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EVALUATION OF ZUCLOPENTHIXOL ACETATE TO DECREASE HANDLING STRESS IN WAPITI

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ABSTRACT: Handling stress and capture myopathy are important consequences of intensively managing wildlife species. Over the last 15 yr, the use of long-acting neuroleptic (LAN) drugs in wildlife has increased, and these drugs have become a valuable tool for decreasing capture and handling stress in many species. At this time, reports on the use of these drugs in North American species are limited. The major objective of this study was to evaluate the use of the LAN, zuclopenthixol acetate (Clopixol-Acuphase®), to decrease both quantifiable and subjective measurements of stress and activity in wild wapiti (*Cervus elaphus,* North American elk). This blinded, randomized study took place in February 1999 in Manitoba (Canada) and involved 11 animals receiving the drug and 12 animals acting as controls. At 24 hr after drug administration, there were measurable and significant decreases in the stress and activity of treated animals versus controls during handling. Treated animals had significantly lower mean body temperatures (39.0 versus 40.6 C), less hemoconcentration (mean packed cell volume 0.42 versus 0.49, mean hemoglobin 159.09 versus 181.75 g/L, mean total protein 65.0 versus 70.25 g/L), lower mean serum cortisol (97.91 versus 139.50 mmol/L), lower mean blood lactate (3.39 versus 5.98 mmol/L), and were less metabolically acidotic (mean pH_v 7.45 versus 7.34, mean bicarbonate 29.36 versus 24.25 mmol/L, mean base excess 5.64 versus −0.83 mmol/L). Only control animals had evidence of muscle damage based on serum biochemistry (creatine phosphate values of two animals of 42,080 and 25,887 U/L). No animals developed clinical capture myopathy, and no animals died. Measurable effects of this drug were still apparent at 72 hr post-administration. The results of this study support the use of Clopixol-Acuphase® in wapiti as a means to decrease handling stress and activity.

Key words: Blood gas analysis, blood lactate, capture myopathy, *Cervus elaphus,* elk, stress, wapiti, zuclopenthixol acetate.

INTRODUCTION

With the worldwide development of game farming and intensified wildlife management, there has been a concurrent increase in the public's concern that the well being of these animals be protected (Moberg, 1987). It has long been assumed that measuring "stress" in these animals would provide an indication of well being. Difficulties arise when attempts are made to measure stress in animals since there is no accepted definition of stress, and even more poorly defined parameters to measure it. Traditionally, increased plasma levels of corticosteroids have been used as a measure of stress, however the adrenal cortical response does not always occur, suggesting an over-reliance on this parameter as the sole measure of stress. When an animal is confronted with a potentially stressful situation, it relies on three biological systems to cope: behavior, the autonomic nervous system, and the neuroendocrine system (Moberg, 1987). Since multiple organs are affected by the adaptive response to the imposed stressor, measurement of several objective variables, in addition to subjective assessment of behavior and activity, will provide a more reliable description of stress (Moberg, 1987; Morton et al., 1995) and possibly assist with earlier detection of capture myopathy.

Capture myopathy is a serious and potentially fatal consequence of capturing and handling wild animals. This syndrome is characterized by varying degrees of homeostatic imbalances resulting from in-

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creased muscular activity, autonomic nervous system activity, and physical injury (Spraker, 1993). As a result of the increased muscular activity associated with capture and handling, body temperature is elevated, muscle damage may result in leakage of enzymes, and anaerobic activity contributes to lactic acidosis. Depending on the degree of activity and the individual animal's ability to compensate for the changes, the syndrome may manifest as shock, myopathy, renal failure, rupture of muscle bodies, and sudden death (Spraker, 1993).

One method of decreasing the incidence of stress, injuries, and mortalities in wild animals is the use of neuroleptics or tranquilizers (Ebedes and Raath, 1999). Injectable neuroleptics were developed for the management of acute psychoses in people who refused to take oral neuroleptics in the initial stages of their treatment (Amdisen et al., 1987). These drugs are used to alleviate anxiety, have various durations of action depending on formulation, and have few side effects when used appropriately. Beneficial effects in animals include general calming, indifference to new and unnatural surroundings, loss of fear of people, and reduction in aggressive behavior (Ebedes and Raath, 1999). These agents have been used successfully around the world in the management of many wild herbivores, but there are few reports of their use in North American species (Ebedes and Raath, 1999).

