early May through late August 2014, 2015, 2016. During the periods animals consumed the marker ration, we collected fecal samples twice weekly from each animal and clipped plant forage samples (5 species) once each month.

We devised a simulation model in the program STELLA (version 10.06 ISEE Systems, Lebanon NH) to examine the sensitivity of the estimation method to variation in the consumption of the marker ration and the quality of the diet. The model predicted that marker concentrations in the feces would equilibrate after 5 days of dosing the marker at 15 $mg \bullet g^{-1}$.

All samples of plants, food and feces were dried to constant mass in a freeze dryer in preparation for analysis. Samples of the supplement and feces were homogenized and analyzed for the marker (Cr) by acid digestion and emission spectrometry. Plant samples were assayed for total ash, total nitrogen, neutral and acid detergent fibers and lignin (Thompson and Barboza 2013, 2014). Digestibility of dry matter and total nitrogen were measured by in vitro digestion of plants (VanSomeren et al. 2015). Total phenolics, an index of toxins, were assayed in both feces and plants (Singleton et al. 1999).

We have observed 15 moose pregnancies, 28 moose calves born alive, 21 moose calves survive to late-August, 13 moose lactation periods, and 17 moose non-lactation periods. We have completed 64 adult chemical immobilizations and 21 calf (late-August) chemical immobilizations without complications. The one problem we have observed is the failure to break of the loop-stitching in the Telonics MOD-335 and ATS MOD-4200 expandable calf collars. As a result, 1 calf suffered a deep skin wound on the dorsal surface of the neck when the collar did not expand. Subsequently, we manually released the stitching on all calf collars allowing the collars to expand and observed no further issues.

III. SIGNIFICANT DEVELOPMENT REPORTS AND/OR AMENDMENTS.

Expandable bull collar development

During the spring of 2017, we collaborated with Telonics to develop an expandable GPS collar that could be deployed on a 10-month-old bull moose. The collar was designed to expand for growth over 5 years using both surgical tubing and a bungee cord. This design also allows the collar to expand for neck swelling during rut. We deployed the collar on our captive bull, Flash, at 14 months of age during July of 2017. The collar was deployed through November, at which time the expandable bungee was broken, resulting in the Kydex sleeve failing and the collar dropping off. This may have been due to Flash, along with the other 2 bulls, being kept in a small 17-acre enclosure, increasing conflicts between bulls and increasing the chances of the collar being caught on the fence. The collar was returned to Telonics, where they replaced the bungee and inserted a new, metal sleeve. The collar was then redeployed on Flash during March 2018. During late spring 2018, the surgical tubing section of the collar released, allowing the collar to expand to adult size, and observations of Flash during the summer of 2018 indicate the collar is functioning as designed.

Core Body Temperature Measurements - development and evaluation

We evaluated a vaginal implant transmitter (TVIT) modified to collect continuous body temperature of captive and wild female moose. We deployed TVITs in 18 moose between 2014 and 2016 at the MRC and in GMU 15A and 15B. We manually removed the TVIT after 51–338 days of deployment and sampled vaginal bacterial flora to assess negative effects of TVIT retention. For comparison, we also sampled vaginal flora from moose that did not have a TVIT. Mean bacterial growth scores were greater for moose with a TVIT than representative vaginal swabs from moose without a TVIT. The TVIT adequately collected body temperature measurements; however, the TVIT design could be improved to fit young, nulliparous moose. TVITs can be easily deployed and removed, but are limited by battery life, can only be deployed in adult female moose, and may increase vaginal bacterial concentrations.

We compared rumen temperatures collected using Mortality Implant Transmitters (MIT) to temperatures collected using vaginal implant transmitters (TVITs) in 8 captive female moose (>2-years-old) at the Kenai Moose Research Center during 2015. Both devices collected continuous body temperature measurements at 5-min intervals for 1 year. We directly observed moose behavior for 384 hr during 4 2-week windows distributed seasonally within the sampling period, to assess potential effects of behavior on MIT-recorded temperatures. We documented a decrease in MIT-recorded temperatures following water intake and developed an approach for censoring these observations. After removing these observations, MIT-based temperatures were, on average, 0.038°C (95% CI= - 0.57–0.558°C) lower than TVIT-based temperatures. We fit linear mixed-effects models to test the relationship between MIT and TVIT-based temperatures across seasons and individuals. On average, the difference between predicted and observed temperatures was 0.058°C(95% PI = - 0.19–0.298°C) and 0.338°C (95% PI = 0.01–0.638°C) for winter and summer seasons, respectively. We conclude that minimally invasive MITs can accurately record internal body temperature in moose, and thus provide a tool for understanding physiological and behavioral responses of moose to environmental stressors.

Thermoregulation and stress hormone responses

We studied moose to examine the effects of endogenous and exogenous factors on core body temperature at seasonal and daily time scales. We recorded continuous core body temperature (Tv) in adult female moose with a modified vaginal implant transmitter at the MRC and in GMU 15A and 15B. Core body temperature in non-pregnant, wild moose showed a seasonal fluctuation, with a higher daily mean Tv during the summer (37.9 °C) than in winter (37.4 °C). Daily change in core body temperature (ΔTv) was greater in summer (0.98 °C) than winter (0.67 °C). In comparison with non-pregnant moose, core body temperature of pregnant moose was warmer (0.2 °C higher Tv) and less variable (0.04 °C lower ΔTv). During winter, core body temperature was lower (Tv) and more variable (ΔTv) as body fat decreased among female moose. Ambient temperature, vapor pressure and wind speed accounted for a large amount of the residual variation in Tv after accounting for variation attributed to season, reproductive status, population and individual. Ambient temperature and solar radiation had the greatest effect on the residual variation of ΔTv. Our study suggests that adult female moose exhibit traits of hypothermia induced heterothermy, and that body temperature is influenced by pregnancy and body energy reserves within seasons and by environmental conditions within days.

