BLOOD PROFILE OF GRIZZLY BEARS IN CENTRAL AND NORTHERN ALASKA

A
THESIS

MASTER OF SCIENCE

By
Robert D. Brannon, B.S.

Fairbanks, Alaska
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Presented to the faculty of the University of Alaska

in Partial Fulfillment of the Requirements

for the Degree of

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RECOMMENDED:

Chairman, Advisory Committee

Chairman, Program in Wildlife and Fisheries

Director, Division of Life Sciences

APPROVED:

Vice Chancellor for Research and Advanced Study

Date

ABSTRACT

Blood from 151 grizzly bears (Ursus arctos) captured between 1973 and 1982 in the Brooks Range, Alaska, and the Alaska Range was examined for 7 hematological, 24 serum chemistry, and 6 protein electrophoretic determinations. Differences in these characteristics between samples collected one hour apart indicate a response to stress during capture. Location differences in leukocyte count, erythrocyte count, hemoglobin, hematocrit, and cortisol suggest that Alaska Range bears were more stressed by capturing than Brooks Range bears.

Sodium, creatinine, and urea nitrogen were negatively correlated with capture date, suggesting varied diet reinstatement and regained renal function as time from den emergence increased. Calcium, phosphorous, and alkaline phosphatase were negatively correlated with age, reflecting increased osteoblast activity and bone formation in young bears.

Males had higher values than females for erythrocyte count, hematocrit, glucose, creatinine, calcium, phosphorous, and alkaline phosphatase, while glutamic-oxalacetic and glutamic-pyruvic transaminases were higher in females.

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ACKNOWLEDGEMENTS

This project was funded by the Alaska Department of Fish and Game (ADF&G) through the Alaska Cooperative Wildlife Research Unit (ACWRU), by the University of Alaska, and the Arctic Institute of North America.

I would like to thank Harry Reynolds of the ADF&G for his assistance in developing and organizing this research, and for serving on my advisory committee. I am grateful to Dr. Sam Harbo who was my major advisor and provided invaluable assistance with the statistical aspects of the thesis. Drs. Erich Follmann and Robert White also were members of my advisory committee and provided valuable advice throughout the research. Dr. David Klein, Unit Leader of the ACWRU, also provided advice. I thank Dr. Gerald Garner, Wildlife Biologist for the U.S. Fish and Wildlife Service (USFWS), for his cooperation.

John Retynski, President, Pathologists Central Laboratory, made special arrangements for analyzing the serum. Dr. Roger Harding arranged for the hematology determinations to be done at Fairbanks Memorial Hospital free of charge. To him I am especially grateful.

I wish to express my gratitude to Junior Kerns, Wildlife Technician, Office of Engineering and Housing for Fort Wainright, who was instrumental in obtaining helicopter support for capturing bears in the Alaska Range. Bruce Watson, CW-3, Fort Wainright, did an excellent job piloting the helicopter during capture efforts, and the various crews accompanying him were very helpful as well. Bill Lentsch piloted the spotter plane used in locating bears. His invaluable eye and pilot

skills may have been solely responsible for having achieved our goal of capturing 35 bears in the Alaska Range. I am grateful to Jim Ackels, of ERA Helicopters in Fairbanks, who piloted the helicopter used in the capture efforts in the Arctic National Wildlife Refuge (ANWR). I thank Bob Bartels, USFWS Wildlife Biologist, for allowing us the use of his home as headquarters for capture efforts in the Refuge.

Fellow graduate students Larry Byrne, Ray Mulé, Jim Gebhard, and Jim Durst, gave advice, support, and encouragement during this research.

Last and certainly not least, I would like to thank my wonderful wife, Ileen, for her concern, support, understanding, and encouragement throughout this endeavor, without which it would have been much more difficult.

INTRODUCTION

Physiological data for ursids in general and the grizzly bear (Ursus arctos) specifically are lacking. Baseline data are vital to determination of normal and abnormal physiological values. Such information is essential if we are to determine what effects nutrition, stress, disease and other physiological factors have on an individual or a population.

Some work has been done measuring physiological characteristics (i.e. respiration rate, pulse rate, body temperature, hematology, serum chemistry, etc.) of the black bear (U. americanus) (Svihla et al. 1955, Erickson and Youatt 1961, Hock 1966A, Seal et al. 1967, Folk et al. 1972, Nelson et al. 1973, Eubanks et al. 1976, Matula 1976, Hamilton 1978, Modafferi 1978, Siperek 1979, Matula et al. 1980, Beeman 1981), grizzly bear (Folk 1967, Seal et al. 1967, Folk et al. 1972, Halloran and Pearson 1972, Pearson and Halloran 1972, Bush et al. 1980, Kingsley et al. In press), and polar bear (U. maritimus) (Folk 1967, Seal et al. 1967, Folk et al. 1972, Lee et al. 1977, Best et al. 1981, Kaduce et al. 1981, Leatherland and Ronald 1981). Most of these studies have involved captive animals. Comparison between these studies is difficult because of differences in drugs used for immobilization, capture methods, sample collection, season, geographic location, and sex and age differences, to name a few.

The physical condition of a grizzly bear is an important factor influencing its activities and, perhaps most importantly, its reproductive

success. Condition varies considerably between individuals and between populations (Hensel et al. 1969, Kistchinski 1972, Mundy and Flook 1973, Glenn et al. 1974, Martinka 1974, Pearson 1975, 1976, Craighead et al. 1976, Reynolds 1976, 1980), and is probably caused by differences in food abundance and availability (Hensel et al. 1969, Craighead et al. 1974, Glenn et al. 1974, Reynolds 1980). Condition also influences survival rates and therefore, population status.

Timing of denning in the fall, date of den emergence in the spring, and survival during winter may be influenced by condition in the black bear (Spencer 1955, Erickson and Youatt 1961, Erickson 1965, Carpenter 1973, Lindzey and Meslow 1976, Rogers 1977, Reynolds and Beecham 1980) grizzly bear (Mills 1919, Craighead and Craighead 1972, Folk et al. 1972, Kistchinski 1972, Pearson 1975) and polar bear (King 1836, Fruechen 1935, Harrington 1968, Uspenski and Kistchinski 1972). Where an individual bear has not accumulated sufficient fat reserves prior to the usual time for denning, that individual may delay denning until its fat reserves are adequate. If a bear enters its den with an insufficient reserve of body fats, it might not survive the winter or might emerge early from its den to feed.

Evaluating a bear's condition is one method that may be useful for standardizing other physiological characteristics for comparative purposes. Franzmann et al. (1976) suggest that once a procedure for evaluating condition is developed, various physiological measurements that reflect condition change should be investigated. This will provide the manager with quantifiable physiological values useful for estimating

survival and productivity of individuals and populations, and for comparing and evaluating population condition.

Rosen and Bischoff (1952) studied the relationships of physical condition with blood characteristics in Rocky Mountain mule deer (Odocoileus hemionus hemionus) and classified each individual as being in poor, fair, or good condition. They indicated that a relationship could probably be found in the future but that their sample was too variable and too small to show any relationships. Robinson (1960) researched the effects of shelter on the condition of penned white-tailed deer (O. virginianus). He developed an 11 category classification from 0 for an animal which dies from malnutrition to 10 for one in excellent condition. Franzmann (1972) and Franzmann et al. (1976) modified this categorization and used it for evaluating condition in bighorn sheep (Ovis canadensis) and moose (Alces alces), respectively. In both studies relationships were found between condition and a few blood measurements (hematocrit, hemoglobin, calcium, phosphorous, total protein); other characteristics may also have been related to condition but small sample sizes and high variability prevented their detection.

Extreme variations in blood values may result from an animal's acute, but temporary, physiological state when blood is collected. Furthermore, variation may occur due to the drug used for immobilization (Rogers 1970, Seal et al. 1970, Miller and Will 1976, Beeman and Pelton 1978, LeCount 1979, Siperek 1979, Bush et al. 1980, Lee et al. 1981). Some characteristics such as LDH, SGOT, SGPT, cortisol, and glucose may vary with short term, acute stress (Vecsei 1974, Eubanks et al. 1976,

Franzmann and Schwartz 1983, Matula et al. 1980); others such as hematocrit, hemoglobin, urea nitrogen, and uric acid (Franzmann and Schwartz 1983) might not. Keeping these relationships in mind, it is possible to use the more plastic assays as excitability indicators, while using those values least affected by handling stress to evaluate physical condition.

Standardization of capture procedures and development of an excitability stress classification would allow managers to more confidently differentiate between the influences of handling stress and other factors. Franzmann and Thorne (1970) developed a 5-category classification of excitability stress for bighorn sheep based on heart and respiration rate, and the amount of struggle prior to and during handling. Franzmann et al. (1975) also used this system for classifying excitability in moose.

To the best of my knowledge no research of ursids has addressed the influences of condition or excitability stress on various physiological values. In this study I have attempted to establish a baseline for selected physiological values of grizzly bears in central and northern Alaska. I have also attempted to identify the specific influences that condition, handling stress, and immobilization have on selected physiological values. The results should help indicate to wildlife professionals the direction future research of this kind should take.

STUDY AREAS

ALASKA RANGE

This study area is that portion of the north slope of the Alaska Range bounded on the east by Delta Creek, on the west by the Wood River, on the north by latitude 64° 5' N, and on the south by the crest of the mountain range (Figure 1). The area, entirely within the ADF&G Game Management Unit (GMU) 20A, is approximately 480 sq. km.

Most of the area is inaccessible by road. However, there are some 4-wheel-drive roads in the lower elevations and drainages along with a few landing strips. These provide access to the trappers' cabins and mining claims distributed throughout the lower elevations.

Timberline is about 1030m although some of the drainages have small spruce (Picea spp.) and/or aspen (Populus tremuloides) stands above this. Elevations range from approximately 600m in the lowlands to 4196m at the highest peak, Mt. Hayes. The largest portion of the area is below 1850m.

Jones and Merriam (1963), in an ecological survey of dall sheep (O. dalli dalli) range, describe the dominant plant communities in the Dry Creek drainage of the Alaska Range. The plant communities in this drainage, which is in the center of the study area, are representative of the entire study area.

Wahrhaftig (1958) and Reed (1961) describe in detail the geology of the eastern portion of the Alaska Range.

There is no weather recording station in the study area. However,

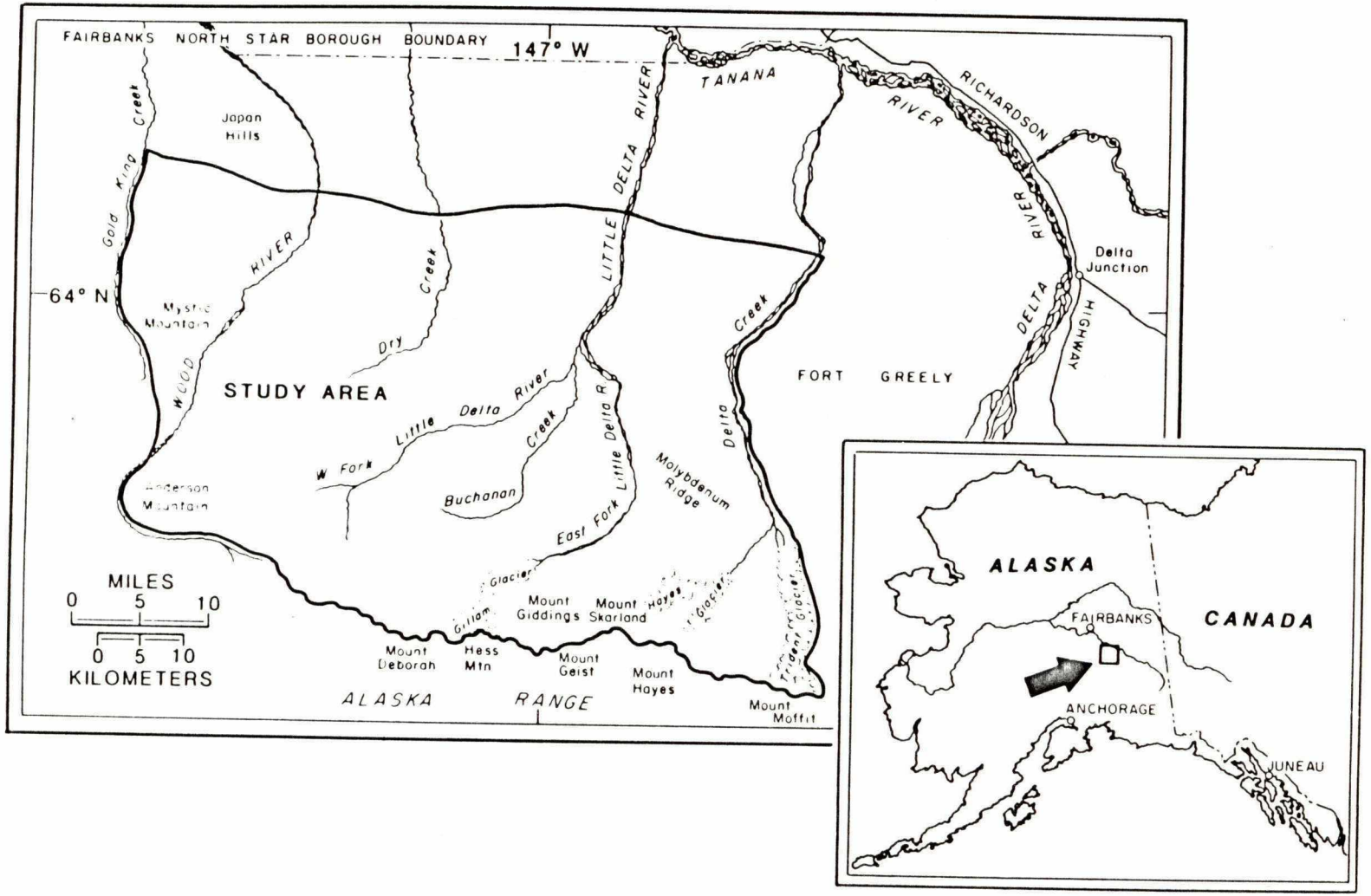

Figure 1. Study area on the north slope of the eastern Alaska Range.

the weather at the closest recording station, Denali National Park Headquarters, is probably similar to that in the study area. Climatological data for Denali Park are presented in Table 1.

The study area is on the north or lee side of the Alaska Range. Storms arriving from the Gulf of Alaska leave most of their precipitation on the south slope of the Range. However, precipitation is greater on the north slope of the Alaska Range than it is in other parts of the Interior, with cooler summer temperatures and warmer winter temperatures (Selkregg 1974-6A). Summer temperatures at Denali National Park Headquarters are 2°C to 19°C, while winter temperatures range from -22°C to -3°C. Temperature extremes are -48°C in the winter and 32°C in the summer. Average annual precipitation is 36.6 cm including 95.6 cm of snow.

ARCTIC NATIONAL WILDLIFE REFUGE

The primary study area is located on the northern coastal plain and foothills of the ANWR. The boundaries of the study area are the Aichilik River on the east, the Canning River on the west, the Beaufort Sea on the north, and roughly latitude 69° 34' N on the south (Figure 2), enclosing an area of about 6300 sq. km. Lands within these boundaries that are owned by the Kaktovik Inupiat Corporation, are excluded from the study area. These exclusions consist of approximately 50 km of coastline and about 267 sq. km of coastal plain surrounding Barter Island (USFWS 1982). The study area lies completely within GMU 26C.

The area is inaccessible by road. To reach the refuge one must fly

Table 1. Climatological data for Denali National Park Headquarters. Data are from Selkregg (1974-6A).

