HEALTH ASSESSMENT OF SHIRAS MOOSE IMMOBILIZED WITH THIAFENTANIL

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ABSTRACT: Seventy-three (30 male, 43 female) free-ranging adult Shiras moose (*Alces alces shirasi*) were captured in southeastern and northwestern Wyoming, blood sampled, and radio-collared in 2004 and 2005. Moose were darted from the ground and air using 10 mg thiafentanil. Blood samples were analyzed for hematology, serum chemistry, cortisol, and bacterial and viral serology. Selected serum chemical parameters and cortisol were analyzed as indicators of physical exertion or physiological stress and none of these parameters suggested that moose were stressed as a result of capture. Hematologic parameters were considered within normal limits. Moose were serologically negative for *Brucella*, *Leptospira*, infectious bovine rhinotracheitis virus, bovine viral diarrhea virus, parainfluenza-3 virus, and bovine respiratory syncytial virus. Fecal and ear swab analysis and examination of the moose indicated that they were relatively free of ecto- and endoparasites. Three moose died within 30 days of capture for reasons probably associated with the capture effort.

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Shiras moose (*Alces alces shirasi*) are the smallest subspecies of North American moose found in parts of Wyoming, Colorado, Utah, Idaho, Montana, Alberta, and British Columbia (Bubenik 1998). Mortality of Shiras moose in northwestern Wyoming has subjectively appeared to increase in recent years. Very few carcasses have undergone extensive necropsy because of their condition when found and no tentative diagnoses have been made. To examine this phenomenon further, a multi-year study has been undertaken to capture, sample, and track moose in an effort to assess survival and mortality factors.

Additionally, we wished to evaluate the efficacy of thiafentanil for the immobilization of Shiras moose. Thiafentanil is a potent opioid that has been used to capture Shiras moose (McJames et al. 1994), but no information regarding physiological parameters of captured moose has been reported while using this drug.

Therefore, the purpose of this report was to obtain hematologic and serum chemical values to evaluate the health of captured Shiras moose, establish reference values for future data collection, and evaluate thiafentanil as a capture drug for moose.

METHODS

Capture of moose took place in northwestern Wyoming in Jackson Hole, in the vicinity of Moran Junction, during February 2004 and 2005 and in southeastern Wyoming in the Snowy Range region of the Medicine Bow National Forest in December 2004. The southeastern moose were captured as part of a habitat utilization study but samples were

taken to compare to the northwestern population. Capture techniques included darting from the ground and aerial darting from a helicopter. Only adult female moose were captured in February 2004 using ground approach. Subsequent captures of both sexes were from the ground and the air. The ground approach employed laser range finders (Bushnell, Overland Park, Kansas, USA) to ensure range accuracy while using CO_2-powered, adjustable dart guns (Dan-Inject North America, Fort Collins, Colorado, USA). The helicopter darting utilized a .22-caliber blank dart gun (Model 193, Pneu-dart, Williamsport, Pennsylvania, USA) with open sights. All guns fired 13 mm, 1.5 ml darts equipped with 32 mm barbed needles (Pneu-dart, Williamsport, Pennsylvania, USA). A pre-loaded dose of 10 mg thiafentanil (A-3080®, Wildlife Pharmaceuticals, Fort Collins, Colorado, USA) was used for all moose, based on previous reports for Shiras moose (McJames et al. 1994). When helicopter capture was employed, ground crews were often utilized to locate and collect biological samples from moose.

Induction times and recovery times were measured by digital stopwatches. Once immobilized, technicians blindfolded, radio collared, (Telonics, Inc., Mesa, Arizona, USA; Advanced Telemetry Systems, Isanti, Minnesota, USA) and collected samples from moose. Fecal samples and ear swabs were collected for parasitic evaluation, while blood samples were collected for: (1) serum chemical analyses (Vetex, Alfa Wasserman, West Caldwell, New Jersey, USA); (2) hematologic analyses (Hemavet 850FS, Drew Scientific, Oxford, Connecticut USA); (3) cortisol concentration (Immulite, Diagnostic Products Corporation, Los Angeles, California USA); and (4) bacterial and viral serology. Moose were given oxytetracycline antibiotics in the event that the dart caused infection (OxyCure 200, Vedco Inc., St. Joseph, Missouri, USA). Thiafentanil was antagonized with 300 mg naltrexone (Trexonil®, Wildlife Pharmaceuticals, Fort Collins, Colorado, USA) administered one-half intramuscularly and one-half subcutaneously.