This study was designed to evaluate the use of zuclopenthixol acetate (ZPTA) to decrease handling stress and activity in wild wapiti (*Cervus elaphus*, North American Elk, Haigh and Hudson, 1993) during physical restraint. This particular formulation of ZPTA is dissolved in coconut oil which permits slow release of drug from the intramuscular site of administration, prolonging the duration of its clinical effect. This drug has been previously evaluated in farmed red deer in Scotland, and was reported to have beneficial effects in decreasing stress in these animals (Diverio et al., 1993, 1996a, b).

Several physiological variables (body temperature, heart rate, respiratory rate, complete blood count, serum biochemistry, serum cortisol concentration, blood lactate concentration, venous blood gas status) were measured in this study. By doing so, we hoped to better characterize the stress of handling, possibly define physiological characteristics which could predispose wapiti to capture myopathy, and determine any benefits from treatment with ZPTA.

MATERIALS AND METHODS

In order to establish a captive population of native wapiti for game farming purposes in Manitoba (Canada) 425 animals were captured in southern Manitoba in January and February 1999. Animals were captured by baiting with food into large pens and were transported to a nearby holding facility (49°24′N and 96°51′W) south of Winnipeg (Manitoba, Canada). Processing of animals at the time of capture included identifying each with unique ear tags, tests for tuberculosis and brucellosis, blood sample collection for DNA genotyping, fecal sample collection for parasite analysis, treatment with an ectoparasiticide (Dectomax Injectable Solution, Pfizer Canada Inc., London, Ontario, Canada) and vaccination with 8-way clostridial vaccine (Fortress 8, Pfizer Canada Inc., Ontario).

The study was approved by the University of Saskatchewan Animal Care Committee (Saskatoon, Saskatchewan, Canada) and regional alternate livestock associations, and was conducted with the cooperation of the Manitoba Department of Agriculture (Winnipeg, Manitoba, Canada). Twenty-three male wapiti aged 1 to 2 yr old were separated and maintained at a holding facility for this project. The study took place 21 to 26 February 1999 with daily temperatures ranging from −5 to +4 C. Food and water were offered to the animals *ad libitum* throughout the study period.

On the first day of the study (Day 1), individual animals were moved through chutes (NV Elk Modular Handling System, Bateman, Saskatchewan, Canada) and held in a hydraulic squeeze chute (Kiwi Elk System, Wildwood, Alberta, Canada) for data collection. Each animal was randomly assigned to a treatment group by flipping a coin prior to processing, and the primary investigator was blinded to the treatment. Once the animal was secure in the

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squeeze and blindfolded, respiratory rate was measured by auscultation over the trachea, and heart rate was measured by auscultation over the heart. To minimize time in the chute, rates were measured over 15 sec each, then converted to rates per min. The hair was clipped over the jugular furrow, and blood was collected from the jugular vein into serum separator tubes for biochemical analysis and measurement of serum cortisol concentration, and into an EDTA tube for measurement of the complete blood count. Free-flowing jugular venous blood was then collected anaerobically into a heparinized syringe for venous blood gas analysis and measurement of blood lactate concentration. Rectal temperature was measured with a digital thermometer.

At the completion of data collection, body weight was estimated and the animal received either 1 mg/kg estimated body weight of ZPTA (Clopixol Acuphase®, 50 mg/ml, Lundbeck Canada Inc., Montreal, Quebec, Canada) or an equivalent volume of saline injected intramuscularly into the muscles of the hindlimb. The animal was marked with livestock paint as to the treatment group ("X" or "O") and was released into a pen based on its treatment. The total time in the chute was recorded to the nearest 30 sec. A subjective assessment of stress was assigned to the animal by the primary investigator based on its ease of handling and excitement in the chute. Stress for each animal was described as mild (minimal struggle and excitement in chute during handling, data collection easy to perform), moderate (intermediate struggle and excitement in chute making data collection more difficult), or marked (struggle and excitement in chute made data collection difficult to perform).