	Temperature (°C)				Precipitation (cm)			
							Snow	
Month	High	Mean Max	Mean Low	Low	Max	Mean	Max	Mean
Jan.	11	-12	-22	-47	12.1	2.0	197.2	30.3
Feb.	10	-8	-20	-44	7.3	1.5	182.0	25.3
March	14	-3	-17	-41	7.8	.8	101.1	15.2
April	18	3	-9	-36	18.5	1.0	250.3	12.6
May	28	12	0	-19	8.6	1.3	58.1	7.6
June	32	19	5	-8	14.9	4.5	10.1	2.5
July	29	18	7	-2	19.0	6.6	Trace	
Aug.	28	17	4	-7	17.7	7.1	Trace	
Sept.	24	11	0	-16	11.1	3.0	30.3	7.6
Oct.	21	1	-8	-31	10.6	2.0	113.8	27.8
Nov.	13	-8	-17	-38	6.8	1.5	108.7	25.3
Dec.	11	-12	-21	-48	7.6	1.3	85.9	27.8

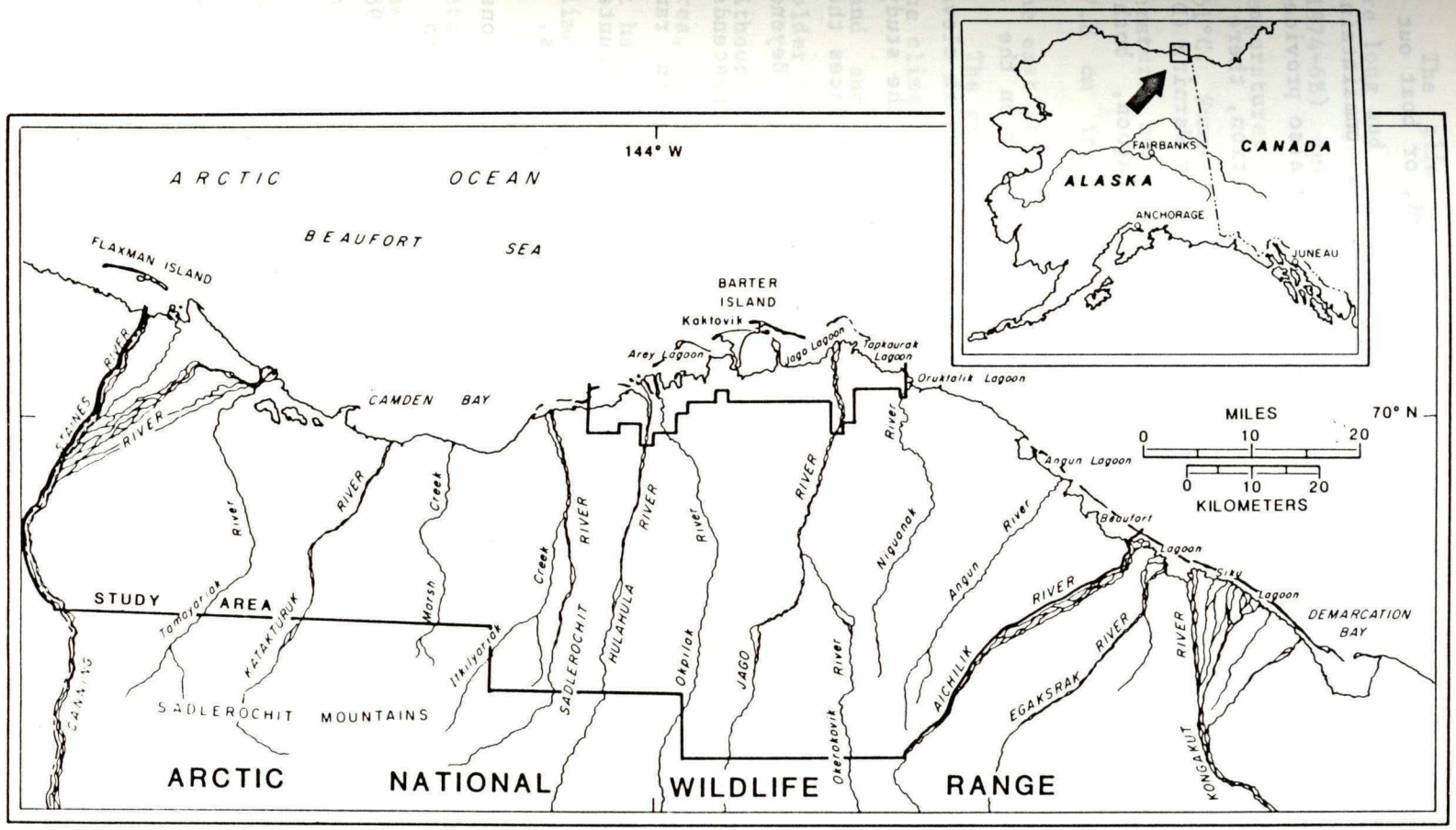

Figure 2. Study area on the coastal plain of the Arctic National Wildlife Refuge.

out of Kaktovik, a native village on Barter Island, or boat out from the island to the coast of the refuge. There are a few unmaintained airstrips within the study area and aircraft access is also provided by the gravel bars along the many glacial rivers. In addition, there are airstrips at two abandoned U.S. Air Force Distant Early Warning (DEW) stations, one at Camden Bay and the other at Beaufort Lagoon, both within the ANWR study area.

The Brooks Range extends from the Canadian border on the east to Cape Lisburne and the Chukchi Sea on the west. It rises in elevation to over 2700m in the Romanzof Mountains which lie south of the study area. The range rises abruptly on the north side where it faces the Arctic foothills which range from 180 to 1700m in elevation. Beyond these foothills to the north is the Arctic Coastal Plain which descends to sea level along the coast. Within the ANWR the coastal plain ranges in width from approximately 20 km, north of the Sadlerochit Mountains, to about 60 km along the drainages of the Okpilik and Jago Rivers.

A discussion of the geology of the region and descriptions of the rock units within the coastal plain of the ANWR can be found in Adkison and Brosge (1970), Mast et al. (1980), Reiser et al. (1971, 1980), and U.S. Navy (1977).

Hultén (1968) provided the first major attempt at compiling the flora of Alaska. Others (Sigafoos 1952, Britton 1957, and Spetzman 1959) provided more detailed descriptions of plant communities in the north. Meyers (1981) presents a geographically restricted description of plant communities within the ANWR.

The climate in the study area is an arctic climate. The winters are long and cold and the summers are short and cool. Selkregg (1974-6B) describes in detail the climate of the arctic region. Winter temperatures at Kaktovik range from -21°C to -29°C with extremes around -51°C. Summer temperatures range between -1°C and 8°C with highest temperatures around 24°C. Average annual precipitation is approximately 17.8 cm including about 113.8 cm of snow. The average wind is out of the east at 21.2 kph (13.1 mph) and may reach 129 kph (80 mph).

The greater the distance inland from the coast the more continental the climate becomes. Kaktovik is on the extreme north end of Barter Island and is often covered in fog and experiences stronger winds and colder temperatures in both winter and summer than does the mainland. Although the climate data presented here are representative of the study area, one should keep in mind the location of Kaktovik and the fact that it has somewhat more extreme weather conditions. Table 2 summarizes the climatological data for Kaktovik.

In the Alaska Range, May is the first month when the mean high temperature reaches above 4°C (40°F) while October is the first month when the mean high drops below this level (Table 1). In the ANWR, the month when the mean high temperature exceeds 4°C and the month it falls below 4°C is June and September, respectively (Table 2). It is apparent then, that the growing season starts earlier and lasts longer in the Alaska Range than in the ANWR.

Table 2. Climatological data for Barter Island, Alaska. Data are from Searby (1968).

	Temperature (°C)			Precipitation (cm)
Month	Mean High	Mean Low	Mean	Mean
Jan.	-23	-31	-27	1.0
Feb.	-25	-32	-29	.9
March	-22	-30	-26	.5
April	-13	-22	-17	.4
May	-3	-9	-6	.6
June	4	-2	1	1.3
July	9	2	5	2.2
Aug.	7	2	4	2.7
Sept.	2	-2	0	2.4
Oct.	-5	-11	-8	2.1
Nov.	-14	-21	-18	1.0
Dec.	-20	-27	-24	.7

METHODS

CAPTURE

Eighty-five grizzly bears were captured in the springs of 1981 and 1982. In the Alaska Range 5 bears were captured between 17 May and 19 June 1981 and 30 between 24 May and 13 July 1982. Fifty bears were captured in the ANWR between 23 June and 3 July 1982. During these periods bears were captured following procedures outlined by Reynolds (1974). The capture crew usually consisted of 3 persons including the pilot, in a helicopter. A pilot and an observer in a Piper PA-18-150 (Super Cub) (Piper Aircraft Corp., Lock Haven, Penn.) aircraft spotted grizzlies and directed the helicopter to a bear's location. The helicopters used were a Bell 206B Jetranger, a Bell UH-1H (Bell Helicopter; Textron Inc., Fort Worth, Texas), or a Hughes 500D (Hughes Helicopters, Inc., Culver City, California).

When a bear was located the pilot of the helicopter made one pass close to a bear to estimate its weight so that a dart could be prepared with the correct dosage of the immobilizing drug. The person darting the bear sat in a rear seat and fired out a window which could be zipped out to provide shooting access. If at all possible, the bear was darted in the rump to reduce risk of injury to less muscular areas and to optimize drug injection. Once the bear was darted the pilot pulled away to a vantage point until the bear was immobilized. This reduced stress on the animal caused by the helicopter. However, if the animal approached water, where it might drown, or dense vegetative cover, where

it could not easily be observed, the pilot pushed it toward a drier or more open area.

Bears were darted using Cap-chur equipment (Palmer Chemical and Equipment Co., Douglasville, Georgia). The drug used for immobilization was Sernylan (phencyclidine hydrochloride, Bio-Ceutic Laboratories, St. Joseph, Missouri) in combination with acepromazine maleate (Ayerst Labs., N.Y., New York) as a tranquilizer to reduce convulsions. The dosage was approximately 1.67 mg/kg of body weight of Sernylan and acepromazine maleate combined, as established by Lentfer et al. (1969). In some instances we could not be sure whether a dart had missed or, if it hit, whether it injected. In these cases we waited for up to 20 minutes for the bear to be immobilized. If it did not go down a lower dosage was prepared and the animal was darted again. Once the animal was immobilized we began the sampling procedure.

SAMPLING

I recorded body measurements for each bear as described by Reynolds (1974). These measurements included weight; total length, from the tip of the nose to the tip of the tail; body length, from the head of the humerus to the base of the tail; shoulder height, from the tip of the scapula to the end of the longest claw on the foreleg; hind foot length, from the end of the calcaneous to the tip of the middle claw; neck girth; chest girth, immediately behind the front legs; width of the head at the widest point of the lateral edges of the zygomatic arches; head length, from the gum line of the first upper incisors to the posterior

protuberance of the parietal crest; and upper and lower canine lengths from the gum line to the tip of the tooth.

Two first premolar teeth were extracted for age determination based on cementum layering (Mundy and Fuller 1964, Stoneburg and Jonkel 1966, Craighead et al. 1970). Techniques used to section, stain, and mount teeth for age determination are described by Glenn (1972). A capture number was tattooed on the inside left upper lip and under the left foreleg at the base of the leg (tattoo pliers and ink were purchased from Stone Manufacturing and Supply Co., Kansas City, Missouri).

I extracted a muscle tissue sample from the right flexor carpi radialis muscle of each bear. To determine the percent fat content of each of these samples I extracted the fat using petroleum ether. Christie (1973) discusses the use of petroleum ether for the extraction of fat from muscle tissue. To the best of my knowledge no other studies of grizzly bears have included the extraction of a muscle sample for fat content analysis. Therefore, there were no documented procedures for me to follow. I solicited the help of the veterinarian for Fort Wainright, Alaska, Dr. Michael Terry, to develop an appropriate procedure.

First, the hair was shaved from the medial portion of the right foreleg in a patch of approximately 360 sq mm. A small oval incision was made in the skin approximately 15 mm wide by 20 mm long. This small piece of skin was removed revealing the fascia between the skin and muscle tissue. This fascia or connective tissue was removed, taking care not to rupture any blood vessels or sever any nerves, permitting access to the muscle tissue below it. A small bundle of muscle tissue

approximately 10 mm thick was separated from the flexor muscle using a probe. A 1 g sample of this bundle approximately 10 mm long was clamped at both ends, removed, and placed in a small whirl pack to be frozen and stored for subsequent analysis. The clamps were then removed and the incision was sutured, using absorbable cat gut suture (Davis and Geck, Inc., Brooklyn, N.Y.) leaving a small (approximately 9 sq. mm) opening to allow the wound to drain. Furacin Powder (Hess and Clark, Inc., Ashland, Ohio) was inserted through this opening directly onto the wound. An antibiotic (Dual-Pen, Med-Tech Inc., Elwood, Kansas) was injected in the right foreleg at an approximate dosage of 0.04 cc/kg of body weight.

Blood samples were collected twice while handling each bear, once as soon after immobilization as was possible and again approximately one hour later. Subsequent analysis of these two samples provided information about the magnitude and duration of excitability stress. The blood was collected from a femoral artery using 10 cc Vacutainers (Becton - Dickinson, Rutheford, N.J.). Blood which I used to determine whole blood characteristics was collected in vials containing ethylenediamine tetra-acetate (EDTA) as an anticoagulant. I used vacutainers without an anticoagulant to collect blood for serum analyses. Upon our return from the field each day, these samples were centrifuged and the serum was extracted, frozen (at -57°C) and stored for future analysis.

WHOLE BLOOD AND SERUM ANALYSIS

Blood samples were analyzed on the date of collection. This assured more accurate results as long periods of time between collection

and analysis may result in hemolysis of erythrocytes and clotting due to the life of the anticoagulant (Coles 1980). The whole blood characteristics which were determined included hematocrit, hemoglobin, total erythrocyte count (RBC), total leukocyte count (WBC), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC). I used the facilities at the University of Alaska's Institute of Arctic Biology to analyze whole blood from the 5 bears captured in 1981. I used the cyanmethemoglobin method for determination of hemoglobin; the microhematocrit method for hematocrit; the hemocytometer method for RBC and WBC; MCV, MCH, and MCHC I determined by calculation (Coles 1980). Whole blood from bears captured in 1982 was analyzed at the Fairbanks Memorial Hospital, Fairbanks, Alaska, using their Ortho EL-7 autoanalyzer (Ortho Diagnostics, Westwood, Mass.).

Upon completion of capturing in July 1982, all serum samples that had been collected were packaged and sent to Pathologists Central Laboratory, Seattle, Washington for a series of three tests. Included with this serum were 21 samples from 20 bears captured in the eastern Brooks Range, Alaska (Reynolds 1974, 1976), and 55 samples from 46 bears captured in the western Brooks Range, Alaska (Reynolds 1980,1981), between 1973 and 1980. I included these samples to provide for geographical comparisons and to increase the data base. Serum from bears captured in the eastern Brooks Range between the Canning and Ivishak Rivers (Reynolds 1974, 1976) will be referred to as serum from Ivishak River bears. The reader should bear in mind this distinction

from bears captured on the coastal plain of the Arctic National Wildlife Refuge (ANWR), which is also in the eastern Brooks Range.

All of the serum samples were analyzed for a basic chemistry profile using the laboratory's SMAC autoanalyzer (Technicon Instruments Corp., Terrytown, N.Y.). The characteristics which were determined include glucose, blood urea nitrogen (BUN), creatinine, sodium, potassium, chloride, carbon dioxide, uric acid, total bilirubin, direct bilirubin, ionized calcium, calcium, phosphorous, alkaline phosphatase, lactic dehydrogenase (LDH), serum glutamic-oxalacetic transaminase (SGOT), serum glutamic-pyruvic transaminase (SGPT), cholesterol, triglycerides, total protein, albumin, globulin, and albumin-globulin ratio.

The second determination, protein electrophoresis, was performed using the Gelman Serum Protein Electrophoresis Procedure (Gelman Sciences, Ann Arbor, Michigan) to measure the concentration of albumin and the alpha, beta, and gamma globulin fractions. Serum used for this testing included the first sample collected from each bear captured in 1981 and 1982. The third test, serum cortisol radioimmunoassay (RIA), was performed on both samples collected from each bear captured in 1981 and 1982. This characteristic was determined using the GammaCoat Cortisol RIA Kit (Clinical Assays; Division of Travenol Laboratories, Inc., Cambridge, Mass.). I did not have the protein electrophoresis or cortisol RIA performed on all samples because of budgetary constraints.

HANDLING STRESS, PHYSICAL CONDITION, AND DRUG EFFECT

To evaluate handling stress I recorded the amount of time the

helicopter was within 0.5 km of a bear before it was immobilized; the time between the first pass over the bear and when it was darted; the time between darting and immobilization, or the induction time; and the time between the first pass and immobilization. I also recorded rectal temperature, and heart and respiration rates. I determined rectal temperature by inserting a 13 cm bulb thermometer (Clayton Rectal, Clayton, Mich.), periodically laboratory calibrated, for a minimum of 5 minutes before reading it. Heart rate was determined by palpation of a femoral artery. Respiration rate was determined by observing the expansion and contraction of the thoracic cavity.

I also subjectively evaluated handling stress for each bear and classified it as: 1) not excited, 2) excited, or 3) very excited, after Franzmann and Thorne's (1970) classification for bighorn sheep.

My 3 category classification is broader than the 5 category classification Franzmann and Thorne (1970) used, which was based on heart and respiration rate and the amount of physical struggle prior to and during examination. They also standardized their capture and handling procedures more than we were able to. We darted bears from a helicopter and the amount of time spent chasing an individual before it was immobilized varied considerably. In addition, we used Sernylan for immobilization which may cause a rise in body temperature (Seal et al. 1970). Because of an increased body temperature the animal's heart and respiration rate will rise to dissipate the heat. This additional influence made use of heart and respiration rates less reliable in classifying handling stress for this study.

I recorded information on objective characteristics to evaluate the physical condition of a bear. This included measuring skinfold thickness at 3 locations following Watts et al. (1977): 1) a point on the belly girth 5 cm right of the midline; 2) 5 cm to the right of the midline between the hind legs; 3) the articulation of the right femur with the tibia and fibula. Other objective measurements used included total weight, total length, body length, and chest girth. I subjectively evaluated each bear's physical condition, based on protrusion of the pelvis and vertebrae, and overall visual appearence, and classified it as: 1) poor, 2) below average, 3) average, 4) above average, or 5) good, modified from Robinson's (1960) classification for white-tailed deer.

As with the handling stress categorization, the condition classification I used has fewer categories than does the 11 category system used by Robinson (1960) and subsequently by Franzmann et al. (1976) for moose. Their classification was based on overall visual appearance; primarily smoothness of the neck, back, shoulders, and legs, and the animal's posture. The morphology and body contour of these ungulates is obviously different but also more discernable than that of the grizzly bear, especially since the bear's contour is masked by its heavy coat. This is even more of a problem in the spring, when we did most of our capturing, because the bear still has its winter coat but has lost a significant amount of weight over the winter. However, we could feel the body contour through this heavy coat and evaluate accordingly. Robinson (1960) and Franzmann et al. (1976) were able to categorize based on visual appearance undoubtedly using knowledge from previous

observations. Prior to this research I had no experience examining bears by touch to define their body contour. As a result, I felt I could not accurately classify individuals into such a narrow categorization as that used by Robinson (1960) and Franzmann et al. (1976).

Each individual was further classified, again based on a subjective evaluation, into one of 4 categories representing its reaction to the immobilizing drug. The categories used were 1) light, 2) moderate, 3) optimum, and 4) heavy (Reynolds 1974).