Descriptive statistics were used to report means and standard errors along with upper and lower 95% confidence intervals. One-way Analysis of Variance was used in comparisons where appropriate. This study was approved by the University of Wyoming Animal Care and Use Committee.

RESULTS

Ten adult female moose in the northwest were immobilized in February 2004, 16 adult southeastern moose (5 male, 11 female) were captured in December 2004, and 47 adult moose (25 male, 22 female) in the northwest were captured in February 2005. Not all analyses were conducted on all moose due to lost or poor quality blood samples. White blood counts (WBC) for the female moose captured in February 2004 were discarded due to laboratory error. Physiological data among different groups could not be compared statistically because the conditions of capture and time to blood sampling could not be controlled. Moose were pursued for 0.25 – 3.0 min before being darted and moose darted on the ground were usually blood sampled in < 5 min after induction whereas some moose darted from a helicopter were not located and sampled for > 60 min post induction. Thus, only descriptive statistical data were reported based on sex and method and location of capture (Tables 1 and 2). Induction times for moose darted on the ground (2.4 ± 0.4 min) were generally lower than moose darted from helicopters (3.6 ± 0.2 min; Table 3), but concentrations of the stress hormone, cortisol, did not appear to correlate with any pattern of capture method (Table 4). Immobilizations were characterized by moose remaining sternal, head upright, slight rigidity, and slight responsiveness to tactile stimulation. The mean recovery time (time from naltrexone administration to standing) for all groups was 2.9 ± 0.2 min. Recoveries

Table 1. Serum chemical analyses of Shiras moose chemically captured in Wyoming.

Parameter (Units)	Method[1]	Sex (*n*)	Mean ± S.E.	95% C.L.[2]
Albumin (g/dl)	Air	Male (27)	2.7 ± 0.1	2.5 – 2.8
	Ground	Male (3)	3.3 ± 0.2	2.5 – 4.1
	Air	Female (30)	3.1 ± 0.1	2.9 – 3.3
	Ground	Female (10)	3.5 ± 0.1	3.2 – 3.9
Alkaline Phosphatase (U/l)	Air	Male (27)	200.0 ± 15.3	168.4 – 231.4
	Ground	Male (3)	223.3 ± 50.0	8.4 – 438.2
	Air	Female (30)	258.2 ± 27.1	202.9 – 313.6
	Ground	Female (10)	257.1 ± 27.7	194.5 – 320.0
Aspartate Aminotransferase (U/l)	Air	Male (27)	64.7 ± 4.3	55.8 – 73.6
	Ground	Male (3)	65.0 ± 10.0	22.0 – 108.0
	Air	Female (30)	63.4 ± 2.6	58.2 – 68.6
	Ground	Female (10)	74.9 ± 4.1	65.6 – 84.1
Blood Urea Nitrogen (mg/dl)	Air	Male (27)	4.1 ± 0.5	3.2 – 5.0
	Ground	Male (3)	4.7 ± 1.2	-0.5 – 9.8
	Air	Female (30)	3.6 ± 0.3	3.0 – 4.3
	Ground	Female (10)	4.2 ± 0.8	2.4 – 5.9
Calcium (mg/dl)	Air	Male (27)	8.0 ± 0.3	7.4 – 8.6
	Ground	Male (3)	9.0 ± 0.2	8.1 – 9.9
	Air	Female (30)	8.8 ± 0.3	8.2 – 9.4
	Ground	Female (10)	10.1 ± 0.2	9.7 – 10.5
Creatine Kinase (U/l)	Air	Male (27)	125.5 ± 14.8	95.1 – 155.8
	Ground	Male (3)	103.3 ± 4.8	82.6 – 124.0
	Air	Female (30)	130.7 ± 15.1	99.8 – 161.6
	Ground	Female (10)	323.7 ± 112.0	70.4 – 577.0
Gamma-glutamyl Transferase (U/l)	Air	Male (27)	12.1 ± 1.6	8.8 – 15.4
	Ground	Male (3)	14.0 ± 2.1	5.0 – 23.0
	Air	Female (30)	14.1 ± 1.4	11.3 – 16.9
	Ground	Female (10)	16.1 ± 1.8	12.0 – 20.2
Globulins (g/dl)	Air	Male (27)	3.4 ± 0.2	3.1 – 3.8
	Ground	Male (3)	3.7 ± 0.5	1.6 – 5.7
	Air	Female (30)	3.4 ± 0.1	3.1 – 3.7
	Ground	Female (10)	4.8 ± 0.4	4.0 – 5.6
Lactate Dehydrogenase (U/l)	Air	Male (27)	186.6 ± 12.5	160.9 – 212.3
	Ground	Male (3)	209.3 ± 18.0	132.0 – 286.7
	Air	Female (30)	202.6 ± 9.9	182.4 – 222.8
	Ground	Female (10)	236.7 ± 16.9	198.4 – 275.0

Table 1. (continued...) Serum chemical analyses of Shiras moose chemically captured in Wyoming.