On Day 2, animals were processed for data collection according to their group (for ease of handling, all animals of one group were processed before those of the other group). Once in the chute, an electronic scale (Eziweigh 2, Tru-test Ltd., Auckland, New Zealand) was used to determine actual body weight. Data collection was performed as before and the animals were released back into their separate pens.

On Day 4, animals were again processed for data collection in the same order as before.

Prior to data collection each day, the two groups were observed for 5 min each to determine a rough estimate of flight distance and activity level when approached by a person.

Blood samples for serum cortisol concentration and biochemical analysis were allowed to clot at room temperature, were centrifuged, and placed on ice. Blood smears were made from the heparinized samples immediately after collection and allowed to dry. Blood samples in EDTA were placed on ice. All blood samples were analyzed in a laboratory within 24 hr where serum biochemistry, serum cortisol, and complete blood cell profiles were performed using standard methods. Blood lactate concentration was measured immediately after collection using a portable analyzer (Accusport Portable Lactate Analyzer, Boehringer Mannheim Corporation, Indianapolis, Indiana, USA). On Days 1 and 2, venous blood samples for blood gas content were analyzed immediately after collection using a portable analyzer (i-STAT Portable Clinical Analyzer, i-STAT Corporation, East Windsor, New Jersey, USA). Due to technical difficulties with the portable analyzer on Day 4, blood samples were put into ice water and analyzed using a different blood gas analyzer (ABL520, Radiometer, Copenhagen, Denmark) within 3 hr.

Statistical analysis was performed using Statistix (Student's Edition of Statistix, Version 1.0, Analytical Software Tallahassee, Florida, USA). Data collected were initially analyzed for normalized distribution. Based on the normalized results, parametric statistics were used and mean data from each treatment group were analyzed for same-day differences using a two-sample *t*-test. Mean data were then analyzed for differences between days within a treatment group using a paired *t*-test. The null hypothesis stated there were no differences between the means for two groups compared in each test. Statistical significance was taken if $P < 0.05$. No statistical analysis was performed on the subjective assessment classification of stress assigned to the animals.

RESULTS

All animals were negative for tuberculosis and brucellosis. There were no clinical cases of capture myopathy and no mortalities occurred. There were no observable adverse reactions at injection sites, and no observed extra-pyramidal signs (incessant restlessness and pacing, facial twitches), the most commonly reported side effects of the use of neuroleptics in animals. There were no differences in the mean handling times in the chute of the ZPTA group versus the control group on any day (Day 1–6.8 versus 7.3 min, Day 2–5.8 versus 6.2 min, Day 4–5.6 versus 6.2 min).

The calculated mean (±SD) dose of ZPTA based on actual body weights for the

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treatment group animals was 1.32 ± 0.31 mg/kg administered intramuscularly.

Data collected from Day 1 showed no statistical significance in differences between means of treatment and control groups for any of the measured variables (all animals had similar physiological responses to the imposed stress of handling in the chute) using a two-sample *t*-test, and was therefore pooled (Table 1). Within 4 to 5 hr of drug administration on Day One, ZPTA-treated animals subjectively appeared calm and their activity levels in the pen were decreased relative to control animals.

Data from Day 2 (~24 hr after treatment) showed statistically significant differences in several variables between treatment groups when compared with a two-sample *t*-test (Table 1). The only animals with markedly elevated creatine phosphate (CPK) and aspartate aminotransferase (AST) values were from the control group. Two control animals had marked, subclinical muscle injury (CPK = 42,080 U/L, 25,887 U/L, and AST = 1,387 U/L, 696 U/L) at the time of blood sampling although they were not observed to be lame.

During observation prior to handling on Day 2, animals in the ZPTA-treatment pen were less active (less circling and pacing) than animals in the control pen, and subjectively showed less excitement when approached by a person. Control animals were much more active in their pen, and became excited and attempted to escape when approached by a person. Flight distance was not estimated for animals in either group. Subjective stress evaluation for the animals during their handling on Day 2 reflected that treated animals were easier to handle than controls.