STATISTICAL ANALYSIS

Statistical analysis of the data included simple data descriptions, paired-t-testing, analysis of variance (ANOVA), multiple range testing, simple linear regression and correlation, and multiple correlation. Simple data descriptions included means, standard errors, and maximum and minimum values for each whole blood, serum, and metabolic characteristic. I performed paired-t-tests on the blood and serum measurements to test for differences between the two samples collected one hour apart from each bear. This provided information about the magnitude and duration of excitability stress. For consistency, where differences occurred I used data from the first sample in subsequent analyses, and where there were no differences I used the mean of the two samples. I examined all variables by ANOVA for the influence of sex, geographic location, and condition, stress, and drug effect classification. Characteristics demonstrating significant grouping effects were tested using Duncan's multiple range test, from the Statistical Package for the

Social Sciences (SPSS) programming, to decide between which groups the difference(s) occurred. Correlation coefficients were calculated to determine the relationships of whole blood and serum variables with metabolic characteristics as well as drug dosages. Simple linear regression analysis was performed to establish the relationships of age and date of capture with metabolic, whole blood, and serum characteristics. To explain the relationships between variables measured in the muscle fat content determination, I again used simple linear regression. Stepwise multiple correlation analysis was used to determine the amount of variation in blood and metabolic measurements that could be explained by the drug dosage or by factors related to condition or stress. With the exception of Duncan's multiple range testing, all analyses were conducted using the Biomedical Computer Program (BMDP) statistical software.

The raw data from this research project has been recorded on hard copy and on magnetic tape. Persons wishing to examine the data may do so with the permission of the Regional Supervisor for the Alaska Department of Fish and Game, 800 College Road, Fairbanks, Alaska, 99701. The hard copy is on file at this office, and the magnetic tape is on file in the Wildlife Library at the University of Alaska, Fairbanks.

RESULTS AND DISCUSSION

In this section I will present and discuss first the results for each blood and serum determination separately, which will permit easier reference. Following these discussions, the metabolic characteristics, including body weight and temperature, and pulse and respiration rates, are considered. Finally, I will discuss the influences of handling stress, physical condition, and drug effect.

Probability levels for significant results that are not tabulated are presented in the text, as are correlation coefficients and their significance levels. However, only those coefficients which are significant and greater than or equal to 0.50 will be presented. With a correlation of 0.50 the coefficient of determination is only 0.25, thus the independent variable only explains 25% of the variation in the dependent variable. Table A of the Appendix contains the sample sizes for sex and location, and for the stress, condition, drug effect, and lactation classifications.

Interpretation and explanation of statistically significant differences are attempted. However, the reader should keep in mind that statistical significance may not always indicate physiological significance. Likewise, physiological significance may not be statistically significant.

Many sources of influence may cause variation in blood values including capture methods, immobilizing drug, method of collection, storage method, time between collection and storage and between storage

and analysis, and analytical methodology. Therefore, it is difficult to interpret differences between studies and between species. As a result, means and ranges for all whole blood and serum determinations in this study are assumed to be within the range of and therefore, comparable to, each of the following publications unless otherwise indicated: Erickson and Youatt (1961), Seal et al. (1967), Pearson and Halloran (1972), Halloran and Pearson (1972), Matula (1976), Lee et al. (1977), Modafferi (1978), and Beeman (1981).

Throughout this thesis I will be using the term stress to indicate stress imposed by handling, excitability, or exercise. As one might imagine, it is difficult if not impossible to differentiate between these influences when examining blood values or other physiological characteristics of wild grizzlies or for that matter any wild animal. Without a laboratory where these influences can be controlled and regulated one must consider these influences together. However, where considerable comparative data have been collected from domestic species or humans, it is possible to differentiate between these influences when the physiologic change in question is in the same direction for the study species as it is for those species used for comparison. Where comparative data were available for a particular characteristic I differentiated between the excitability and exercise influences.

BLOOD CHARACTERISTICS

The following is a presentation and discussion of the results of each of 7 whole blood determinations on 140 blood samples collected from

78 grizzly bears. Data descriptions for Alaska Range and ANWR bears are presented in Tables 3 and 4. Data for both these locations combined are presented in Table B of the Appendix. Significant results from statistical tests for effects of time of sampling, sex, location, condition, stress, and drug effect are presented in Tables 5 - 8. Table C of the Appendix contains the data descriptions for both locations combined for first and replicate blood samples of those characteristics which exhibited significant difference between sampling times.

Briefly, paired-t-testing revealed significant within individual variability for 5 blood characteristics. ANOVA testing showed that there was no significant difference between males and females for any variable in all locations combined. However, for ANWR bears, sex differences were apparent for some hematological variables. Data descriptions for these variables are presented for both sexes in Table D of the Appendix. There was a significant location effect; bears captured in the ANWR had lower values than did bears in the Alaska Range for WBC, RBC, hemoglobin, hematocrit, and MCHC. Correlation analysis indicated that hemoglobin was significantly correlated with age for males. Hemoglobin and hematocrit were correlated with age for bears in the ANWR.

Total Leukocyte Count

The total leukocyte count or white blood cell count (WBC) reported here ($8.0 \times 10^3/mm^3$) is somewhat lower than that reported by Pearson and Halloran (1972) ($10.0 \times 10^3/mm^3$). The latter study included values from

Table 3. Whole blood characteristics of grizzly bears

CHARACTERISTIC	N
Total Leukocytes ($10^3/mm^3$)	25
Total Erythrocytes ($10^6/mm^3$)	29
Hemoglobin (g/dl)	29
Hematocrit (%)	29
Mean Cell Volume (u^3)	29
Mean Cell Hemoglobin (uug)	29
Mean Cell Hemoglobin Conc. (%)	29

in the eastern Alaska Range.

MEAN	S.E.	RANGE
9.0	0.74	2.6 - 16.5
6.3	0.11	4.95 - 7.24
16.3	0.25	13.7 - 19.5
51.0	0.80	42.6 - 61.8
81	0.95	70 - 90
25.8	0.36	21.6 - 32.5
32.0	0.30	29.7 - 36.5

Table 4. Whole blood characteristics of grizzly bears in the Arctic National Wildlife Refuge.

CHARACTERISTIC	N	MEAN	S.E.	RANGE
Total Leukocytes ($10^3/mm^3$)	49	7.0	0.32	3.7 - 12.5
Total Erythrocytes ($10^6/mm^3$)	49	5.9	0.07	5.06 - 6.95
Hemoglobin (g/dl)	49	15.0	0.19	10.9 - 17.9
Hematocrit (%)	49	49.0	1.00	37.0 - 58.0
Mean Cell Volume (u^3)	49	82.0	0.55	74.0 - 88.0
Mean Cell Hemoglobin (uug)	49	25.3	0.22	21.5 - 27.8
Mean Cell Hemoglobin Conc. (%)	49	31.0	0.10	29.0 - 33.0

Table 5. Significant statistics from paired-t-testing for differences between the first and replicate samples for whole blood characteristics of grizzly bears in the eastern Alaska Range and Arctic National Wildlife Refuge.

	BOTH LOCATIONS			ALASKA RANGE			ANWR		
CHARACTERISTIC	ALL	MALES	FEMALES	ALL	MALES	FEMALES	ALL	MALES	FEMALES
Total Leukocytes	-5.54†	-3.31†	-4.57†	-3.09†	--	-3.29†	-5.28†	-3.49†	-4.10†
Total Erythrocytes	6.23†	6.30†	3.22†	4.22†	2.68°	3.21†	4.56†	5.62†	--
Hemoglobin	6.27†	5.06†	3.89†	4.91†	2.65°	3.99†	4.32†	4.24†	1.98*
Hematocrit	6.84†	6.59†	3.76†	5.19†	2.96°	4.13†	4.71†	5.77†	1.70*
Mean Cell Volume	4.14†	2.17°	3.71†	4.20†	--	4.53†	2.13°	1.89*	--
Mean Cell Hemoglobin	--	--	--	--	--	--	--	--	--
Mean Cell Hemoglobin Conc.	--	--	--	-2.23°	--	--	--	--	--

† - ($p<0.01$)
° - ($p<0.05$)
* - ($p<0.10$)

Table 6. F-statistics from ANOVA testing for significant sex, location, condition, stress, and drug effects for whole blood characteristics of grizzly bears in the eastern Alaska Range and Arctic National Wildlife Refuge.

CHARACTERISTIC	SEX	LOCATION	CONDITION	STRESS	DRUG
Total Leukocytes	--	7.74†	--	--	--
Total Erythrocytes	--	12.22†	--	--	--
Hemoglobin	--	17.75†	--	--	--
Hematocrit	--	5.82°	3.69*	--	--
Mean Cell Volume	--	--	--	--	2.51*
Mean Cell Hemoglobin	--	--	--	--	--
Mean Cell Hemoglobin Concentration	--	19.86†	--	--	--

† - ($p<0.01$)
° - ($p<0.05$)
* - ($p<0.10$)

Table 7. F-statistics from ANOVA testing for significant sex, location, condition, stress, and drug effects for whole blood characteristics of male grizzly bears in the eastern Alaska Range and Arctic National Wildlife Refuge.

CHARACTERISTIC	SEX+	LOCATION	CONDITION	STRESS	DRUG
Total Leukocytes	--	3.44*	--	--	--
Total Erythrocytes	--	5.49°	--	--	--
Hemoglobin	--	7.34†	--	--	--
Hematocrit	--	--	--	--	--
Mean Cell Volume	--	--	--	--	--
Mean Cell Hemoglobin	--	--	--	--	2.84*
Mean Cell Hemoglobin Concentration	--	7.59°	--	--	--

† - ($p<0.01$)
° - ($p<0.05$)
* - ($p<0.10$)
+ - Testing for sex effect not possible.

Table 8. F-statistics from ANOVA testing for significant sex, location, condition, stress, and drug effects for whole blood characteristics of female grizzly bears in the eastern Alaska Range and Arctic National Wildlife Refuge.

CHARACTERISTIC	SEX+	LOCATION	CONDITION	STRESS	DRUG
Total Leukocytes	--	3.58*	--	--	--
Total Erythrocytes	--	11.85†	--	--	--
Hemoglobin	--	19.25†	--	--	3.16°
Hematocrit	--	11.16†	--	--	--
Mean Cell Volume	--	--	--	--	2.59*
Mean Cell Hemoglobin	--	--	--	--	--
Mean Cell Hemoglobin Concentration	--	5.05°	--	--	--

† - ($p<0.01$)
° - ($p<0.05$)
* - ($p<0.10$)
+ - Testing for sex effect not possible.

bears known to be diseased. Total leukocyte count increases in response to disease (Searcy 1969).

For all bears captured during this study the replicate samples had significantly higher white counts than did the first samples (Table C, APPENDIX). This could be a result of within individual variability but is more likely due to the tissue damage caused by the dart and the removal of muscle tissue samples.

In humans, leukocytosis occurs in response to strenuous exercise but within one hour following this initial increase, leukocyte levels return to normal (Wintrobe 1974). Lee et al. (1977) and Beeman (1981) reported higher white counts for bears captured in snares than for those captured in culvert traps or darted from a helicopter. They attributed the difference to the increased stress associated with capture in a snare trap. In the present study the strenuous exercise associated with the capture probably caused white counts to be elevated above normal but the higher level of the replicate samples is likely due to neutrophilia (Guyton 1981) caused by the tissue damage.

The immobilizing drug, Sernylan, may have had some influence on WBC since this drug causes release of adrenalin (Levy et al. 1960) which may increase the WBC (Guyton 1981). However, the only significant correlation with the dosage of Sernylan occurred with males ($r = 0.54$; $p<0.01$).

ANOVA testing showed that bears captured in the Alaska Range (Table 3) had a higher WBC than those in the ANWR (Table 4). This may indicate that bears in the Alaska Range were more vigorously exercised by their capture or that the population is in poorer condition. It may also be

related to neutrophilia caused by tissue damage in Alaska Range bears. I did not collect muscle samples from 35 of the 50 bears captured in the ANWR. These 35 bears had a lower ($p<0.01$) mean ($6.7 \times 10^3/mm^3$) WBC than the 15 others ($8.6 \times 10^3/mm^3$), which probably accounts for the lower mean WBC for all ANWR bears. I collected muscle samples from 25 of the 35 bears captured in the Alaska Range.

There were no significant sex or age differences in white counts, but there was a significant ($r= 0.51$; $p<0.01$) correlation with date of capture for males in the ANWR. Of 28 males captured there, I collected muscle samples from 10 and these were all captured after 28 June 1982, the last 5 days of the 11 day capture period. ANOVA testing for difference between bears from which samples were collected and those which were not sampled revealed a significantly ($p<0.05$) higher WBC for the 10 bears from which muscle samples were collected. I attribute this difference to the neutrophilia caused by the extraction of muscle samples. This is the first documented case of neutrophilia in response to tissue damage in bears.

Total Erythrocyte Count

Bears captured during this study had total erythrocyte counts or red blood cell counts (RBC) ($6.08 \times 10^6/mm^3$) somewhat lower than what Matula (1976) ($8.00 \times 10^6/mm^3$) and Pearson and Halloran (1972) ($7.00 \times 10^6/mm^3$) reported for black bears and grizzly bears, respectively. Matula (1976) stated that the higher red count for bears compared to other species was probably a compensatory mechanism for the lower MCV of

erythrocytes in bears.

Red counts were higher from the first samples than from those collected one hour later from each bear (Table C, APPENDIX). This would suggest a response to the capture effort. Wintrobe (1974) stated that in some animals transient erythrocytosis may occur as a result of contraction of the spleen. This ability is important in times of strenuous exercise because an increased red count increases the oxygen carrying capacity of the blood which facilitates the replenishing of muscle tissue with oxygen (Guyton 1981).

Seal et al. (1972) in a study of white-tailed deer, found that hemoglobin, hematocrit, and RBC were lower in the second blood sample they collected than in the first and they attributed the difference to the influence of the immobilizing drug. However, these differences may have been due to a reduced level of stress as the length of the recumbent period increased. Gartner et al. (1965) found a significant increase over resting levels, for the same three characteristics, as stimulation increased in cattle. In the present study the same response is apparent for these three characteristics, as evidenced by the differences between sampling times (Table C, APPENDIX). In contrast to what Seal et al. (1972) reported, MCV was lower in the replicate samples from grizzlies. Seal et al. (1972) also reported, as I do, that there was no change in MCH or MCHC. The above information indicates that for bears the initial response to physical exertion is the release of more and larger erythrocytes with no change in hemoglobin concentration but absolutely more hemoglobin in the blood. This finding is

physiologically sound since it would provide more oxygen carrying capacity to replenish oxygen depleted muscle tissue.

The RBC of bears captured in the Alaska Range (Table 3) was higher than for those in the ANWR (Table 4). Since there was also a difference ($p<0.01$) between the mean number of darting attempts (3.78 for the Alaska Range and 2.42 for the ANWR) made on each bear before successful immobilization, the observed difference in RBC may be due to a higher level of stress for Alaska Range bears. In the Alaska Range the terrain is mountainous with abundant cover which made darting difficult. In the ANWR capturing was concentrated on the coastal plain where darting was much easier because there is little or no cover for the bears and very little relief.

The only significant ($r= 0.56$; $p<0.05$) correlation between red count and age was for males from the Alaska Range. Pearson and Halloran (1972) and Seal et al. (1967) found that young bears had lower red counts than did adults. Matula (1976) and Beeman (1981) found no age differences. In the ANWR, males had a higher ($p<0.01$) red count than did females (Table D, APPENDIX). Red count was significantly correlated with the dosage of Sernylan only for males ($r= 0.58$; $p<0.01$).

Hemoglobin

Hemoglobin content of the blood was greater in the first sample than in the replicate (Table C, APPENDIX). As discussed for RBC, this is probably due to the excitability influence. In moose, rectal temperature was positively related to excitability but did not influence

hemoglobin content (Franzmann et al. 1976). They suggested that since their values were elevated in relation to other species, catecholamines, which are released during excitation, may have been maintaining high hemoglobin levels. Hemoglobin is the main constituent of the erythrocyte and functions in oxygen transport (Wintrobe 1974). As discussed previously, elevated levels are associated with muscle tissue oxygen demand during exercise.

Bears in the Alaska Range (Table 3) had higher hemoglobin values than those in the ANWR (Table 4). As for the other hematology variables, this may reflect population condition or stress level differences between these populations.

Hemoglobin was positively correlated with body weight for all bears ($r= 0.55$; $p<0.01$). Seal and Erickson (1969) reported low values for white-tailed deer severely under-nourished before death and higher values for those in good condition. Rosen and Bischoff (1952) reported that as mule deer lost weight, hemoglobin content of the blood decreased. Franzmann et al. (1976) reported that hemoglobin was positively related to condition in moose. The findings from the present study along with the studies just mentioned indicate that hemoglobin may be a good indicator of both individual and population condition.

There was a significant correlation of hemoglobin with age for all males ($r= 0.52$; $p<0.01$). Pearson and Halloran (1972) also reported lower values for young bears. Hemoglobin was also correlated with date of capture for bears in the ANWR ($r= 0.51$; $p<0.01$). I can offer no explanation for this since the capture period only lasted 11 days. There

was a significant ($p<0.01$) correlation with the dosage of Sernylan for all bears ($r= 0.60$) and with acepromazine maleate for males ($r= 0.65$).

Hematocrit

The percent of the blood volume that is blood cells is termed the hematocrit (Guyton 1981). This variable was greater in the first sample collected from each bear than in the replicate (Table C, APPENDIX). The physiological significance of this finding is probably related to stress and has been discussed under the preceding characteristics. In addition though, Beeman (1981) reported that the hematocrit was higher in black bears captured in snares than for those captured in culvert traps or by darting from a helicopter. She attributed this difference to the stress of the capture method.

Hematocrit also was greater for Alaska Range bears (Table 3) than for bears in the ANWR (Table 4), which again may be caused by a greater level of stress for Alaska Range bears. It was also higher ($p<0.05$) in males than in females for ANWR bears (Table D, APPENDIX). Pearson and Halloran (1972) found no difference between the sexes and no differences were reported in studies of other species (Matula 1976, Lee et al. 1977, Beeman 1981). Franzmann et al. (1976) reported lower values for bull moose than for cows, during the rut. That finding may be condition-related since these authors found that hematocrit was positively related to condition in moose; during the rut, bull moose are nutritionally stressed.