Parameter (Units)	Method[1]	Sex (*n*)	Mean ± S.E.	95% C.L.[2]
Magnesium (mg/dl)	Air	Male (27)	2.0 ± 0.1	1.8 – 2.2
	Ground	Male (3)	2.2 ± 0.2	1.4 – 3.1
	Air	Female (30)	2.2 ± 0.1	2.1 – 2.4
	Ground	Female (10)	2.7 ± 0.1	2.5 – 2.8
Phosphorous (mg/dl)	Air	Male (27)	4.1 ± 0.2	3.6 – 4.6
	Ground	Male (3)	4.2 ± 0.6	1.6 – 6.9
	Air	Female (30)	4.0 ± 0.2	3.6 – 4.4
	Ground	Female (10)	4.2 ± 0.2	3.7 – 4.6
Total Protein (g/dl)	Air	Male (27)	6.0 ± 0.2	5.7 – 6.4
	Ground	Male (3)	6.9 ± 0.3	5.7 – 8.2
	Air	Female (30)	6.5 ± 0.2	6.1 – 7.0
	Ground	Female (10)	8.3 ± 0.2	7.8 – 8.8

[1]Moose were darted with 10 mg thiafentanil either by ground personnel or from a helicopter.

[2]Lower and upper 95% confidence limits.

Table 2. Hematologic analyses of Shiras moose chemically captured in Wyoming.

Parameter (Units)	Method[1]	Sex (*n*)	Mean ± S.E.	95% C.L.[2]
Hematocrit (%)	Air	Male (25)	51.7 ± 1.0	49.7 – 53.7
	Ground	Male (3)	52.3 ± 1.2	47.2 – 57.4
	Air	Female (29)	52.7 ± 0.9	50.8 – 54.5
	Ground	Female (9)	52.2 ± 2.1	47.4 – 57.0
Hemoglobin (g/dl)	Air	Male (25)	16.0 ± 0.4	15.1 – 16.9
	Ground	Male (3)	14.5 ± 1.0	9.9 – 19.0
	Air	Female (29)	16.9 ± 0.3	16.3 – 17.6
	Ground	Female (9)	16.4 ± 0.6	15.1 – 17.7
Mean Corpuscular Hemoglobin Concentration (g/dl)	Air	Male (25)	31.1 ± 0.9	29.2 – 33.0
	Ground	Male (3)	27.7 ± 1.5	21.3 – 34.1
	Air	Female (29)	32.3 ± 0.6	31.1 – 33.6
	Ground	Female (9)	31.6 ± 0.6	30.2 – 33.1
Red Blood Count (x10^6/µl)	Air	Male (25)	7.8 ± 0.2	7.5 – 8.1
	Ground	Male (3)	7.8 ± 0.1	7.2 – 8.4
	Air	Female (29)	7.9 ± 0.1	7.6 – 8.1
	Ground	Female (9)	7.4 ± 0.2	6.9 – 7.9
White Blood Count (/µl)	Air	Male (25)	5355 ± 329	4677 – 6034
	Ground	Male (3)	6053 ± 1123	1219 – 10887

Table 2. (continued...) Hematologic analyses of Shiras moose chemically captured in Wyoming.