Data collected from Day 4 (~72 hr after treatment) also showed statistically significant differences using a two-sample *t*-test in packed cell volume (PCV), hemoglobin (HgB), serum sodium concentration and serum cortisol concentration (Table 1). Other parameters which had previously showed significant differences on Day 2, were no longer found to be different between treatment groups on Day 4.

During observation prior to handling on Day 4, differences in pen activity between the groups were not as obvious. The subjective assessment of activity during handling was also more difficult to make since differences between groups were not as apparent.

Differences within a group over time were compared with a paired *t*-test. Day 1 versus Day 2 and Day 1 versus Day 4 differences were calculated for each treatment group to assess acclimatization over time. The results (Table 1) showed that although all animals appeared to acclimate over the study period, ZPTA treated animals did so sooner than controls.

DISCUSSION

Attempts to assess "stress" in an animal utilize examination of the three systems that the animal uses to cope with the disruption to its homeostasis: behavior, the autonomic nervous system, and the neuroendocrine system (Moberg, 1987). Behavioral changes are often difficult to measure, and are frequently restricted to subjective assessment of abnormal behaviors such as aggression and attempts to escape confinement. The animals in this study demonstrated marked excitement and struggle during their initial handling, but there was a noticeable decrease in the treated animals on the second day. These animals were easier to move through the handling facility and stood quietly in the chute during data collection. Paired *t*-tests were performed on data from each treatment group to compare variables between different days of data collection (Day 1 versus Day 2, Day 1 versus Day 4). These analyses suggest that not only were drug effects diminishing over the study period in the ZPTA-treated animals, but that there was also gradual acclimatization of control animals to handling. The ZPTA-treated animals appeared to acclimate sooner based on comparing their parame-

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TABLE 1. Mean physiological values ± SD for wild wapiti. ZPTA denotes treatment with zuclopenthixol acetate, while control denotes treatment with saline.

Variable	Day 1—pooled	Day 2—ZPTA	Day 2—control	Day 4—ZPTA	Day 4—control
Number of Animals	23	11	12	11	12
Temperature (C)	41.1 ± 0.94	39.0 ± 0.40[a,c]	40.6 ± 0.60[a,c]	39.8 ± 0.35[d]	40.6 ± 0.60[d]
Heart rate (/min)	86 ± 26.2	73 ± 8.0	71 ± 10.6[c]	65 ± 8.5[d]	69 ± 6.1[d]
Respiratory rate (/min)	35 ± 19.0	20 ± 4.7[c]	41 ± 18.1	30 ± 12.2	42 ± 23.6
pH_v	7.30 ± 0.06	7.45 ± 0.02[a,c]	7.34 ± 0.03[a]	7.39 ± 0.04[d]	7.35 ± 0.04[d]
HCO_3^- (mmol/L)	24 ± 4.1	29 ± 2.7[a,c]	24 ± 3.1[a]	26 ± 4.1	25 ± 2.9
BE (mmol/L)	−1.5 ± 4.43	5.6 ± 2.94[a,c]	−0.8 ± 3.56 [a]	1.9 ± 3.34[d]	1.1 ± 2.58[d]
Blood lactate (mmol/L)	7.5 ± 2.24	3.4 ± 1.17[a,c]	6.0 ± 1.49[a,c]	4.4 ± 1.71[d]	5.9 ± 1.79[d]
Serum cortisol (mmol/L)	118 ± 32.6	98 ± 29.0[a]	140 ± 44.1[a]	93 ± 27.3[b,d]	136 ± 0.5[b]
Serum glucose (mmol/L)	12.8 ± 2.75	9.5 ± 1.65[c]	10.2 ± 2.37[c]	10.3 ± 1.06[d]	10.1 ± 2.28[d]
Serum Na (mmol/L)	146 ± 1.7	145 ± 1.3[a]	148 ± 2.4[a]	148 ± 1.1[b]	150 ± 1.6[b]
Serum Cl (mmol/L)	101 ± 2.1	102 ± 1.8[a]	106 ± 2.8[a]	104 ± 1.7	105 ± 2.1
Serum urea (mmol/L)	10.2 ± 1.19	10.8 ± 1.25	11.0 ± 1.46[c]	9.5 ± 0.74[d]	12.3 ± 1.58[d]
Serum creatinine (mmol/L)	142 ± 17.5	135 ± 18.3[c]	148 ± 13.7[c]	140 ± 16.7	149 ± 13.7[d]
TP (g/L)	68 ± 5.6	65 ± 4.5[a,c]	70 ± 6.5[a,c]	70 ± 5.6	69 ± 7.0
RBC ($\times 10^{12}$/L)	10.45 ± 0.87	9.19 ± 0.78[a,c]	10.43 ± 0.92[a]	9.81 ± 0.81[d]	10.59 ± 1.09
PCV (L/L)	0.49 ± 0.04	0.42 ± 0.04[a,c]	0.49 ± 0.03[a]	0.45 ± 0.04[b,d]	0.50 ± 0.04[b]
HgB (g/L)	178 ± 10.5	159 ± 11.4[a,c]	182 ± 7.0[a]	168 ± 10.4[b]	179 ± 8.5[b]
WBC ($\times 10^9$/L)	5.4 ± 1.72	5.6 ± 1.68[a]	7.3 ± 1.89[a,c]	6.7 ± 2.20	6.1 ± 1.00
Neutrophils ($\times 10^9$/L)	2.84 ± 1.44	3.84 ± 1.92	4.66 ± 1.76[c]	4.76 ± 2.08[d]	3.71 ± 1.16
Lymphocytes ($\times 10^9$/L)	2.26 ± 0.61	1.43 ± 0.47[a,c]	2.41 ± 0.44[a]	1.74 ± 0.45[d]	2.15 ± 0.73