Franzmann (1972), in a study of bighorn sheep, reported that

hematocrit was positively related to condition. In the present study the level significantly decreased between two improving condition classes; (2) below average and (3) average. The sample size here (n=67) however, is much smaller than for the moose (n=810, Franzmann et al. 1976) or sheep (n=220, Franzmann 1972) studies.

No age difference in hematocrit was detected in this study (ages ranged from 0.5 to 28.5 years). Pearson and Halloran (1972) reported lower values for young age bears than for adults. As with hemoglobin, hematocrit was significantly correlated with date of capture for bears in the ANWR ($r= 0.51$; $p<0.01$). Hematocrit was also correlated ($p<0.01$) with Sernylan for males ($r= 0.56$), and for all Alaska Range bears ($r= 0.51$), and with acepromazine maleate dosage for males ($r= 0.58$), and for all Alaska Range bears ($r= 0.50$). Wesson et al. (1979), in a study of white-tailed deer, reported that hematocrit in both males and females dropped 30 minutes after injection of Sernylan plus promazine hydrochloride and rose as the deer recovered from recumbency. Seal et al. (1972) stated that these drugs appeared to cause hemodilution, and a consequent fall in hematocrit, as plasma volume expanded due to the addition of extracellular fluid. In view of these findings, I cannot explain the results of this study. In the studies just mentioned, the deer were captives and probably very docile in comparison to the bears. Also, Wesson et al. (1979) reported that manually restrained deer had a higher hematocrit than did drug immobilized deer. In the present study the drug effect may be masked by a more pronounced effect from excitability.

Mean Corpuscular Volume (MCV)

The mean corpuscular volume (MCV) for grizzly bears in this study (81.6 u^3) is higher than that reported by Matula (1976) (61.0 u^3) or Beeman (1981) (61.0 u^3) for black bears. The mean RBC from the present study is within the ranges reported by these authors but is somewhat lower than their means. The hemoglobin content is very similar for all three studies as is the MCHC, but the MCH is somewhat higher for this study (25.5 uug as opposed to 20.0 uug and 21.0 uug, respectively). The increased MCV and corpuscular hemoglobin may be compensating for the lower red cell count to maintain the hemoglobin content at a constant level. Since bears in this study were captured earlier in the year than were bears in the two previous studies, post arousal erythropoiesis may be responsible for the higher MCH, since younger red cells have a higher hemoglobin content than do older ones (Wintrobe 1974). However, the similarity in MCHC levels between studies supports, as Matula (1976) also indicated, Wintrobe's (1974) suggestion of a maximal concentration of hemoglobin in erythrocytes of normal or anemic individuals.

The MCV reported here (Table B, APPENDIX) is higher than Pearson and Halloran (1972) (69.0 u^3) reported while the RBC and MCH values are similar. However, Seal et al.'s (1967) findings for black bears support the previous suggestions.

There was statistical significance in the higher values for the first sample compared to the replicate samples for MCV (Table C, APPENDIX). The physiological significance of this finding was discussed previously (see Total Erythrocyte Count). There was a significant

($p<0.01$) positive correlation for MCV with both the Sernylan ($r= 0.53$) and acepromazine maleate ($r= 0.61$) dosages for bears in the ANWR, indicating that these immobilizing drugs increase the MCV. The difference between drug effect classes, with class 1 (light) being significantly higher than all other classes, may indicate that the immobilizing drug decreases the MCV. However, the means for all 4 classes do not decrease consistently from class 1 to 4.

Mean Corpuscular Hemoglobin (MCH)

Mean corpuscular hemoglobin (MCH) is the ratio of hemoglobin to total erythrocyte count and indicates the weight of hemoglobin in the average red corpuscle (Wintrobe 1974). Differences in MCH between this study and others were discussed previously (see Mean Corpuscular Volume). The correlation between MCH and the dosage of acepromazine maleate for all males ($r= 0.60$) and for ANWR bears ($r= 0.59$) is significant ($p<0.01$). However, the difference ($p<0.10$) between drug effect categories for males, if it is meaningful, is difficult to interpret since the ranking of category means does not increase with increasing drug effect classification.

Mean Corpuscular Hemoglobin Concentration (MCHC)

Mean corpuscular hemoglobin concentration (MCHC) is the ratio of hemoglobin to hematocrit, and measures the concentration of hemoglobin in the average red corpuscle (Wintrobe 1974). The replicate samples were higher than were first samples in MCHC for Alaska Range bear. These bears (Table 3) also had significantly higher values than did ANWR

bears (Table 4). Females had levels exceeding ($p<0.05$) those for males in the ANWR (Table D, APPENDIX). Matula (1976) reported higher values for males than for female black bears. It is difficult to interpret the differences in the present study since no differences or differences inconsistent with the above are apparent for the other erythrocyte variables.

SERUM CHARACTERISTICS

In this section I present and discuss the results of 24 serum chemistry analyses performed on 215 blood samples collected from 155 grizzly bears in central and northern Alaska. Of 161 bears captured we could not obtain blood from 5 cubs of the year or from one 5.5 year old sow which drowned during the capture effort. Data descriptions for serum characteristics of grizzly bears in each of the four locations is presented in Tables 9 - 14. Data for all locations combined is presented in Table E of the Appendix.

Statistical testing for time of sampling, sex, location, condition, stress, and drug effect was performed and significant results are presented in Tables 15 - 21. Paired t-testing showed a significant difference between first samples and replicates for all determinations with the exceptions of glucose, sodium, bilirubin, ionized calcium, calcium, SGOT, cholesterol, triglycerides, albumin, and cortisol. As determined by ANOVA testing, males differed significantly from females in amounts

Table 9. Serum characteristics of grizzly bears in the eastern Alaska Range.

CHARACTERISTIC	N	MEAN	S.E.	RANGE
Glucose (mg/dl)	29	92.0	6.29	48.0 - 195.0
Urea Nitrogen (mg/dl)	30	35.0	2.88	8.0 - 68.0
Creatinine (mg/dl)	30	1.18	0.06	0.7 - 1.8
Sodium (mEq/L)	30	136.0	0.54	129.5 - 141.0
Potassium (mEq/L)	30	4.4	0.08	3.8 - 5.4
Chloride (mEq/L)	30	99.0	0.83	91.0 - 108.0
Carbon Dioxide (mEq/L)	29	15.0	1.11	1.0 - 25.0
Uric Acid (mg/dl)	30	2.0	0.22	1.2 - 7.4
Total Bilirubin (mg/dl)	35	0.11	0.01	0.0 - 0.2
Direct Bilirubin (mg/dl)	35	0.09	0.01	0.0 - 0.2
Ionized Calcium (mg/dl)	30	4.0	0.08	3.25 - 4.8
Calcium (mg/dl)	30	9.0	1.04	7.35 - 39.35

Table 9. Continued.

CHARACTERISTIC	N
Phosphorous (mg/dl)	30
Alkaline Phosphatase (U/L)	30
Lactic Dehydrogenase (U/L)	30
Glutamic-Oxalacetic Transaminase (U/L)	30
Glutamic-Pyruvic Transaminase (U/L)	30
Cholesterol (mg/dl)	30
Triglycerides (mg/dl)	30
Total Protein (g/dl)	30
Albumin (g/dl)	30
Globulin (g/dl)	30
Albumin:Globulin Ratio	30
Cortisol (ug/dl)	30

MEAN	S.E.	RANGE
4.3	0.25	2.0 - 6.9
81	9.04	14 - 209
797	32.07	433 - 1152
236.0	52.90	59.5 - 1307.5
79.0	18.43	16.5 - 500.5
202.0	9.20	86.5 - 300.5
197	12.60	89 - 415
6.0	0.13	4.65 - 7.75
3.5	0.09	2.55 - 4.75
2.7	0.06	1.90 - 3.25
1.3	0.04	1.0 - 1.7
19.0	0.92	6.4 - 28.1

Table 10. Serum electrophoretic determinations of grizzly bears in the eastern Alaska Range.

CHARACTERISTIC	N	MEAN	S.E.	RANGE
Total Protein (g/dl)	30	6.0	0.13	4.6 - 7.8
Albumin (g/dl)	30	3.6	0.09	2.5 - 4.9
Alpha (g/dl)	30	0.87	0.04	0.4 - 1.3
Beta (g/dl)	30	0.9	0.03	0.7 - 1.5
Gamma (g/dl)	30	0.67	0.04	0.4 - 1.6
Albumin:Globulin Ratio	30	1.4	0.04	1.1 - 1.9

Table 11. Serum characteristics of grizzly bears in the Arctic National Wildlife Refuge.

CHARACTERISTIC	N	MEAN	S.E.	RANGE
Glucose (mg/dl)	47	92.0	4.57	33.0 - 158.0
Urea Nitrogen (mg/dl)	49	40.0	2.08	19.0 - 91.0
Creatinine (mg/dl)	49	0.9	0.04	0.5 - 1.8
Sodium (mEq/L)	49	134.8	0.34	129 - 140
Potassium (mEq/L)	49	4.5	0.08	3.6 - 5.8
Chloride (mEq/L)	49	98.8	0.64	87.0 - 111.5
Carbon Dioxide (mEq/L)	49	14.0	0.88	1 - 27
Uric Acid (mg/dl)	49	2.5	0.15	1.2 - 6.3
Total Bilirubin (mg/dl)	50	0.1	0.004	0.0 - 0.2
Direct Bilirubin (mg/dl)	50	0.08	0.005	0.0 - 0.2
Ionized Calcium (mg/dl)	49	4.06	0.05	3.5 - 5.1
Calcium (mg/dl)	49	8.5	0.09	7.3 - 10.0

Table 11. Continued.

CHARACTERISTIC	N	MEAN	S.E.	RANGE
Phosphorous (mg/dl)	49	5.0	0.19	2.2 - 7.9
Alkaline Phosphatase (U/L)	49	86	6.53	29 - 183
Lactic Dehydrogenase (U/L)	49	741	21.69	487 - 1361
Glutamic-Oxalacetic Transaminase (U/L)	49	141	8.95	74 - 311
Glutamic-Pyruvic Transaminase (U/L)	49	39	2.45	19 - 93
Cholesterol (mg/dl)	49	231	7.31	101 - 367
Triglycerides (mg/dl)	49	172.0	6.47	45.0 - 279.5
Total Protein (g/dl)	49	6.0	0.08	4.25 - 6.90
Albumin (g/dl)	49	3.29	0.04	2.55 - 3.80
Globulin (g/dl)	49	2.8	0.06	2.00 - 3.95
Albumin:Globulin Ratio	49	1.2	0.03	0.65 - 1.70
Cortisol (ug/dl)	48	17.0	0.48	9.70 - 25.85

Table 12. Serum electrophoretic determinations of grizzly bears in the Arctic National Wildlife Refuge.

CHARACTERISTIC	N	MEAN	S.E.	RANGE
Total Protein (g/dl)	48	6.0	0.10	2.7 - 6.8
Albumin (g/dl)	48	3.3	0.04	2.5 - 3.9
Alpha (g/dl)	48	0.89	0.02	0.6 - 1.2
Beta (g/dl)	48	0.98	0.03	0.7 - 1.7
Gamma (g/dl)	48	0.66	0.03	0.3 - 1.2
Albumin:Globulin Ratio	48	1.26	0.04	0.7 - 2.0

Table 13. Serum characteristics of grizzly bears from the Ivishak River.

CHARACTERISTIC	N	MEAN	S.E.	RANGE
Glucose (mg/dl)	19	103	10.20	46 - 187
Urea Nitrogen (mg/dl)	21	30	4.19	8 - 87
Creatinine (mg/dl)	21	1.0	0.09	0.4 - 2.2
Sodium (mEq/L)	16	129	5.20	93 - 153
Potassium (mEq/L)	20	4.3	0.25	2.0 - 6.1
Chloride (mEq/L)	20	92	4.78	46 - 126
Carbon Dioxide (mEq/L)	20	13	1.94	1 - 39
Uric Acid (mg/dl)	13	1.6	0.29	0.8 - 4.4
Total Bilirubin (mg/dl)	21	0.09	0.01	0.0 - 0.2
Direct Bilirubin (mg/dl)	21	0.08	0.01	0.0 - 0.2
Ionized Calcium (mg/dl)	20	3.0	0.20	1.1 - 4.6
Calcium (mg/dl)	20	7.0	0.54	2.5 - 13.2

Table 13. Continued.

CHARACTERISTIC	N
Phosphorous (mg/dl)	19
Alkaline Phosphatase (U/L)	16
Lactic Dehydrogenase (U/L)	21
Glutamic-Oxalacetic Transaminase (U/L)	20
Glutamic-Pyruvic Transaminase (U/L)	20
Cholesterol (mg/dl)	21
Triglycerides (mg/dl)	21
Total Protein (g/dl)	20
Albumin (g/dl)	20
Globulin (g/dl)	20
Albumin:Globulin Ratio	20

MEAN	S.E.	RANGE
3.8	0.41	1.4 - 8.7
32	5.60	10 - 95
389	39.94	126 - 771
128	31.42	21 - 660
129	38.86	6 - 680
160	14.27	23 - 278
122	14.05	24 - 261
5.8	0.43	1.1 - 9.8
3.3	0.21	1.6 - 5.2
2.6	0.21	0.4 - 4.7
1.2	0.06	0.8 - 1.8

Table 14. Serum characteristics of grizzly bears in the western Brooks Range.

CHARACTERISTIC	N	MEAN	S.E.	RANGE
Glucose (mg/dl)	54	102	5.24	35 - 244
Urea Nitrogen (mg/dl)	55	39	1.94	17 - 77
Creatinine (mg/dl)	55	0.79	0.04	0.3 - 1.8
Sodium (mEq/L)	48	135	2.24	87 - 160
Potassium (mEq/L)	54	4.3	0.10	2.4 - 6.6
Chloride (mEq/L)	54	99	2.18	38 - 122
Carbon Dioxide (mEq/L)	55	15	0.94	1 - 29
Uric Acid (mg/dl)	46	1.6	0.09	0.9 - 4.3
Total Bilirubin (mg/dl)	55	0.09	0.01	0.0 - 0.3
Direct Bilirubin (mg/dl)	55	0.09	0.007	0.0 - 0.2
Ionized Calcium (mg/dl)	55	3.9	0.09	2.2 - 6.5
Calcium (mg/dl)	54	8.0	0.23	3.3 - 10.8

Table 14. Continued.

CHARACTERISTIC	N
Phosphorous (mg/dl)	54
Alkaline Phosphatase (U/L)	48
Lactic Dehydrogenase (U/L)	54
Glutamic-Oxalacetic Transaminase (U/L)	55
Glutamic-Pyruvic Transaminase (U/L)	54
Cholesterol (mg/dl)	54
Triglycerides (mg/dl)	55
Total Protein (g/dl)	53
Albumin (g/dl)	54
Globulin (g/dl)	55
Albumin:Globulin Ratio	55

MEAN	S.E.	RANGE
4.3	0.19	1.3 - 8.3
60	5.71	12 - 233
526	36.36	88 - 1456
117	9.25	14 - 340
42	4.01	2 - 132
212	10.45	81 - 423
166	8.89	48 - 388
6.0	0.17	2.3 - 8.9
3.1	0.09	1.1 - 4.2
3.0	0.15	0.8 - 6.7
1.18	0.06	0.6 - 2.6

Table 15. Significant statistics from paired-t-testing for differences between the first and replicate samples for serum characteristics of grizzly bears in the eastern Alaska Range and Arctic National Wildlife Refuge.

	BOTH LOCATIONS			ALASKA RANGE			ANWR		
CHARACTERISTIC	ALL	MALES	FEMALES	ALL	MALES	FEMALES	ALL	MALES	FEMALES
Glucose	--	--	--	--	--	--	--	--	--
Blood Urea Nitrogen	7.61†	4.97†	5.95†	4.97†	2.18*	4.39†	5.65†	4.52†	3.91†
Creatinine	7.69†	5.92†	5.10†	5.75†	2.70°	5.17†	5.32†	5.23†	2.80°
Sodium	--	--	--	--	--	--	--	--	--
Potassium	--	--	-2.15°	--	--	--	--	--	-2.56°
Chloride	-3.71†	-1.75*	-3.60†	-4.74†	-2.74°	-3.75†	--	--	--
Carbon Dioxide	-7.61†	-5.82†	-5.24†	-3.28†	-2.05*	-2.58°	-7.00†	-5.28†	-4.68†
Uric Acid	7.82†	6.44†	5.08†	3.83†	3.09°	3.17†	7.41†	5.49†	5.19†
Total Bilirubin	--	--	--	--	--	--	--	--	--
Direct Bilirubin	--	--	--	--	--	--	--	--	--
Ionized Calcium	--	--	--	--	--	--	--	--	--
Calcium	--	--	--	--	--	--	--	--	--

Table 15. Continued.

CHARACTERISTIC	BOTH LOCATIONS		
	ALL	MALES	FEMALES
Phosphorous	3.54†	2.17°	2.68†
Alkaline Phosphatase	--	--	4.42†
Lactic Dehydrogenase	--	-1.70*	--
Glutamic-Oxalacetic Transaminase	--	--	--
Glutamic-Pyruvic Transaminase	1.97*	--	--
Cholesterol	--	--	--
Triglycerides	--	--	--
Total Protein	--	--	--
Albumin	--	--	--
Globulin	--	--	1.89*
Albumin-Globulin Ratio	--	--	-2.18°
Cortisol	--	--	--

† - ($p<0.01$)
° - ($p<0.05$)
* - ($p<0.10$)

ALASKA RANGE			ANWR		
ALL	MALES	FEMALES	ALL	MALES	FEMALES
--	--	--	3.19†	2.36°	2.10°
--	--	3.68†	4.78†	4.36†	3.64†
--	--	--	--	-2.04*	--
--	3.64°	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--
1.80*	--	--	--	--	--
--	--	--	--	--	--
2.17°	--	1.93*	--	--	--
--	--	--	--	--	--
-1.90*	--	-2.28°	--	--	--

Table 16. F-statistics from ANOVA testing for significant sex, location, condition, stress, and drug effects for serum characteristics of grizzly bears in central and northern Alaska.