Parameter (Units)	Method[1]	Sex (*n*)	Mean ± S.E.	95% C.L.[2]
White Blood Count (/µl)	Air	Female (28)	5801 ± 355	5074 – 6529
	Ground	Female (3)	4460 ± 574	1992 – 6928
Neutrophils (/µl)	Air	Male (25)	1739 ± 134	1462 – 2016
	Ground	Male (3)	1566 ± 326	165 – 2968
	Air	Female (28)	1769 ± 110	1543 – 1995
	Ground	Female (3)	1765 ± 355	239 – 3291
Lymphocytes (/µl)	Air	Male (25)	3233 ± 229	2760 – 3706
	Ground	Male (3)	3930 ± 963	-217 – 8077
	Air	Female (28)	3582 ± 283	3000 – 4162
	Ground	Female (3)	2378 ± 483	300 – 4457
Monocytes (/µl)	Air	Male (25)	176 ± 17	140 – 212
	Ground	Male (3)	242 ± 45	48 – 436
	Air	Female (28)	182 ± 16	150 – 215
	Ground	Female (3)	73 ± 16	4 – 141
Eosinophils (/µl)	Air	Male (25)	193 ± 40	111 – 276
	Ground	Male (3)	315 ± 183	-476 – 1106
	Air	Female (28)	266 ± 40	183 – 350
	Ground	Female (3)	243 ± 100	-187 – 674
Platelets ($x10^{-5}$/µl)	Air	Male (25)	214 ± 17	179 – 249
	Ground	Male (3)	180 ± 43	-3 – 363
	Air	Female (29)	187 ± 13	159 – 214
	Ground	Female (3)	134 ± 26	22 – 247

[1]Moose were darted with 10 mg thiafentanil either by ground personnel or from a helicopter.

[2]Lower and upper 95% confidence limits.

were characterized by moose standing and calmly walking away.

Moose were negative for antigens against *Brucella*, *Leptospira*, infectious bovine rhinotracheitis virus, bovine viral diarrhea virus, parainfluenza-3 virus, and bovine respiratory syncytial virus. No southeastern moose had evidence of endoparasites, but 3 moose had a few *Dermacentor albipictus* ticks present. Fecal examination of northwestern moose indicated a low infection of *Nematodirus* roundworms (< 8 eggs/gm) in 10 moose and *Trichuris* in 1 moose. No moose had evidence of ear mites and some had a few *Dermacentor albipictus* ticks.

One female moose died 9 days post capture. There was no apparent cause of death and no problems associated with the capture event for this moose were noted. Two males were found dead at 3 weeks post-capture with gross evidence of pneumonia in one (discolored lungs, adhesions) and malnutrition (depleted bone marrow) in the other. Six other moose died > 4 weeks post capture; evidence suggested that 3 were possibly killed by wolves (*Canis lupus*), mountain lion (*Felis concolor*),

Table 3. Induction and recovery times of Shiras moose chemically captured in Wyoming.

	Method[1]	Sex (*n*)	Mean ± S.E.	95% C.L.[2]
Induction (min)	Air	Male (25)	3.5 ± 0.3	2.9 – 4.0
	Ground	Male (3)	2.9 ± 0.8	-0.8 – 6.5
	Air	Female (25)	3.7 ± 0.4	3.0 – 4.4
	Ground	Female (11)	2.2 ± 0.3	1.5 – 2.9
Recovery (min)	Air	Male (27)	2.6 ± 0.2	2.2 – 2.9
	Ground	Male (2)	2.1 ± 0.9	-9.0 – 13.2
	Air	Female (29)	2.7 ± 0.2	2.3 – 3.0
	Ground	Female (13)	4.2 ± 0.8	2.4 – 6.0

[1]Moose were darted with 10 mg thiafentanil either by ground personnel or from a helicopter.

[2]Lower and upper 95% confidence limits.

and grizzly bear (*Ursus arctos*), 1 was possibly due to natural causes (no evidence of predation found), and 2 were unknown due to scavenging of the carcasses.

DISCUSSION

This is thought to be the first report on serum chemical and hematologic values for Shiras moose. The many variables associated with the collection of these data rendered statistical comparisons inappropriate both within this study as well as with other reports. Data collection variables included sex, sample size, location, date, method of capture, and time from induction to sampling. This latter variable may have been the most troublesome because blood values, which may have changed in response to capture method for instance, may have reverted closer to baseline as time to sampling increased. Nonetheless, serum chemical and hematologic values for Shiras moose were subjectively similar to most values for other moose (Franzmann et al. 1977, Franzmann and LeResche 1978, Forbes et al. 1996).