[a] $P < 0.05$ between treatment groups on Day 2 (two sample *t*-test).
[b] $P < 0.05$ between treatment groups on Day 4 (two sample *t*-test).
[c] $P < 0.05$ within a treatment group between Day 1 to Day 2 (paired *t*-test).
[d] $P < 0.05$ within a treatment group between Day 1 to Day 4 (paired *t*-test).

ters with those of the control animals on respective days of handling, supporting the description of this drug as a taming agent.

Since autonomic nervous system activation alters cardiopulmonary status, the end points of heart rate and respiratory rate have been previously used to study stress (Moberg, 1987). In this study, there was no significant difference in these two parameters between treatment groups on any of the days. This suggests that these variables may not be adequate as the sole measure of stress and indicates the importance of examining multiple variables in order to make a better assessment of stress. In addition to these vital parameters, it is necessary to measure variables which reflect the hematological, biochemical, and acid-base status of wild animals which allows us to better describe their predisposition to, and development of capture myopathy—one end-point of stress in wildlife.

The benefits of using ZPTA in wapiti were most apparent when comparing treatment groups 24 hr after drug administration. The ZPTA-treated animals were easier to move through the chutes, and had less excitement and struggle in the chute which made data collection easier to perform. These observations agree with previous reports on the use of ZPTA in farmed red deer, which described the LAN treated animals as being more approachable and easier to handle (Diverio et al., 1996b).

The mean rectal temperature was 1.6 C less in treated animals, which could be attributed to less muscular activity during handling. Rectal temperature is a reliable indicator of excitement and increased muscular activity, and has been used to evaluate stress in other species (Franzmann, 1972; Delgiudice et al., 1990b; Drew, 1998). Increased activity can be a predisposing factor to the development of capture myopathy (Spraker, 1993). Activity results in increased catabolism, increased heat production, and subsequent increased body temperature. As body temperature increases, oxygen consumption in the body increases, which can lead to tissue hypoxia and the onset of anaerobic metabolism and an oxygen debt. If uncontrolled, this can progress to lactic acidosis, hypotension, shock and death. Drew (1998) reported that elevated rectal temperature in fallow deer reflected heat generation from exertion during short-term physical restraint. In our study, decreases in activity and lower rectal temperatures, suggest that the ZPTA-treated animals had less risk of developing capture myopathy through this mechanism.