CHARACTERISTIC	SEX	LOCATION	CONDITION	STRESS	DRUG
Glucose	4.24°	--	--	2.45*	--
Urea Nitrogen	--	2.58*	--	--	--
Creatinine	--	8.92†	--	--	--
Sodium	--	--	--	--	--
Potassium	--	--	--	2.55*	--
Chloride	--	--	--	--	--
Carbon Dioxide	--	--	6.60°	4.25°	--
Uric Acid	--	8.39†	--	--	--
Total Bilirubin	--	2.41*	--	--	--
Direct Bilirubin	6.26°	--	3.49*	--	--
Ionized Calcium	--	11.15†	--	--	--
Calcium	--	--	--	--	--

Table 16. Continued

CHARACTERISTIC	SEX
Phosphorous	3.41*
Alkaline Phosphatase	3.07*
Lactic Dehydrogenase	--
Glutamic-Oxalacetic Transaminase	4.15°
Glutamic-Pyruvic Transaminase	4.25°
Cholesterol	2.70*
Triglycerides	--
Total Protein	--
Albumin	4.55°
Globulin	--
Albumin-Globulin Ratio	3.45*
Cortisol	--

† - ($p<0.01$)
° - ($p<0.05$)
* - ($p<0.10$)

LOCATION	CONDITION	STRESS	DRUG
4.58†	--	--	--
6.30†	--	--	--
28.08†	--	--	--
3.28°	--	--	--
4.12°	--	--	--
6.42†	--	--	--
6.39†	--	--	--
--	--	--	--
2.30*	--	--	--
--	--	--	--
--	--	2.69*	--
2.88*	--	--	--

Table 17. F-statistics from ANOVA testing for significant sex, location, condition, stress, and drug effects for serum protein electrophoretic determinations of grizzly bears in the eastern Alaska Range and Arctic National Wildlife Refuge.

CHARACTERISTIC	SEX	LOCATION	CONDITION	STRESS	DRUG
Total Protein	--	--	--	--	2.35*
Albumin	4.03°	7.13†	--	--	--
Alpha	--	--	--	--	--
Beta	--	--	--	--	--
Gamma	5.84°	--	--	--	--
Albumin-Globulin Ratio	7.18*	6.41°	--	--	--

† - ($p<0.01$)
° - ($p<0.05$)
* - ($p<0.10$)

Table 18. F-statistics from ANOVA testing for significant sex, location, condition, stress, and drug effects for serum characteristics of male grizzly bears in central and northern Alaska.

CHARACTERISTIC	SEX[+]	LOCATION	CONDITION	STRESS	DRUG
Glucose	--	--	--	--	--
Blood Urea Nitrogen	--	--	--	--	--
Creatinine	--	5.11†	--	--	--
Sodium	--	--	--	--	--
Potassium	--	--	--	--	--
Chloride	--	--	--	4.16†	--
Carbon Dioxide	--	--	--	--	--
Uric Acid	--	4.21†	--	--	--
Total Bilirubin	--	3.22°	--	--	--
Direct Bilirubin	--	2.63*	--	--	5.05†
Ionized Calcium	--	6.28†	--	--	--
Calcium	--	--	--	--	--

Table 18. Continued.

CHARACTERISTIC	SEX+	LOCATION	CONDITION	STRESS	DRUG
Phosphorous	--	2.98°	--	--	2.97°
Alkaline Phosphatase	--	5.38†	--	--	--
Lactic Dehydrogenase	--	14.00†	--	--	--
Glutamic-Oxalacetic Transaminase	--	--	--	4.76*	--
Glutamic-Pyruvic Transaminase	--	--	--	4.55°	--
Cholesterol	--	2.65*	--	--	--
Triglycerides	--	--	--	--	2.36*
Total Protein	--	--	--	--	--
Albumin	--	--	--	--	--
Globulin	--	--	--	--	--
Albumin-Globulin Ratio	--	2.36*	--	3.90*	--
Cortisol	--	--	--	--	4.48†

† - ($p<0.01$)
° - ($p<0.05$)
* - ($p<0.10$)
+ - Testing for sex effect not possible.

Table 19. F-statistics from ANOVA testing for significant sex, location, condition, stress, and drug effects for serum protein electrophoretic determinations of male grizzly bears in the eastern Alaska Range and Arctic National Wildlife Refuge.

CHARACTERISTIC	SEX+	LOCATION	CONDITION	STRESS	DRUG
Total Protein	--	--	--	--	--
Albumin	--	3.03*	--	--	--
Alpha	--	5.94°	--	4.94°	--
Beta	--	--	--	--	--
Gamma	--	--	--	--	--
Albumin-Globulin Ratio	--	10.66†	--	--	--

† - ($p<0.01$)
° - ($p<0.05$)
* - ($p<0.10$)
+ - Testing for sex effect not possible.

Table 20. F-statistics from ANOVA testing for significant sex, location, condition, stress, and drug effects for serum characteristics of female grizzly bears in central and northern Alaska.

CHARACTERISTIC	SEX[+]	LOCATION	CONDITION	STRESS	DRUG
Glucose	--	--	--	8.03†	--
Urea Nitrogen	--	--	--	--	--
Creatinine	--	9.03†	--	--	6.35†
Sodium	--	--	--	6.53°	--
Potassium	--	--	--	5.24°	--
Chloride	--	--	--	--	--
Carbon Dioxide	--	--	--	9.97†	2.29*
Uric Acid	--	7.26†	--	--	4.75†
Total Bilirubin	--	--	--	--	--
Direct Bilirubin	--	--	--	--	--
Ionized Calcium	--	4.50†	--	--	--
Calcium	--	--	--	--	--

Table 20. Continued.

CHARACTERISTIC	SEX[+]
Phosphorous	--
Alkaline Phosphatase	--
Lactic Dehydrogenase	--
Glutamic-Oxalacetic Transaminase	--
Glutamic-Pyruvic Transaminase	--
Cholesterol	--
Triglycerides	--
Total Protein	--
Albumin	--
Globulin	--
Albumin-Globulin Ratio	--
Cortisol	--

† - ($p<0.01$)
° - ($p<0.05$)
* - ($p<0.10$)
+ - Testing for sex effect not possible.

LOCATION	CONDITION	STRESS	DRUG
--	--	--	--
--	--	--	2.28*
13.79†	--	--	--
3.29°	--	--	--
3.54°	--	--	--
4.76†	--	--	--
6.88†	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--
--	--	--	--

Table 21. F-statistics from ANOVA testing for significant sex, location, condition, stress, and drug effects for serum protein electrophoretic determinations of female grizzly bears in the eastern Alaska Range and Arctic National Wildlife Refuge.

CHARACTERISTIC	SEX+	LOCATION	CONDITION	STRESS	DRUG
Total Protein	--	--	--	--	--
Albumin	--	4.99°	--	--	--
Alpha	--	--	--	--	--
Beta	--	4.18°	--	--	--
Gamma	--	--	--	--	--
Albumin-Globulin Ratio	--	--	--	--	--

° - ($p<0.05$)
+ - Testing for sex effect not possible.

of glucose, bilirubin, phosphorous, alkaline phosphatase, SGOT, SGPT, cholesterol, albumin, and albumin-globulin ratio. Only phosphorous ($r= -0.51$; $p<0.01$) and alkaline phosphatase ($r= -0.58$; $p<0.01$) were significantly correlated with age for all bears combined. However, significant correlation did exist for other determinations within some sex and location classes.

No significant correlation was found for any serum characteristic with date of capture for all bears combined. However, as with age, there was significance within some sex and location classes. This same pattern holds for correlation with the dosage of Sernylan. There was also a significant correlation with the dosage of acepromazine maleate for creatinine ($r= 0.50$; $p<0.01$) and ionized calcium ($r= -0.55$; $p<0.01$) for all bears. Henry (1964) summarizes reports concerning the stability of serum characteristics during storage. Briefly, he found that stability, for all the characteristics I am discussing, varied dependent on the report. Generally, a characteristic was stable for a few months as long as the serum was frozen (at -20°C). A few characteristics (creatinine, carbon dioxide, alkaline phosphatase, and total protein and its fractions) were reported as being stable from several months to over a year; cholesterol was reported to be stable for 5 years, and phosphorous and potassium were reported as having no stability problems. The reader should bear in mind these stability questions when reading my discussion of location differences. Serum samples from Ivishak River bears were stored the longest (starting in 1973) and until 1977 at a temperature of -23°C, at which time these samples, along with samples

from bears in the western Brooks Range, were transferred to a storage temperature of -57°C. Serum from bears captured in the Alaska Range and ANWR was not stored nearly this long (see METHODS). These differences in storage time and temperature may be at least partially responsible for some of the location differences in this study. In some instances the means for a characteristic are similar between Ivishak River and western Brooks Range bears but different than the means for the two other locations. In these cases, the differences are most likely due to storage time and temperature differences, and I have indicated so where appropriate.

Glucose

In contrast to most other determinations, the level of glucose in the blood of grizzly bears captured during this study did not differ between first and replicate samples.

Searcy (1969) indicated that transitory hyperglycemia may occur as a result of strenuous exercise in humans. Coles (1980) noted that transitory hyperglycemia may be associated with release of epinephrine, which can be induced by Sernylan (Levy et al. 1960), excitement, or ingestion of high quantities of carbohydrates. Seal et al. (1972) reported that levels of glucose 45 minutes after restraint in white-tailed deer were higher than at the initiation of restraint. ANOVA testing revealed a significant difference between stress classification categories for all bears. Duncan's multiple range testing failed to indicate where the difference(s) occurred ($p<0.10$). However, the mean for

class 2 was higher than that for class 1 or 3, as was the sample size (Table A, APPENDIX). Males also had a greater amount of glucose in their serum than did females (Table 22), which may have been caused by a higher level of stress in males. Beeman (1981) reported higher values for black bears captured in snares than for those captured in culvert traps or by darting from a helicopter. She attributed the difference to a higher level of stress associated with snare trapping. Franzmann (1972) found that glucose was positively related to excitability in bighorn sheep.

Glucose was significantly correlated with date of capture for males in the Alaska Range ($r= 0.61$; $p<0.05$), and for females in the ANWR. This may indicate improving condition, in these bears, as the season progresses. Matula (1976) stated that higher glucose levels in bears he captured in comparison to captives may have been due to high carbohydrate ingestion since bears were captured near dumps. Franzmann et al. (1976) reported a positive relationship with condition in moose, due to a higher plane of nutrition.

Urea Nitrogen

Urea nitrogen (BUN) levels reported by Matula (1976), (13.0 mg/dl) Modafferi (1978) (11.2 mg/dl), and Beeman (1981) (12.0 mg/dl) for black bears and Lee et al. (1977) (8.3 mg/dl) for polar bears are lower than for this study (Table E, APPENDIX). Halloran and Pearson (1972) reported a spring mean (37.1 mg/dl) similar to that in this study, but their fall mean (15.9 mg/dl) was lower. They indicated the seasonal dif-

Table 22. Blood characteristics of grizzly bears in central and northern Alaska which exhibited significant sex differences.

CHARACTERISTIC		N	MEAN	S.E.	RANGE
Glucose (mg/dl)					
	Males	79	103.0	4.27	34.5 - 244.0
	Females	70	90.0	4.01	33.0 - 195.0
Direct Bilirubin (mg/dl)					
	Males	83	0.1	0.005	0.0 - 0.2
	Females	78	0.07	0.01	0.0 - 0.2
Phosphorous (mg/dl)					
	Males	78	4.7	0.16	1.3 - 8.1
	Females	74	4.3	0.18	1.4 - 8.7
Alkaline Phosphatase (U/L)					
	Males	75	76	5.49	10 - 233
	Females	68	63	5.19	13 - 183
Glutamic-Oxalacetic Transaminase (U/L)					
	Males	80	125	7.08	14 - 340
	Females	74	176	24.08	21 - 1307
Glutamic-Pyruvic Transaminase (U/L)					
	Males	79	46	3.41	2 - 173
	Females	74	74	13.41	5 - 680
Cholesterol (mg/dl)					
	Males	81	217	7.79	86 - 423
	Females	73	200	7.16	23 - 377
Albumint (g/dl)					
	Males	80	3.4	0.07	1.1 - 5.2
	Females	73	3.2	0.06	1.20 - 3.85

Table 22. Continued.

CHARACTERISTIC		N
Albumin:Globulin Ratio†		
	Males	80
	Females	74
Albumin†† (g/dl)		
	Males	38
	Females	40
Gamma (g/dl)		
	Males	38
	Females	40
Albumin:Globulin Ratio††		
	Males	38
	Females	40

† - Determined by SMAC autoanalyzer.
†† - Determined by electrophoresis.

MEAN	S.E.	RANGE
1.27	0.04	0.6 - 2.6
1.18	0.03	0.6 - 1.9
3.49	0.07	2.8 - 4.9
3.3	0.06	2.5 - 4.0
0.6	0.03	0.4 - 1.1
0.7	0.04	0.3 - 1.6
1.4	0.04	0.9 - 2.0
1.25	0.04	0.7 - 2.0

ference may have been due to slowed renal function and a varied diet reinstatement in spring. Searcy (1969) stated that changes in renal function will affect serum urea content. In the present study bears were captured in the spring. Matula (1976), Lee et al. (1977), Modafferi (1978), and Beeman (1981) did their capturing from late summer to early winter. The fact that BUN values for bears from these four studies represent summer and fall values and are lower than for bears from the present study supports Halloran and Pearson's (1972) suggestion.

BUN was significantly higher for first samples than for replicates (Table C, APPENDIX). Searcy (1969) noted that prolonged physical exertion will cause an increase in BUN and that even moderate exercise may also, if protein must be metabolized to provide energy. Evaporative water loss is associated with physical exertion to facilitate cooling. Since this water loss may cause dehydration and a reduction in the total body water pool, and since urea nitrogen is in all the body tissues, then the high BUN values of first samples may be a result of an increased concentration of BUN rather than an absolute increase. Considering that we spent in some cases up to 2 hours attempting to immobilize a bear, it would be reasonable to conclude that this prolonged physical exertion accounts for the difference between first and replicate samples. Apparently BUN levels in first samples were elevated and then declined toward baseline levels in the replicate samples. Multiple range testing showed that BUN values were significantly ($p<0.10$) higher for bears in the ANWR classified as (3) very excited than as (2)

excited. This finding is also supported by Searcy's (1969) statement. However, Franzmann (1972) found no difference in BUN values for excitability classes in bighorn sheep.

There was a significant location effect on BUN; bears from the Ivishak River (Table 13) had significantly ($p<0.10$) lower values than did grizzlies in the western Brooks Range (Table 14) and ANWR (Table 11). This may reflect dietary differences in protein intake. Seal et al. (1975) for wolf pups, related low levels of BUN, uric acid, and cholesterol to a diet low in protein. Searcy (1969) also stated that low BUN levels may be due to diets chronically low in protein. The apparent difference also may simply be due to differences in storage time and temperature, thus affecting stability. Samples from the Ivishak River bears were stored for up to 9 years and initially at a temperature of -23 °C. After as much as 4 years at that temperature, the serum was transferred to a storage temperature of -57 °C.

Creatinine

Creatinine was higher in first than in replicate samples (Table C, APPENDIX). Since most animals were captured in the spring when body condition is poor and body reserves are depleted, protein metabolism may have been necessary to sustain the strenuous exercise associated with the capture effort. Since creatinine is a derivative of protein metabolism (Searcy 1969), the elevated levels of the first sample may have been caused by this exercise.

Bears in the Alaska Range (Table 9) had creatinine levels sig-

nificantly ($p<0.01$) higher than those for bears in all other locations. Ivishak River (Table 13) and ANWR (Table 11) bears also had higher ($p<0.01$) values than did animals in the western Brooks Range (Table 14). Bears in the Alaska Range were captured from May to July while those in the ANWR were captured in late June and early July. The Ivishak River and western Brooks Range bears were captured over a longer period of time extending into September and October. These differences in dates of capture may explain the apparent location differences. Since high levels of creatinine are associated with renal dysfunction (Searcy 1969), the above evidence appears to support Halloran and Pearson's (1972) suggestion that bears slowly regain renal function following winter dormancy. Additionally, significant correlation with date of capture was apparent for bears from the Ivishak River ($r= -0.61$; $p<0.01$) and for males in the Alaska Range ($r= -0.53$; $p<0.05$).

For Alaska Range and ANWR bears, creatinine was lower ($p<0.10$) in nonlactating females (1.0 mg/dl) than in lactating females (1.2 mg/dl). Searcy (1969) stated that in humans pregnant females exhibited lower values than did nonpregnant females because glomerular filtration is increased during pregnancy. This is not likely the cause for this study since bears were captured before or during the mating season. It is probably due to a greater amount of stress for lactating sows with young. Significant ($p<0.01$) correlation with age was apparent for some sex and location classes ranging from $r= 0.57$ for females in the ANWR to $r= 0.85$ for males in the Alaska Range. There was also a significant ($p<0.01$) correlation with body weight for ANWR ($r= 0.65$), Alaska Range

(r= 0.73), and all bears combined (r= 0.54). Beeman (1981), for black bears, reported higher values for males and adults than for females and subadults. Tietz (1970) stated that the sex difference was due to a relationship of creatinine production to muscle mass.

Creatinine was significantly ($p<0.01$) correlated with the dosage of Sernylan for Alaska Range (r= 0.66) and ANWR bears (r= 0.53), and with acepromazine maleate ($p<0.01$) for Alaska Range bears (r= 0.53), all males (r= 0.66), and all bears (r= 0.50).

Sodium

In contrast to most other serum and whole blood characteristics the amount of sodium in the serum of grizzly bears did not differ significantly between first samples and replicates. This finding is supported by Guyton's (1981) statement that sodium levels are closely regulated by the body allowing little variation.