We are evaluating the thermal and stress response of moose to chemical immobilization. We recorded continuous core body temperature (Tv) in adult female moose with a modified vaginal implant transmitter after immobilization at the MRC and in GMU 15A and 15B. We collected serum and fecal samples from immobilized moose to assess stress hormone levels prior (fecal) and during (serum) the immobilization event. Additionally, we collected fecal samples from captive moose for 1 week prior, and 2 weeks after an immobilization to evaluate how long the immobilization event may influence moose stress response. Preliminary data analysis indicates that moose, both captive and wild, show a response to immobilization with an elevated core body temperature for 1-2 days post immobilization, and some of this can be attributed to stress levels. We are waiting hormone analysis to finish this manuscript.

Stress hormones can be analyzed from two mediums collected from blood by different assays. We are comparing the levels of cortisol analyzed from moose serum and moose plasma to determine which medium provides the most robust values by conducting inter and intra assay comparisons. Furthermore, we are comparing assay techniques by evaluating the same serum or plasma sample with radioimmunoassay and chemiluminescence to establish relationships between these two techniques. Radioimmunoassay is the “gold standard” for hormone analysis, however, the use of radioactive materials makes this assay expensive and requires additional regulation. Samples have been collected for these comparisons and have been submitted for analysis.

We are reevaluating the thermal response of moose to warm temperatures. We recorded continuous core body temperature (Tv) in adult female moose at the MRC with a modified vaginal implant transmitter and paired this with measurements of heart rate (n = 721; observed or with a polar heart rate belt), respiration rate (n = 1065), respiration temperature (n = 75), and ear temperature (n=206; FLIR camera). These physiological responses of moose will then be evaluated to determine at what operative temperature ranges moose begin to thermoregulate and potentially become heat stressed.

We collected fine scale (30-minute fix rate) GPS locations for 50 adult cow moose in GMU 15A and 15B over 3 years from 2014-2017. In addition, we recaptured a subset of these animals every spring and autumn for body condition assessment and pregnancy status. All GPS collars have been retrieved and offloaded, resulting in 1.7 million moose locations. We plan to utilize either step selection functions or hidden Markov models to evaluate if moose are selecting habitats based on their state (i.e. body condition, pregnant, calf at heel), or how habitat selection influences the state of an animal (i.e. summer habitat selection influencing autumn body condition). Climate conditions will also be evaluated to determine if moose may be using behavioral choices by selecting habitat to minimize thermoregulatory demands. Presently, we are waiting on the final version of the Kenai Vegetation Map (winter 2018) to complete analysis of this dataset.

<u>Contrasting nutritional condition and reproductive performance between early and late seral boreal forests of the Kenai Peninsula</u>

We initiated a long term, course scale moose location study using GPS collars (GPS locations every 4 hours). Obtaining course scale data will determine differences for individual moose over 5 years and changes to home ranges in association with the Funny River Fire in 15B. Furthermore, we can assess current habitat use and any response to future prescribed or wildland fires facilitated by the fuel breaks along the wildland/urban interface in 15A. Course scale GPS collars were deployed on moose in the autumn of 2016 and spring of 2017 in both 15B in the Funny River Fire footprint (n=25), and in GMU 15A (n=25) along the wildland/urban interface from Sterling to Nikiski. A subset of collared moose was recaptured for body condition assessment and pregnancy status in autumn 2017 (n=37) and spring 2018 (n=20). Additionally, we captured and weighed 27 calves during the spring of 2018, and deployed GPS collars on 15 of the female calves. Parturition surveys were also flown during May and June, 2018.

<u>Vegetation Map</u>

In 2016, ADFG partnered with the U.S. Forest Service, U.S. Fish and Wildlife Service, Kenai Peninsula Borough, and Ducks Unlimited to create a vegetation map for the Kenai Peninsula. MRC staff collected field data in July 2017 by navigating to 56 predefined locations on the Northern Kenai Peninsula in GMU 15A and 15B and measured vegetation cover and species abundance. Data collected from these points was then used to calibrate vegetation polygons created by remote sensing.

IV. PUBLICATIONS

Minicucci, L., M. Carstensen, **J. Crouse**, J. M. Arnemo, and A. Evans. 2018. A technique for deployment of rumen bolus transmitters in free-ranging moose (Alces alces). Journal of Zoo and Wildlife Medicine 49(1):227-230. doi:10.1638/2017-0027R.1

Thompson, D. P., J. A. Crouse, T. J. McDonough, O. H. Badajos, J. Adsem, and P. S. Barboza. 2018. Vaginal implant transmitters for continuous body temperature measurement in moose. Wildlife Society Bulletin 42:321–327. doi.wiley.com/10.1002/wsb.857

Herberg, A. M., V. St-Louis, M. Carstensen, J. Fieberg, **D. P. Thompson, J. A. Crouse**, and J. D. Forester. 2018. Calibration of a rumen bolus to measure continuous internal body temperature in moose. Wildlife Society Bulletin 42:328–337. doi: 10.1002/wsb.894

V. RECOMMENDATIONS FOR THIS PROJECT

Prepared by: John Crouse and Dan Thompson

Date: August 21, 2018