Hematological variables have been shown to provide valuable information for stress assessment in many species (Karns and Chrichton, 1978; Pedersen and Pedersen, 1975; Seal and Hoskinson, 1978; Wesson et al., 1979a; Wilson and Pauli, 1982; Cross et al., 1988; Delgiudice et al., 1990a; Marco et al., 1997). The ZPTA-treated group had lower red blood cell count, packed cell volume, hemoglobin, and total serum protein than the control group on Day 2, and showed a similar trend on Day 4. With activation of the autonomic nervous system, there is release of catecholamines from the adrenal medulla. These hormones cause splenic contraction, resulting in increased numbers of red blood cells in circulation which can help to increase oxygen delivery to tissues during stressful events. Hemoconcentration is measured as increased red cell mass, and has been documented in many species (Karns and Chrichton, 1978; Pedersen and Pedersen, 1975; Seal and Hoskinson, 1978; Wesson et al., 1979a; Wilson and Pauli, 1982; Cross et al., 1988; Delgiudice et al., 1990a; Marco et al., 1997). In addition, studies have reported a greater degree of hemoconcentration in manually restrained animals than in chemically immobilized animals, suggesting that manual restraint is more stressful to the animal than the capture process and immobilization with drugs (Wesson et al., 1979a; Cross et al., 1988 Delgiudice et al., 1990a). The significant reduction in the degree of

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hemoconcentration in the ZPTA-treated animals is suggestive of less splenic contraction, resulting from less sympathetic stimulation from stress. Since all animals had similar hematological profiles on Day 1, the decrease in red cell mass in ZPTA-treated animals on Day 2 and Day 4 is likely due to the effectiveness of the ZPTA in decreasing the stress response to physical restraint and captivity.

A second possible cause of the lower degree of hemoconcentration in the ZPTA group could be from splenic sequestration of red blood cells. Although ZPTA has not been reported as causing this to occur in wildlife, other phenothiazine tranquilizer derivatives have been reported to cause relaxation of the spleen, resulting in sequestration of red blood cells and lower measure numbers in circulation (Booth, 1988). This explanation cannot be ruled out as a cause of these findings in these wapiti, and may have contributed to the lower PCV and red blood cell parameters in the ZPTA-treated animals.

Another contributing factor to the greater degree of hemoconcentration in the control group could be mild dehydration. Over the days of the study, facility personnel observed the control animals to spend less time than LAN treated animals performing normal behaviors such as eating and drinking, as has been reported previously in farmed red deer (Diverio et al., 1996a). Although serum urea and creatinine concentrations were not significantly different between treatment groups, serum sodium and chloride concentrations were significantly greater in control animals on Day 2. This finding could reflect mild dehydration in this group, since all animals had similar levels of these electrolytes on Day 1. Serum sodium levels were still significantly elevated in control animals on Day 4.

ZPTA-treated animals had a significantly lower white blood cell count and absolute lymphocyte count than the control animals. Catecholamine release during an animal's initial alarm phase causes neutrophilia and lymphocytosis, while the release of corticosteroids from the adrenal gland in response to more chronic stress can cause a decrease in lymphocyte count (Marco et al., 1997). Although no significant difference existed for segmented neutrophil counts between groups, the ZPTA treated animals had fewer circulating lymphocytes. This likely reflects blood sampling in the acute phase of the stress response, when catecholamine effects on lymphocyte dynamics in circulation predominate over cortisol effects. Control animals were more difficult to handle, and their heightened sympathetic response likely caused the measured leukocytosis and lymphocytosis in these animals. These findings contrast previous findings from studies performed on elk, which describe higher neutrophil than lymphocyte counts (Pedersen and Pedersen, 1975; Wilson and Pauli, 1982). This difference between studies could be due to the timing of blood collection, as sampling in the previous study could have take place during a later phase of the stress response when cortisol effects on white blood cells dominate (Marco et al., 1997), causing the reported neutrophilia and lymphopenia (Pedersen and Pedersen, 1975; Wilson and Pauli, 1982).