There was a significant stress classification effect for sodium with class 2 significantly ($p<0.05$) lower than class 3. Gartner et al. (1965), in a study of beef cattle, reported that sodium increased with visual stimulation of the cattle. The causative factor for the difference between stress classes in the present study is probably the same.

Sodium was significantly ($p<0.01$) correlated with age (r= 0.51) and body weight (r= 0.51) only for Alaska Range bears. Searcy (1969) reported that in humans there was a continuous change in sodium levels throughout life because the composition of tissues was continuously

changing. He stated that levels were higher in fetuses and adults than in infants. Matula (1976) reported stability in sodium levels of black bears with respect to sex, season, and age, which he thought reflected close control by the body.

Searcy (1969) noted that high levels of sodium may be associated with kidney dysfunction. As mentioned in the previous discussion of creatinine, it is suggested that bears slowly regain renal function following winter dormancy (Halloran and Pearson 1972). Since sodium was significantly ($p<0.05$) correlated with date of capture for males from the Ivishak River ($r= -0.65$) and Alaska Range ($r= -0.53$), these findings may further support Halloran and Pearson's (1972) contention. However, it has also been shown in reindeer (Rangifer tarandus L.) that plasma sodium concentration is positively correlated with sodium pool size (Staaland et al. 1982). Therefore, these correlations of sodium with date of capture may be indicative of a decrease in sodium intake as the season progresses.

Potassium

Only for female grizzly bears was potassium significantly higher in replicate samples than in first samples. The fact that this is the only sex or location class which exhibited a difference supports Searcy's (1969) statement that kidneys function to maintain constant levels of potassium in the serum.

There was a significant stress classification affect on potassium but multiple range testing failed ($p<0.10$) to reveal where the dif-

ference(s) occurred. The mean for class 2 was greater than that for class 3 which was greater than that for class 1. Gartner et al. (1965) reported an increase in potassium with increasing stimulation in beef cattle.

In the present study, potassium was correlated with pulse rate ($r= 0.53$; $p<0.01$) for both ANWR and Alaska Range bears. Previous studies have shown that pulse rate is significantly affected by excitability and exercise (Franzmann et al. 1976, Best et al. 1981). In the present study, pulse rate was also significantly ($p<0.05$) affected by stress classification for ANWR bears with class 1 lower than classes 2 or 3. Class 3 was also lower than class 2 although not significantly ($p<0.05$). In addition to the evidence just mentioned, it appears that since, in the present study, potassium is correlated with pulse rate and pulse rate is affected by excitability and exercise, then potassium may be a good indicator of stress in grizzly bears.

Potassium levels are reciprocally affected by sodium intake (Guyton 1981). This may explain why potassium was positively correlated ($r= 0.67$; $p<0.01$) with date of capture for Alaska Range bears while sodium was negatively correlated (see Sodium). Potassium was also correlated ($r= -0.55$; $p<0.01$) with the dosage of acepromazine maleate only for females.

Chloride

The level of chloride in the serum of grizzly bears was significantly higher in replicate than first samples (Table C, APPENDIX).

The reason behind this is unclear unless the response of serum chloride to stress and immobilization is either delayed or more pronounced as time progresses.

Chloride levels are related to the pH of the blood, and increase and decrease during respiratory alkalosis and acidosis, respectively (Tietz 1970). Beeman and Pelton (1978) suggest that if black bears hyperventilated when immobilized with Sernylan, then associated high chloride levels may be due to respiratory alkalosis. They further suggest that this relationship, along with slight respiratory acidosis in bears immobilized with M-99, could explain the significant difference between bears immobilized with M-99 and those immobilized with Sernylan.

Matula (1976) reported a respiration rate of 9 breaths/min for black bears which is considerably lower than the mean of 33 breaths/min for grizzly bears in this study. Since Matula (1976) used M-99 and we used Sernylan, the difference in respiration rates between the two studies would seem to support Beeman and Pelton's (1978) suggestion. Therefore, the higher level of chloride in replicate samples from this study may be related to a delayed or progressive response to stress and immobilization with Sernylan.

Surprisingly, chloride was lowest ($p<0.05$) in bears classified as being most stressed. In light of the previous evidence it is not clear what may have caused this relationship. Secretions of the adrenal cortex and medulla may play a role in gastric secretions. Stressful stimuli cause increased secretion of ACTH and a consequent increase in circulating glucocorticoids. These glucocorticoids stimulate gastric

acid (including HCl) and pepsin secretion in the dog (Ganong 1975), which would reduce chloride levels in the serum. However, epinephrine and norepinephrine inhibit gastric secretions and are secreted in large amounts during some stresses (Ganong 1975). Therefore, it is difficult to interpret the relationship, in this study, of chloride with the stress classification.

Chloride was significantly correlated ($r= -0.64$; $p<0.05$) with date of capture only for males from the Ivishak River.

Carbon Dioxide

Replicate serum samples from grizzly bears exhibited higher values of carbon dioxide (CO_2) than did first samples (Table C, APPENDIX). Searcy (1969) noted that CO_2 during strenuous exercise may rise sharply but hyperventilation usually more than compensates for the hypercapnia and the CO_2 may fall below normal. Once immobilized, the bears' CO_2 levels apparently returned to normal during the hour of recumbency before the replicate samples were collected. This would explain the difference between the two sampling times. In addition, hyperventilation caused by Sernylan (see Chloride), may contribute to the initially reduced CO_2 levels.

ANOVA testing showed a significant stress classification affect on CO_2 for all bears, with class 3 being significantly ($p<0.05$) greater than classes 1 or 2. The most stressed animals might be expected to have somewhat higher respiration rates (see Chloride) which may have caused respiratory alkalosis to occur more quickly, thus permitting a

more rapid return to normal CO_2 levels. This might explain the higher CO_2 levels in the most stressed individuals.

Females in drug effect class 4 had a significantly ($p<0.10$) greater amount of CO_2 than did class 3 individuals. The same explanation as for the stress influence may hold here, with hyperventilation being influenced more by the drug than by stress. The reason for a significantly ($p<0.05$) higher level of CO_2 in condition class 3 individuals over class 2 is not clear, nor is the reason for the correlation of CO_2 ($r= -0.69$; $p<0.05$) with age, unless it is a result of inadequate sample size.

Uric Acid

High uric acid content in serum is indicative of prolonged physical activity and increased adrenal cortical activity (Searcy 1969). The capture effort probably caused both these factors to influence uric acid levels in bears from this study. This is evidenced by the significantly higher values from first samples over replicates that are more likely representative of normal values (Table C, APPENDIX).

All Alaska Range (Table 9) and ANWR bears (Table 11) had significantly ($p<0.01$) greater amounts of uric acid than did all other bears while males from the ANWR had higher ($p<0.01$) values than did males in all other locations. Other researchers have reported seasonal, yearly, species, and age differences, attributing them to dietary differences (Halloran and Pearson 1972, Matula 1976, Beeman 1981). In this study the location differences may also be due to dietary influences.

However, the means for Ivishak River (Table 13) and western Brooks Range bears (Table 14) were similar but lower than the means for the two other locations. Therefore, the apparent location difference could be due to a longer storage time for samples from Ivishak River and western Brooks Range bears, resulting in instability of uric acid, or it may be a seasonal difference resulting from differences in dates of capture at the different locations (see Creatinine).

There was a significant difference between drug effect classes but multiple range testing ($p<0.10$) failed to reveal where the difference(s) occurred.

Bilirubin

For this study both total and direct bilirubin were determined. The difference between the two is that total bilirubin consists of both direct (conjugated) and indirect (nonconjugated) bilirubin (Henry 1964).

Total bilirubin was significantly ($p<0.05$) higher in males than in females in the ANWR (Table D, APPENDIX) and direct bilirubin was higher in males than in females for all locations combined (Table 22). In general, these findings support that for humans, in which males have higher values than do females (Searcy 1969). Absence of a difference in some locations was probably due simply to sample size and variability.

Reproductive aged females (4.5 years or older) with young (0.11 mg/dl) exhibited higher ($p<0.10$) levels of total bilirubin than did females without young (0.09 mg/dl). Perhaps those with young became more stressed during the capture effort which caused levels to rise.

Franzmann et al. (1976) noted a positive relationship between bilirubin and rectal temperature (which increased for each stress class), which they indicated was due to breakdown of hemoglobin and a subsequent release of bilirubin. Since body temperature generally rises during strenuous exercise, this may explain the difference in the present study between sows with young and those without. Henry (1964) noted that levels were higher in humans during exercise.

Location differences in total bilirubin were apparent (Tables 9, 11, 13, and 14) but multiple range testing failed to reveal where the difference(s) occurred. Since the ranking of the means are different within the two sexes and for both sexes combined the location difference is difficult to interpret.

Bears in condition class 3 had more ($p<0.10$) direct bilirubin than did those in class 2. Bilirubin is a pigment of hemoglobin and derived primarily from its degradation (Searcy 1969). Since Franzmann et al. (1976) indicated that stress causes a breakdown of hemoglobin and subsequent release of bilirubin, and since they found that hemoglobin was positively related to condition, perhaps the breakdown of hemoglobin during the stress of the capture explains the positive relationship of bilirubin with condition in this study.

Direct bilirubin was correlated with date of capture for Ivishak River bears ($r= -0.64$; $p<0.01$) and for females in the ANWR ($r= -0.60$; $p<0.01$). The physiological significance of this too is unclear unless it is related to improving condition with time, although capturing was only conducted for an 11 day period in the ANWR.

Calcium

Both ionized calcium and total calcium were determined for grizzly bears in this study. Ionized calcium refers to the free or unbound calcium and is important because it is the fraction (50-58%) of total calcium which is physiologically active (Henry 1964).

Ionized calcium showed a significant location effect with Ivishak River bears (Table 13) having lower ($p<0.01$) levels than did bears in the other locations (Tables 9, 11, and 14). This difference may be due to dietary differences. Searcy (1969) noted that in humans on a low calcium diet the levels of ionized and total calcium may be slightly depressed; however, the levels generally remain relatively constant despite wide dietary fluctuations.

Males in the ANWR had significantly more total and ionized calcium in their serum than did females (Table 22), probably due to a reduced level of calcium in lactating sows. The fact that lactating sows (3.9 mg/dl) had significantly ($p<0.05$) less ionized calcium than all other bears (4.1 mg/dl) substantiates that suggestion. Matula (1976) also reported higher values for male black bears but was not sure of the cause. It was probably the same as I have suggested here.

Both ionized and total calcium were significantly ($p<0.01$) correlated with age for most sex and location classes, ranging from $r= -0.51$ for males in the ANWR to $r= -0.86$ for males in the Alaska Range. Lee et al. (1977) also reported higher values for cubs than for adults and suggested this was due to greater osteoblast activity associated with skeletal growth and bone ossification. Findings from the present

study concur with their suggestion.

For males in the Alaska Range ionized calcium ($r= 0.70$) and total calcium ($r= 0.90$) were significantly ($p<0.01$) correlated with date of capture. I cannot explain this relationship, unless it is related to dietary differences, especially since Halloran and Pearson (1972) reported that total calcium decreased from spring to summer. I am also unable to explain the significant ($p<0.01$) correlation of ionized calcium with the dosage of Sernylan for Alaska Range ($r= -0.60$) and ANWR ($r= -0.56$) bears, and with acepromazine maleate ($r= -0.55$) for all bears.

Phosphorous

In humans, serum phosphorous rises quickly to peak levels, in response to physical activity, and returns to baseline values shortly thereafter (Searcy 1969). The same response is evident for grizzly bears as indicated by the significantly lower phosphorous values in replicate samples (Table C, APPENDIX). Seal et al. (1972) also reported reduced levels 45 minutes after restraint of white-tailed deer.

Phosphorous was higher ($p<0.01$) for ANWR bears (Table 11) than for bears from any other location (Table 9, 13, and 14). The physiological significance of this finding is unclear unless it is related to dietary differences.

Males in drug effect class 1 had lower ($p<0.05$) values for phosphorous than did bears in any other class. Beeman and Pelton (1978) reported lower levels for black bears immobilized with Sernylan as op-

posed to bears immobilized with M-99. One would suspect then, that the greater the effect of the drug the lower the phosphorous levels. This was not apparent in the present study based on the subjective evaluation of drug effect. However, there was a negative correlation with dosages of Sernylan ($r= -0.52$; $p<0.01$) and acepromazine maleate ($r= -0.51$; $p<0.01$).

Males had greater amounts of phosphorous than did females (Table 22); also nonlactating females (5.0 mg/dl) had larger amounts ($p<0.05$) than did lactating females (3.8 mg/dl). These differences are probably due to a higher phosphorous demand for milk production in lactating sows. Although no other studies of bears have shown a similar difference, Franzmann et al. (1976) did report the same difference for moose. They speculated that phosphorous may be more critical than calcium for lactating moose since calcium showed no difference. In this study there was a difference for calcium probably because it is so closely related to phosphorous (Searcy 1969).

Henry (1964) and Searcy (1969) both noted that phosphorous decreased with age in humans. The same response is evident for bears in this study with significant ($p<0.01$) correlation coefficients ranging from $r= -0.51$ for ANWR bears to $r= -0.67$ for Alaska Range females. Younger bears have a greater demand because of rapid bone growth. Beeman (1981) also reported the same relationship.

Enzymes

The four enzymes determined for this study, alkaline phosphatase,

lactic dehydrogenase (LDH), glutamic-oxalacetic transaminase (SGOT), and glutamic-pyruvic transaminase (SGPT), will be considered together in this section. They are all influenced similarly with one exception; alkaline phosphatase is important for bone growth while the other three are not (Henry 1964, Searcy 1969).

In this study I found significant correlation of alkaline phosphatase with age for most sex and location classes (Table 23). This correlation is related to reduced bone formation as young animals grow older (Searcy 1969). Matula (1976) and Beeman (1981) reported the same relationship for black bears as did Lee et al. (1977) for polar bears. Correlation with age for the other three enzymes is almost entirely missing in this study. Matula (1976) reported a decrease in LDH with age and speculated that it might be due to older animals being less excitable and therefore, having lower LDH values. As can be seen from Table 23, the same relationship was apparent for this study and probably has the same cause. The fact that alkaline phosphatase ($r= -0.62$) and LDH ($r= -0.55$) were both significantly ($p<0.01$) negatively correlated with body weight for ANWR bears also supports the above discussion since weight increases with age. In addition, LDH ($r= -0.58$) and alkaline phosphatase ($r= -0.53$) were correlated ($p<0.01$) with Sernylan dosage for ANWR bears, and alkaline phosphatase was correlated ($p<0.01$) with dosage of acepromazine maleate for females ($r= -0.55$) and Alaska Range bears ($r= -0.52$). These findings are probably also related to body weight and therefore, skeletal mass, for alkaline phosphatase since the dosage of both drugs administered to each bear was dependent on their estimated

Table 23. Significant ($p<0.01$) correlation coefficients with age for serum enzymes of grizzly bears.

	ALASKA RANGE			ANWR			IVISHAK RIVER			W. BROOKS RANGE		
CHARACTERISTIC	ALL	MALES	FEMALES	ALL	MALES	FEMALES	ALL	MALES	FEMALES	ALL	MALES	FEMALES
Alkaline Phosphatase	-.61	-.75	-.57	-.66	-.58	-.73	-.56	-.68	--	--	--	-.51
Lactic Dehydrogenase	--	-.69	--	-.51	--	-.64	--	--	--	--	--	--
Glutamic-Oxalacetic Transaminase	--	--	--	--	--	--	--	--	--	--	--	--
Glutamic-Pyruvic Transaminase	--	--	--	--	--	--	--	-.57*	--	--	--	--

* - ($p<0.05$)

weight. The negative correlation of LDH with the drug dosages is probably related to stress since dosages were related to estimated weight, weight is related to age, and older animals may be less excitable.

All four enzymes were influenced by stress as determined either by ANOVA testing for significant stress classification effect or by paired-t-testing for difference between the first and replicate samples. SGOT and SGPT showed significant stress classification effect for males and SGPT the same for ANWR bears. In all cases class 3 means were significantly higher than the means for classes 1 or 2 (at least $p<0.05$). First samples exhibited higher values than did replicates for all enzymes except LDH (Table C, APPENDIX); the LDH mean for first samples was lower than the replicate mean for at least one sex and location class. Searcy (1969) noted that all four enzymes increased markedly with physical activity, probably because of tissue damage. Franzmann and Thorne (1970) attributed higher levels of SGOT in moose to cell necrosis and stress. Matula (1976) noted that LDH and SGOT were higher in black bears than in other animal species probably because of the excitability and exercise associated with snare trapping. Lee et al. (1977) also reported high SGOT and LDH values for snared as opposed to culvert trapped bears. For this study, perhaps each enzyme increases initially, because of excitability and physical exertion, and then declines to normal levels. LDH apparently shows a similar but delayed response.

With the exception of LDH, which showed no sex effect, and alkaline phosphatase, which was higher in males, levels of the four enzymes were

higher in females (Table 22). The higher levels of SGOT and SGPT may be due to a higher level of stress in females. The higher levels of alkaline phosphatase in males are probably related to a greater skeletal mass. Franzmann et al. (1976) also reported higher levels for bull moose than for cows. Searcy (1969) and Henry (1964) noted slightly higher levels of SGOT and SGPT for females. Matula (1976) reported higher levels in males for SGOT.

The significant location effects exhibited by all four enzymes and described in Table 24 are probably caused by differences in storage times for the various locations. The means for enzymes from Ivishak River (Table 13) and western Brooks Range bears (Table 14) were generally the lowest means of all locations (Tables 9 and 11), and the serum from these locations was stored for as long as 9 years. These enzymes generally are not stable for long periods of time unless properly stored. Serum samples from the two locations mentioned were not properly stored until 4 years after collection (see Urea Nitrogen).

The correlation of alkaline phosphatase with date of capture for some sex and location classes may be related to higher demand caused by increased bone growth as the season progresses (Table 25). I cannot explain the correlation for LDH and SGPT.