Thiafentanil appeared to be an effective immobilizing drug for moose. Induction times for moose darted on the ground (2.4 ± 0.4 min) were faster than moose darted on the ground from this same region with carfentanil and xylazine (4.4 ± 1.9 min; Roffe et al. 2001). Moose invariably became recumbent in a sternal position in a semi-rigid state (Figure 1). This characteristic was desirable because moose that roll onto their sides often regurgitate and subsequently develop aspiration pneumonia (Kreeger 2000). For example, the male that died from pneumonia 3 weeks post capture had rolled over from an initial sternal position and regurgitation was noted. The use of only thiafentanil in this drug regimen without the addition of tranquilizers, such as xylazine, supported previous studies, which showed that use of the opioids alone increased the probability of moose remaining sternal (Kreeger 2000). The sternal position with the head raised also enhanced blood sampling and

Table 4. Serum cortisol concentrations (µg/dl) of Shiras moose chemically captured in Wyoming.

Method[1]	Sex (*n*)	Mean ± S.E.	95% C.L.[2]
Air	Male (27)	4.4 ± 0.3	3.8 – 5.1
Ground	Male (3)	4.7 ± 0.2	3.8 – 5.6
Air	Female (30)	4.6 ± 0.2	4.2 – 5.1
Ground	Female (10)	4.5 ± 0.5	3.3 – 5.7

[1]Moose were darted with 10 mg thiafentanil either by ground personnel or from a helicopter.

[2]Lower and upper 95% confidence limits.

Fig. 1. Shiras moose demonstrating typical sternal posture resulting from immobilization with thiafentanil. This posture reduces the possibility of rumen regurgitation with subsequent aspiration and aids in blood sampling and radio-collar attachment.

radio collar attachment.

It should be noted that opioids (carfentanil, thiafentanil) resulted in immobilization as opposed to anesthesia (Kreeger et al. 2002). The prime characteristic of general anesthesia is loss of consciousness and this does not occur with opioids. Moose (and other cervids) will respond to tactile stimulation (attaching ear tags, blood sampling, fecal sampling, and loud sharp noises). Handlers should be aware of this phenomenon and either hobble the animal or be aware that it can jerk its head or feet and may even stand, although it will become recumbent again on its own.

We measured cortisol concentrations to analyze any stress response to methods of capture. We hypothesized that moose chased and darted from helicopters would be more stressed than those darted from the ground. Serum cortisol concentrations have been historically measured as an indicator of stress (Matteri et al. 2000). When data from all groups were combined and compared, cortisol concentrations of moose darted from the ground (4.5 ± 0.4 µg/dl) were the same ($P = 0.98$) as moose darted from a helicopter (4.5 ± 0.2 µg/dl). Even when comparisons between a balanced group (e.g., northwest female moose darted from the ground and air) were made, the concentrations were still the same (4.3 ± 0.6 vs. 4.3 ± 0.2 µg/dl, respectively; $P = 0.95$). Cortisol concentrations for these moose were similar to unstressed Alaskan moose (Bubenik et al. 1994). The explanation for these data remains elusive. It was possible that cortisol concentrations in the supposedly stressed helicopter darted groups subsided to baseline before blood sampling occurred. However, this seemed unlikely because the cortisol response to stress (simulated by ACTH administration) in Alaskan moose (Bubenik et al. 1994) resulted in cortisol concentrations being elevated above controls for > 2 hr and all moose in the current study were sampled in < 2 hr. Another explanation could be that the serum test employed in this study did not measure cortisol accurately. This also seemed unlikely because, even though not validated for moose cortisol, these commercial radioimmunoassay tests for cortisol have provided consistently appropriate results across species (Kreeger et al. 1990, 1992; Bubenik et al. 1994). It was also possible that these moose simply were not stressed by the capture methods, although moose are physiologically capable of generating classic endocrine stress responses under certain handling conditions (Franzmann et al. 1975).

We considered that the 3 moose that died within 30 days of being captured succumbed to some sequela of the capture event. The male moose that died from pneumonia was an obvious result of being captured. Moose that become laterally recumbent under anesthesia often regurgitate rumen contents which are aspirated, resulting in pneumonia and death (Kreeger 2000). The malnourished moose also probably died after being captured because moose in poor physical condition due to sickness, injury, or malnutrition are high immobilization risks and often die subsequent to capture (Kreeger et al. 2002). The female moose that died of unknown causes was in good physical condition and laboratory analyses suggested no underlying pathogens but, because she died shortly after capture, it

appeared that this event precipitated her death. Moose that died > 30 days post-capture most likely died from reasons not directly related to the capture event, although this cannot be proven.

Mortality of Shiras moose in northwest Wyoming has increased in recent years due to unknown causes, which was in part why this current capture and collaring effort was initiated. The data gathered herein will provide a basis for future comparison and analysis for Shiras moose.

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