Few measured variables of the serum biochemical analysis had significant difference between treatment groups. Although not statistically significant, the only animals to have marked elevations in the muscle enzymes CPK and AST were control animals. Two animals in the control group had elevations of CPK on Day 2 with values of 42,080 U/L and 25,887 U/L, consistent with muscle injury within the last 24 hrs. Severe muscle damage in red deer has been reported to cause elevations of CPK to 35–47,500 U/L (Wilson and Pauli, 1983). It is interesting that the two animals in this study showed no clinical signs of injury. It has been reported that in white-tailed deer that 10- to 200-fold increases in CPK values occurred approximately 24 hr after handling, without overt

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signs of external damage or altered behavior in affected animals (Seal et al., 1972). The absence of marked elevation in muscle enzyme levels in ZPTA-treated animals suggests that use of this drug may be effective in decreasing the severity of conditions which can predispose to capture myopathy.

Measurement of blood gas concentrations is useful for assessing activity during handling. The increased struggle and muscular activity in stressed animals leads to anaerobic metabolism for energy production (Spraker, 1993). This process generates large amounts of lactic acid, which dissociates to form lactate and hydrogen ions. The rise in hydrogen ions overwhelms the buffering capacity in the body and a state of acidosis is produced (Martucci et al., 1992). The recent development of portable blood lactate and blood gas analyzers provides the opportunity to measure lactate and blood gas concentrations in the field and to assess the degree of anaerobic metabolism, the ability of the animal to compensate, and the degree of physiological imbalance. Venous blood gas analysis of free-flowing jugular samples can provide this measure of acid-base balance.

Animals in the control group had blood gas values that were more suggestive of metabolic acidosis than those of the ZPTA-treated animals. There were significant differences in venous blood pH, bicarbonate, and base excess between the two groups. The most likely cause was increased activity and lactate production due to anaerobic cellular metabolism in the control group. Acute lactic acidosis likely developed during the handling process. The ZPTA-treated animals had approximately 40% lower blood lactate levels than in the control group. The acid-base status of the control animals is similar to reported blood gas values from bighorn sheep which showed marked metabolic acidosis after pursuit and capture (Martucci et al., 1992).

Increases in blood lactate levels occur with metabolic acidosis resulting from anaerobic metabolism. In this study, the ZPTA-treated animals had significantly lower blood lactate concentrations which reflects less anaerobic activity and stress during handling. More investigation is warranted to determine prognostic levels of blood lactate in this species, and documentation of concentrations present during episodes of acute capture myopathy. Blood lactate concentration has been studied previously as a measure of stress in domestic sheep, where individual animals were isolated from the flock and subjected to repeated restraint for blood collection (Apple et al., 1993). The investigators in that study found significant increases in plasma lactate of greater than double the values from controls due to this repeated stressor.

This study also assessed the "classic" measure of stress by measuring serum cortisol concentrations. ZPTA-treated animals had significantly lower concentrations of serum cortisol than did control animals. These findings agree with previously reported differences in cortisol levels in response to stress in ZPTA-treated red deer (Diverio et al., 1996a). Although serum cortisol concentration should not be used as the only determinant of stress, it has been found to be useful in a number of species (Delgiudice et al., 1990a; Wesson et al., 1979b; Franzmann et al., 1975). Serum cortisol levels in white-tailed deer and moose have been found to reflect the degree of excitement during capture and restraint, and agreed well with subjective evaluations of their handling stress (Wesson et al., 1979b; Franzmann et al., 1975).

Measurement of a variety of physiological variables provides the ability to characterize the stress response to handling in wild wapiti. The use of ZPTA in these animals was very effective in decreasing their stress response and activity during physical restraint. Treated animals were easier to handle, demonstrated lower rectal temperatures, less hemoconcentration, less lactic acidosis, normal muscle enzyme concentrations, and lower serum cortisol con-

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centrations. The drug was effective within several hours of administration, and its effects were measurable but waning by 72 hr. Evidence of acclimatization to the handling process occurred in all animals, however treated animals did so sooner, supporting the use of this drug as a "taming" agent. This drug shows great potential for use in this species, and its use during other stressful procedures such as transportation, should be evaluated. It has potential for use in other North American species, and further research is especially warranted to evaluate its use in other intensively farmed and managed species.

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