Cholesterol and Triglycerides

Serum cholesterol levels reported by Matula (1976) (320 mg/dl) for black bears and by Lee et al. (1977) (357 mg/dl) for polar bears are somewhat higher than values in this study (Table E, APPENDIX) but the values for triglycerides are similar. Matula (1976), when culvert

Table 24. Significant ($p<0.01$) location differences for serum enzymes of grizzly bears.† A - Alaska Range; B - Arctic National Wildlife Refuge; C - Ivishak River; D - western Brooks Range. Means of underlined locations are not different.††

ALKALINE PHOSPHATASE			LACTIC DEHYDROGENASE		
ALL	MALES	FEMALES	ALL	MALES	FEMALES
C D A B	C D A B	C D A B	C D B A	C D B A	C D B A

GLUTAMIC-OXALACETIC TRANSAMINASE+			GLUTAMIC-PYRUVIC TRANSAMINASE		
ALL	MALES	FEMALES	ALL	MALES	FEMALES+
D C B A	D C B A	D B C A	B D A C	B D A C	B D A C

† - Determined using Duncan's multiple range test.
†† - Locations are arranged in order of lowest to highest mean from left to right.
+ - ($p<0.05$)

Table 25. Significant ($p<0.01$) correlation coefficients with date of capture for serum enzymes of grizzly bears.

	ALASKA RANGE			ANWR			IVISHAK RIVER			W. BROOKS RANGE		
CHARACTERISTIC	ALL	MALES	FEMALES	ALL	MALES	FEMALES	ALL	MALES	FEMALES	ALL	MALES	FEMALES
Alkaline Phosphatase	.51	.69	.50	--	--	--	--	--	--	--	--	.55
Lactic Dehydrogenase	--	--	--	--	--	--	--	--	--	--	--	.55
Glutamic-Oxalacetic Transaminase	--	--	--	--	--	--	--	--	--	--	--	--
Glutamic-Pyruvic Transaminase	.52	.56*	.55	--	--	--	--	--	--	--	--	--

* - ($p<0.05$)

trapping bears, used a high cholesterol, high caloric bait consisting of a chunk of suet floated in a mixture of corn syrup, molasses, sugar, and anise oil. Lee et al. (1977) also culvert trapped bears probably using some kind of high caloric bait. Henry (1964) and Searcy (1969) both state that cholesterol levels in humans appear unrelated to immediate ingestion but more to long term high fat diets. However, high caloric intake did increase cholesterol levels; amount and type of carbohydrate intake may also have some influence (Searcy 1969). It may be that the high cholesterol levels reported in these two previous bear studies are due to diet rather than immediate ingestion. Also, since serum cholesterol and triglycerides are lower in poor nutrition, grizzly bears captured for this study may have been in poorer condition than were bears in these previous studies.

For both characteristics, Ivishak River bears (Table 13) had significantly ($p<0.01$) lower values than did bears from any other location (Tables 9, 11, and 14). This difference may have been caused by dietary differences or by differences due simply to storage time and temperature (see Urea Nitrogen). For triglycerides, multiple range testing failed ($p<0.10$) to reveal where the difference(s) in drug effect classes occurred. The same is true of the difference(s) between stress classes for ANWR bears.

In humans, males have higher levels of both cholesterol and triglycerides than do females (Henry 1964, Searcy 1969). The same differences have been reported for cholesterol in black bears by Matula (1976) and Beeman (1981). In this study, cholesterol was higher in males than in

females (Table 22) and triglycerides were higher ($p<0.10$) in all nonlactating bears (187 mg/dl) than in lactating females (161 mg/dl), although there was no difference ($p<0.10$) between nonlactating and lactating females. Franzmann et al. (1976) reported higher cholesterol levels in lactating than in nonlactating cow moose.

Although increases in cholesterol and triglycerides with age have been reported in humans (Henry 1964, Searcy 1969) and black bears (Matula 1976, Beeman 1981), there was no relationship for either in this study.

Significant ($p<0.01$) correlation coefficients with date of capture for cholesterol were contradictory. Females in the ANWR had a correlation coefficient of $r= -0.68$, whereas for females in the western Brooks Range it was $r= 0.56$. This difference could be dietary in nature. The same is probably true for triglycerides which were correlated ($r= 0.58$; $p<0.05$) with date of capture for Alaska Range males.

Protein

Total protein, albumin, globulin, and albumin-globulin ratio were determined by an autoanalyzer and by electrophoresis. Alpha, beta, and gamma-globulin fractions were analyzed by electrophoresis. Use of these two methods provided a comparison to determine which of the two methods might be most accurate for grizzly bear serum. Paired-t-testing (Table 26) revealed that of the four characteristics determined by both methods, all but total protein exhibited significant difference between the two methods. Of the three characteristics exhibiting significant

Table 26. Paired-t-test results for difference between autoanalyzer and electrophoretic determination of serum protein characteristics of grizzly bears in the eastern Alaska Range and Arctic National Wildlife Refuge (n=78).

CHARACTERISTIC	MEAN DIFFERENCE	S.E.	CORR.	PROB.	T-VALUE	PROB.
Total Protein	0.030	0.023	0.959	0.000	1.50	0.139
Albumin	-0.050	0.013	0.955	0.000	-3.71	0.000
Globulin	0.200	0.021	0.884	0.000	9.76	0.000
Albumin-Globulin Ratio	-0.060	0.013	0.896	0.000	-4.62	0.000

difference, all but globulin were greater in the electrophoretic determination. Since the autoanalyzed determinations had lower values they may have been incomplete, indicating electrophoresis was the more accurate method. The electrophoretic determination of globulin involved simply summing the globulin fractions. Any error in these three fractions, if in the same direction for each, would be more apparent in the combined globulin determination and may account for the lower globulin value for the electrophoretic determination. Henry (1964), Searcy (1969), and Schalm et al. (1975), do not consider electrophoresis to be as reliable as other methods for quantitative determination of protein characteristics. In light of this evidence it is difficult to explain the differences I found in this study between the two methods I used.

The albumin-globulin ratio was higher in this study (Table E, APPENDIX) than what Matula (1976) (0.7) reported for black bears. The difference is that I found a higher albumin and lower globulin in the present study. Halloran and Pearson (1972) (7.1 g/dl and 4.2 g/dl) reported higher values than I have for total protein and albumin, respectively, and Erickson and Youatt (1961) (1.1 g/dl and 4.5 g/dl) reported lower values than I have for globulin and higher albumin values, respectively. Since protein characteristics may vary as a result of many influences and because of inconsistencies between studies (see page 37), I will not speculate as to the cause for the observed differences between this study and the others, except to say that they may be due to species differences.

Serum protein characteristics, unlike others I have discussed,

showed essentially no difference between first and replicate sampling. The differences that did occur were not significant at as high a level as were other characteristics, and the differences were only apparent in select sex and location classes. Therefore, I consider the differences that did occur to be physiologically insignificant. There were no differences between first and replicate samples for electrophoretic determinations. Searcy (1969) noted that there was no change in serum protein immediately following exercise, but 11-12 hours later, albumin, and to a lesser extent beta-globulin values show a transient increase.

For clarity, in the remaining discussion I will distinguish autoanalyzed determinations of total protein and its fractions with an (A) and electrophoretic determinations with a (B). Albumin (A) and (B) both exhibited location differences with (A) being lower ($p<0.10$) for western Brooks Range than for Alaska Range bears. Albumin-globulin ratio (A) was significantly lower in Ivishak River and western Brooks Range than in Alaska Range males, and ratio (B) was lower in ANWR than in Alaska Range bears. Beta-globulin was lower in Alaska Range than in ANWR females, which may account for the lower albumin-globulin ratio (B) in ANWR than in Alaska Range bears. It is difficult at best to interpret these location differences except to say that they are probably dietary in nature. Total protein is higher in healthy than in nonhealthy individuals and albumin is the major fraction of total protein (Henry 1964, Searcy 1969, Franzmann et al. 1976). Therefore, the albumin and albumin-globulin ratios in Alaska Range bears may reflect a better nutritional state for these bears. Franzmann and Schwartz (1983) sug-

gested that extremes in condition related blood characteristics might be useful for comparing and evaluating population condition in moose.

Albumin and albumin-globulin ratios from both determinations for grizzly bears were higher in males than in females (Table 22). Globulin (A) was higher in Alaska Range and lower in Ivishak River females than in males. This contradiction is eliminated in the alpha and gamma-globulin fractions. For both, in at least one sex and location class, females had greater values than did males, which in part accounts for the lower albumin-globulin ratios in females. No sex differences were reported in any of the studies I have used for comparison (see page 37) or by Henry (1969) or Searcy (1969), for any of the protein characteristics I have discussed. Franzmann et al. (1976) noted that higher globulin in male moose during the rut was due to higher demand of protein for transport of hormones, lipids, and fat soluble vitamins. They also reported higher total protein in adult females than in males. The cause for sex differences in the present study is unclear.

A significant stress classification effect was apparent in the albumin-globulin ratio (A) of all bears with class 3 significantly ($p<0.10$) lower than 2. Alpha-globulin was also significantly affected with classes 1 and 2 lower ($p<0.10$) than 3 for ANWR bears. For all males, multiple range testing could not ($p>0.10$) show where the significant difference(s) occurred but means for the classes were ordered as for ANWR bears. Total protein (B) was also lower for class 1 than for classes 2 or 3 in ANWR bears.

Two metabolic characteristics which were suggested previously as

being related to excitability and exercise are pulse and respiration rates. A relationship with respiration rate was evident for both determinations of total protein and albumin and with beta-globulin for Alaska Range bears. Correlation coefficients ranged from $r = 0.51$ ($p<0.05$) for total protein (A), to $r = 0.60$ ($p<0.01$) for beta-globulin. Also, albumin-globulin ratio (B) was correlated ($r = -0.55$; $p<0.05$) with pulse rate for these bears.

Franzmann et al. (1976) noted that albumin increased with rectal temperature and that rectal temperature was also related to stress. They noted globulin was highest in moose with a high rectal temperature, but they attributed the relationship to nutritional state since moose in poor condition also had low body temperatures. Gartner et al. (1965) in a study of beef cattle, reported that total protein increased with visual stimulation of the cattle but exercise did not cause much increase above this. Henry (1964) reported that total protein increased after a short period of exercise. Searcy (1969) indicated a similar but delayed response (11-12 hrs.). In grizzly bears, the response to excitability and exercise appears to be an increase in total protein and a decrease in the albumin-globulin ratio, both caused by an increase in globulin, particularly alpha-globulin.

Seal et al. (1972) in a study of white-tailed deer, reported that total protein declined with drug effect, indicating an increase in plasma volume. Wesson et al. (1979) also studying white-tailed deer, noted the same decline in males. Beeman and Pelton (1978) reported a higher globulin level, reflected primarily by higher alpha-globulin, and lower

albumin-globulin ratios in black bears immobilized with Sernylan than in bears injected with M-99. In this study, albumin (A) for ANWR bears, and total protein (B) for all bears were significantly affected by drug effect classification. Classes 2 and 4 were both significantly ($p<0.10$) lower than class 1 for total protein (B). Although multiple range testing did not ($p>0.10$) reveal where the difference(s) occurred for albumin (A), the ordering of the means for each class was similar to the ordering for total protein (B). These findings are consistent with those mentioned above and indicate that the drugs used for immobilization in this study may reduce levels of albumin and total protein.

Correlation of serum protein characteristics with date of capture were contradictory and inconsistent and therefore, are not reported. Seasonal differences that might be found would most likely be dietary in nature.

Henry (1964) and Searcy (1969) noted indefinite changes in protein characteristics with age. Matula (1976) reported a higher level of total protein and globulin, and a lower albumin-globulin ratio in adult as compared to young black bears. The lowered ratio was due to no change in albumin and an increase in globulin. Franzmann et al. (1976) noted that gamma-globulins are associated with antibodies and the lower levels in young moose reflect the fact that antibody producing mechanisms are still developing. Seal et al. (1975) reported that serum protein and albumin increased with age in wolf pups. For grizzly bears in this study, correlations with age were apparent primarily for males in the Alaska Range. Total protein (A) ($r= 0.76$) and (B) ($r= 0.75$), al-

bumin (A) (r= 0.77) and (B) (r= 0.76), globulin (r= 0.60), and beta (r= 0.74) and gamma (r= 0.71) globulin fractions were all significantly ($p<0.01$) correlated with age for these bears. Albumin-globulin ratio (A) (r= -0.51) and (B) (r= -0.59) were correlated ($p<0.01$) with age for females and beta-globulin (r= 0.53) for males in the ANWR. Similar correlations were found with body weight for Alaska Range bears. I attribute this to the age relationship since body weight increases with age. In addition, most protein characteristics were similarly related to dosages of the immobilizing drugs. Since dosages of these drugs were administered based on estimated body weight, the correlations with these drug dosages can probably also be attributed to the age relationship. Unfortunately, I am not sure what is causing this age relationship, but it could be related to dietary changes.

Cortisol

Serum cortisol was determined for this study because of evidence that it might provide a good indication of stress (Searcy 1969, Ganong 1975, Franzmann et al. 1975, Guyton 1981). I hoped I could use it to classify and compare individual levels of excitability.

A number of serum corticoids can be determined by a variety of methods (Searcy 1969) which give different results. However, all glucocorticoids appear to vary with almost any stress (Guyton 1981). If direct comparison cannot be made between corticoids and between studies, at least variations in corticoids can be compared between studies.

Searcy (1969) noted that 30 minutes following a period of strenuous

exercise, cortisol levels drop almost 50% below baseline values. There was no difference, in this study, between first and replicate samples except for Alaska Range bears. In these bears, the mean for the replicates (20.0 mg/dl) was higher than the mean for the first samples (19.0 mg/dl). This difference indicates that, in this study, excitability may have a more pronounced influence on cortisol levels than exercise, and is masking the influence of exercise.

Bears in the Alaska Range (Table 9) had significantly higher levels of serum cortisol than did those in the ANWR (Table 11), indicating that the former may have been more heavily stressed by the capture effort.

As mentioned previously, almost any form of stress will increase cortisol concentrations including trauma of any kind, infection, and injection of norepinephrine (Searcy 1969, Ganong 1975, Guyton 1981). One possible explanation for the increase in cortisol is that cortisol causes rapid mobilization of amino acids and fats making them available for energy and synthesis of other compounds such as glucose, needed by the tissues of the body (Guyton 1981). Unfortunately, I did not have bears in a basal excitability state to use as controls for comparison with other bears. However, it is probably safe to say that cortisol levels in grizzly bears captured during this study, are not basal but are elevated. Franzmann et al. (1975) reported that 11-hydroxycorticosteroids were higher in each stress class, and that they were useful in classifying individuals into stress classes, thus aiding in interpreting other influences.

Serum cortisol levels for male grizzlies were significantly af-

fected by drug effect classification, with class 2 individuals having lower levels ($p<0.01$) than all other classes. Cortisol was also correlated ($p<0.01$) with dosages of Sernylan ($r= 0.57$) and acepromazine maleate ($r= 0.60$) for males. I do not know why males should have a more pronounced effect from these drugs than do females.

METABOLIC CHARACTERISTICS

Metabolic characteristics of grizzly bears that were recorded during this study include body temperature, body weight, pulse rate, and respiration rate. Results from statistical tests of this data for sex, location, condition, stress, and drug dosage influences are presented and discussed in this section. The data descriptions are presented in Table 27.

Body weight was the only characteristic for all bears that exhibited significant ($p<0.01$) location differences. It was also the only characteristic affected ($p<0.10$) by stress classification for all bears. Condition classification affected the body temperature of grizzly bears significantly ($p<0.01$). Pulse ($p<0.05$) and respiration rates ($p<0.10$), and body temperature ($p<0.01$) were all significantly affected by drug effect classification. Pulse rate was significantly correlated with the dosage of Sernylan ($r= -0.56$; $p<0.05$). Body weight was significantly ($p<0.01$) correlated with age ($r= 0.59$) and greater ($p<0.10$) in males than in females. There was no correlation ($p>0.10$) with date of capture for any characteristic for all bears; for select sex and location classes there was.

Table 27. Metabolic characteristics† of grizzly bears in central and northern Alaska.

CHARACTERISTIC	N	MEAN	S.E.	RANGE
Body Weight (kg)	153	79.0	3.98	6.3 - 270.0
Pulse Rate (beats/min.)	39	107	3.88	60 - 144
Respiration Rate (breaths/min.)	47	33	4.87	5 - 200
Body Temperature (°C)	67	38.6	0.16	33.9 - 41.1

† - Data on pulse rates, respiration rates, and body temperatures were not available for Ivishak River and western Brooks Range bears.

Temperature

The body temperature for captive black bears reported by Erickson and Youatt (1961) (36.6°C) is somewhat lower than that reported here (Table 27) for grizzly bears. The mean body temperature for undisturbed, undrugged grizzly bears, measured using radio-telemetry, was 37.7°C (Follmann, pers. comm.) and is also lower than the mean reported here. Franzmann et al. (1976) for moose, and Franzmann (1972) for bighorn sheep, reported increasing body temperature with increasing excitability. Best et al. (1981) reported increasing body temperatures in polar bears, independent of ambient temperature, as walking speed increased. If captive bears are less excitable and if body temperature also increases with excitability for grizzly bears, then this may explain the temperature difference between captive and wild bears.

Condition classification significantly ($p<0.01$) affected body temperature but multiple range testing failed ($p>0.10$) to reveal between which classes the difference(s) occurred. However, mean temperature for each class was ordered in the following manner from lowest to highest: 3-4-2-1. This finding may be simply an artifact of inadequate sample size in the extreme condition classes (Table A, APPENDIX) and therefore, without meaning, or it may indicate that animals in better condition are not stressed physiologically as heavily as those in poorer condition; hence the animals in better condition have lower temperatures. Most bears were classified into condition class 2 (below average) and would be expected to have the highest body temperatures because of a more severe effect from the stress of the capture effort. Contradicting the

above discussion is the finding that temperature of Alaska Range bears was positively related ($p<0.10$) to stress classification. I can offer no explanation for this finding, if in fact it is real.

Drug effect classification also significantly ($p<0.01$) affected the body temperature of grizzly bears, with mean temperature for class 1 being lower than the means for all other classes. However, means for the other classes are not ranked from lowest to highest in order of increasing drug effect but in order of decreasing drug effect. Therefore, the greater the effect of the drug, evaluated subjectively, the lower the body temperature. Sernylan is known to affect thermoregulatory abilities and to affect respiration rate (Seal et al. 1970). The subjective evaluation of drug effect did not appear to be useful for body temperature since drug effect class decreased as temperature increased.

Weight

Many of the significant affects on body weight are expected and require no explanation. These include sex, with males (87 kg) being heavier ($p<0.10$) than females (72 kg); condition, which was positively related ($p<0.01$) to body weight for males, females, and Alaska Range bears; and the significant ($p<0.01$) correlation with age ($r= 0.59$) for all bears. Also, since condition was related to weight, and bears in better condition should be more able to tolerate stress, then the negative relationship ($p<0.10$) of stress classification to weight would be expected. The negative relationship ($p<0.05$) of drug effect classification with weight, would be expected if weight were increasingly un-

derestimated as actual weight increased, since drug dosages were based on estimated weights. Also, since heavier bears were in better condition, the standard weight related drug dosage used (see METHODS) may not have had as profound of an effect as for lighter bears. Bears in better condition probably have more subcutaneous fat than other bears. In bears with heavy fat layers it is more difficult to get the needle of the dart into muscle tissue, therefore, reducing the effect of the drug dosage.

One significant ($p<0.01$) result which I did not expect was a location effect. Bears in the western Brooks Range (52 kg) were lighter than those in any other location, while Ivishak River bears (129 kg) were heavier than bears in any other location (Alaska Range, 88 kg; ANWR, 85 kg).

There was a significant ($p<0.01$) age difference between locations; mean age of Ivishak River bears (12 years) was greater ($p<0.01$) than all other locations (Alaska Range, 7 years; ANWR, 7 years; western Brooks Range, 9 years). This may explain why the mean weight of Ivishak River bears was greater than the mean weight for bears at any other location, since weight increases with age.

Alaska Range bears were captured at an earlier mean date (12 June) than bears in any other locations, and Ivishak River bears were captured at a later mean date (6 July) than either ANWR (26 June) or Alaska Range bears. The mean capture date for western Brooks Range bears was 1 July. These location differences in date of capture are consistent with the location differences in body weight with one exception; western Brooks

Range bears while lighter than ANWR (84 kg) or Alaska Range bears (88 kg), were captured at a later mean date than these bears. I cannot explain why western Brooks Range bears were lighter than any others, especially since this population appears to have a higher density and is more productive than the Ivishak River population (Reynolds 1980). Ivishak River bears were heavier than any other bears perhaps because they were captured at a later mean date than all but western Brooks Range bears, thus having more time to gain weight.

Pulse Rate

Pulse rate was determined as a matter of course for this study. However, I hoped I could use it, as I did cortisol, for classifying and comparing individual levels of excitability. Pulse rate was useful for evaluating excitability in bighorn sheep (Franzmann 1972) and moose (Franzmann et al. 1976). Pulse rate in the present study, was highest ($p<0.05$) in the most stressed animals for ANWR bears. Class 1 individuals had lower ($p<0.05$) pulse rates than did those in Class 2 or 3. These results support the findings of Franzmann (1972), Franzmann et al. (1976), and Reynolds et al. (1983).

Females in the Alaska Range (111 beats/min) had higher ($p<0.05$) pulse rates than did females in the ANWR (102 beats/min). In the Alaska Range, females (118 beats/min) had a higher ($p<0.05$) pulse rate than males (95 beats/min). Matula (1976) also reported a tendency for higher rates in female black bears.

The mean pulse rate reported here (Table 27) is somewhat lower than

those reported for black bears by Erickson and Youatt (1961) (131 beats/min), and Matula (1976) (159 beats/min). Bush et al. (1980) report a mean of 90 beats/min for grizzly bears anesthetized with Sernylan and 121 beats/min for those anesthetized with tiletamine-zolazepam. The mean pulse rate for undisturbed and undrugged grizzly bears, measured using radio-telemetry, was 102 beats/min (Follmann, pers. comm.), which is also lower than the mean I report. In the present study, pulse rate in males was negatively correlated with the dosage of Sernylan ($r = -0.56$; $p<0.05$). However, grizzly bears classified as having an optimum drug effect (Class 3) had higher ($p<0.05$) pulse rates than did those in the other three classes. It appears from the above findings, with the exception of the subjective drug effect classification, that Sernylan may have a depressing effect on the pulse rate of bears.

Hock (1966B) reported a decline in pulse rate with increasing age up to adulthood. Matula (1976) reported a similar but statistically insignificant trend. In this study, pulse rate was significantly ($p<0.01$) correlated with age ($r = -0.73$) for males. Pulse rate was also correlated with date of capture for most sex and location classes ranging from $r = 0.54$ ($p<0.05$) for ANWR males to $r = 0.69$ ($p<0.01$) for Alaska Range females. I can offer no explanation for these correlations especially considering that capturing was only conducted from mid-May to mid-July for Alaska Range bears and only for 11 days in the ANWR.

Respiration Rate

The mean respiration rate in this study (Table 27) is comparable to that reported by Bush et al. (1980) for grizzlies immobilized with Sernylan (32 breaths/min), but higher than what they report for grizzlies when using teletamine-zolazepam (26 breaths/min). My values are also higher than those reported by Matula (1976) for black bears immobilized with M-99 (9 breaths/min). The difference in respiration rates between these studies is probably a result of the different immobilizing drugs used (see Chloride).

There were no sex, age, location, or date of capture relationships with respiration rate nor any relationship with condition, stress, or drug effect classification.

CLASSIFICATIONS FOR CONDITION, STRESS, AND DRUG EFFECT

Having presented and discussed the sources of influence on all whole blood, serum, and metabolic characteristics individually, I will now present jointly the significant relationships of the condition, stress, and drug effect classifications with the appropriate variables. For a discussion of these relationships the reader can refer to the appropriate section of the discussions for whole blood, serum, and metabolic measurements. In addition, I will present and discuss the results of stepwise multiple correlation analyses using condition, stress, and drug related characteristics to attempt to explain the variations in physiologic measurements. The above information should provide an insight into which physiological variables might be useful in

assessing an individual bear's condition and its reactions to the capture effort and immobilizing drug. In the condition section I will discuss the use and results of the skinfold thickness measurements and the muscle fat content analyses.

Condition

The condition classification developed for this study included 5 categories; 1) poor, 2) below average, 3) average, 4) above average, and 5) good, based on a subjective evaluation of condition (see METHODS). The reader should keep in mind that although there are only 5 categories here, in contrast to the 11 used by Robinson (1960) and Franzmann and Schwartz (1983), the number of bears in each category is less than desired for making statements about relationships with physiological characteristics.

There were 5 physiological measurements which individually were significantly affected by condition classification. These include hematocrit which decreased with improving condition, and carbon dioxide, direct bilirubin, and body temperature ($p<0.01$), all of which increased with improving condition. Body weight also increased with improving condition as expected for both males ($p<0.05$) and females ($p<0.01$).

The condition-related variables which I used in the stepwise multiple correlation analyses included weight (MWT), total length (TLEN), body length (BLEN), chest girth (CGIR), and the three skinfold thickness measurements (BEL, BLEGS, ALEG) (see METHODS). Results of these analyses are presented in Table 28.

Table 28. Multiple correlation analysis of physiological characterisitics and condition-related variables. F-multiple is the F statistic for significance of the multiple corelation.

CHARACTERISTIC	VARIABLE††	MULTIPLE R	MULTIPLE RSQ	INCREASE IN RSQ	F-TO-ENTER	F-MULTIPLE	# OF IND. VARIABLES
Creatinine (Alaska Range & ANWR bears)	BLEN	0.6821	0.4653	0.4653	52.21†	52.21†	1
	BEL	0.7530	0.5670	0.1017	13.87†	38.64†	2
	MWT	0.7728	0.5972	0.0302	4.34°	28.67†	3
	ALEG	0.7895	0.6233	0.0261	3.94*	23.57†	4
Alk. Phosph. (Alaska Range & ANWR bears)	BLEN	0.4827	0.2330	0.2330	18.23†	18.23†	1
	ALEG	0.5416	0.2933	0.0603	5.03°	12.24†	2
Lac. Dehydrog. (ANWR bears)	BLEN	0.4326	0.1871	0.1871	8.52†	8.52†	1
	BLEGS	0.5068	0.2569	0.0698	3.38*	6.22†	2
	ALEG	0.5605	0.3141	0.0573	2.92*	5.34†	3
Total Protein (Alaska Range)	CGIR	0.7753	0.6011	0.6011	31.65†	31.65†	1
	BEL	0.8110	0.6577	0.0566	3.31*	19.22†	2
Albumin+ (Alaska Range bears)	CGIR	0.7928	0.6285	0.6285	35.54†	35.54†	1
	TLEN	0.8605	0.7405	0.1119	8.63†	28.54†	2
	MWT	0.8722	0.7607	0.0203	1.61	20.14†	3
	BEL	0.8824	0.7786	0.0179	1.45	15.83†	4
	ALEG	0.9046	0.8183	0.0397	3.71°	15.31†	5
Albumin++ (Alaska Range bears)	CGIR	0.7477	0.5591	0.5591	26.62†	26.62†	1
	TLEN	0.8403	0.7061	0.1470	10.01†	24.03†	2
Gamma Globulin (Alaska Range bears)	TLEN	0.5692	0.3240	0.3240	10.06†	10.06†	1
	BEL	0.5990	0.3588	0.0348	1.09	5.60°	2
	ALEG	0.6721	0.4517	0.0929	3.22*	5.22†	3

†† - ALEG-skin thickness right hindleg; BEL-skin thickness belly girth; BLEGS-skin thickness between hindlegs; BLEN-body length; CGIR-chest girth; MWT-body weight; TLEN-total length.

† - ($p<0.01$)

° - ($p<0.05$)

* - ($p<0.10$)

+ - Determined by autoanalyzer.

++ - Determined by electrophoresis.

The variables which I have stated as being related to condition are simply assumed to be so. It would stand to reason that body measurements (i.e. linear and weight) would increase with improved body condition and decrease with deteriorating condition. Therefore, the assumption is not without justification. However, ideally I should have examined the relationships between these characteristics and the condition classification by correlation analysis, and found positive correlations. But this was not justifiable since I used only 5 condition classes and sample sizes in the extreme classes were very limited. Future research should include relating body measurements to condition and both of these to physiologic variables, thus providing scientists with quantifiable physiologic data useful for comparing and evaluating individual and population condition. Table 28 includes the physiological measurements related to condition for grizzly bears in the present study.

Skinfold thickness measurements were taken (see METHODS) using Watts et al. (1977) guidelines for polar bears. The belly girth measurement (BEL) was significantly correlated ($r= 0.60$; $p<0.01$) with age for females in the Alaska Range. The measurement on the right hindleg (ALEG) was also correlated with age for ANWR males ($r= 0.52$; $p<0.01$). These relationships would be expected. ALEG was also correlated ($p<0.01$) with date of capture for ANWR bears ($r= 0.58$) and for females in the Alaska Range ($r= 0.62$). If one assumes improving condition the more time a bear has been out of its den, then these correlations may indicate a relationship with condition.

Muscle samples were collected from 23 bears in the Alaska Range and

14 in the ANWR to be analyzed for percent fat content (see METHODS). I hoped this too might provide a good indication of body condition. Ringberg et al. (1981) found that chemically extractable fat in muscles of lean reindeer was correlated with amount of fat in homogenates of whole carcasses. They indicated that muscle fat gave a good indication of the condition of reindeer.

For the present study, mean weight of muscle samples was 0.67 grams (n=37). All but six of the muscle samples collected weighed more after extraction than before. Each sample was put through an extraction procedure (see METHODS), freeze dried for 48 hours and then weighed. Since the samples were so small and the average water content so high (78.42%) (Figure 3), the amount of fat, if any, in each sample may have been so low that detection was not possible with the methodology used. Also, since the samples were so minute the negative weight difference may have been caused by the samples hydrating during the few seconds between being taken off the freeze drier and being weighed. Ringberg et al. (1981) showed a negative correlation between percent fat content and water content in reindeer. Sheng and Huggins (1979) noted that total body water ranged from 63% in the beagle to 80% for the mouse with the mean for most animals between 70% and 76%. Since the total body water appears to be negatively correlated with body size and total fat content (Sheng and Huggins 1979), relatively high water content in muscle samples from grizzly bears in this study indicates they have very little muscle fat.

Although the results from this study indicate that bears had little

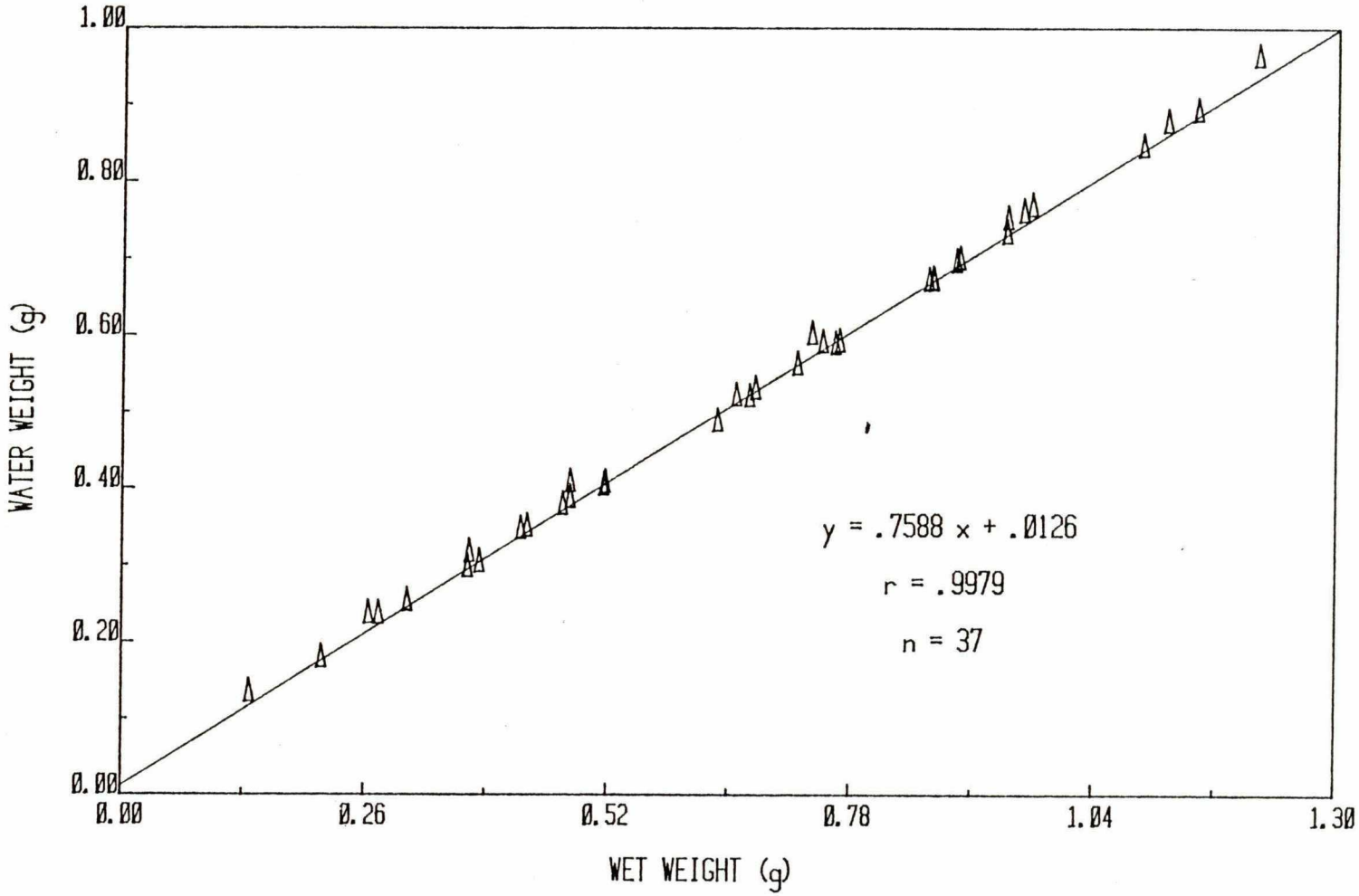

Figure 3. Water versus wet weight of muscle samples collected from grizzly bears in Alaska.

or no intramuscular fat, I believe muscle fat content would be a good indicator for condition in grizzly bears. However, if it were to be used with samples as small as I used, a more appropriate method of analysis should be used (Christie 1973). Otherwise, larger samples should be collected but not so large as to cause serious injury to the bear. Figure 4 is a plot of dry sample weight versus wet sample weight.

Finally, I wanted to use back fat depth as another indicator of body condition for grizzly bears. I practiced use of a method outlined by Hazel and Kline (1952) on carcasses of problem bears that had been killed. The method worked well for the carcasses but they were all very fat and I could check my results by skinning the bear and measuring depth directly. For live captured bears, condition was much worse. In the case of one mortality due to capture myopathy, which we examined by necropsy, the animal had no observable fat. Also, for the first few bears captured, when I inserted the back fat probe through the hide into the tissue beneath, I could not determine when or whether the probe was in fat or had reached muscle. Therefore, I did not attempt to measure back fat on any other bears. Folk et al. (1972) encouraged the use of back fat depth measurements as a means of evaluating condition in bear species. The method I used, and suggested by Folk et al. (1972), might be more useful if a larger incision were made in the skin, but I did not want to risk serious injury.

Stress

As with the condition classification, I used fewer categories (3)

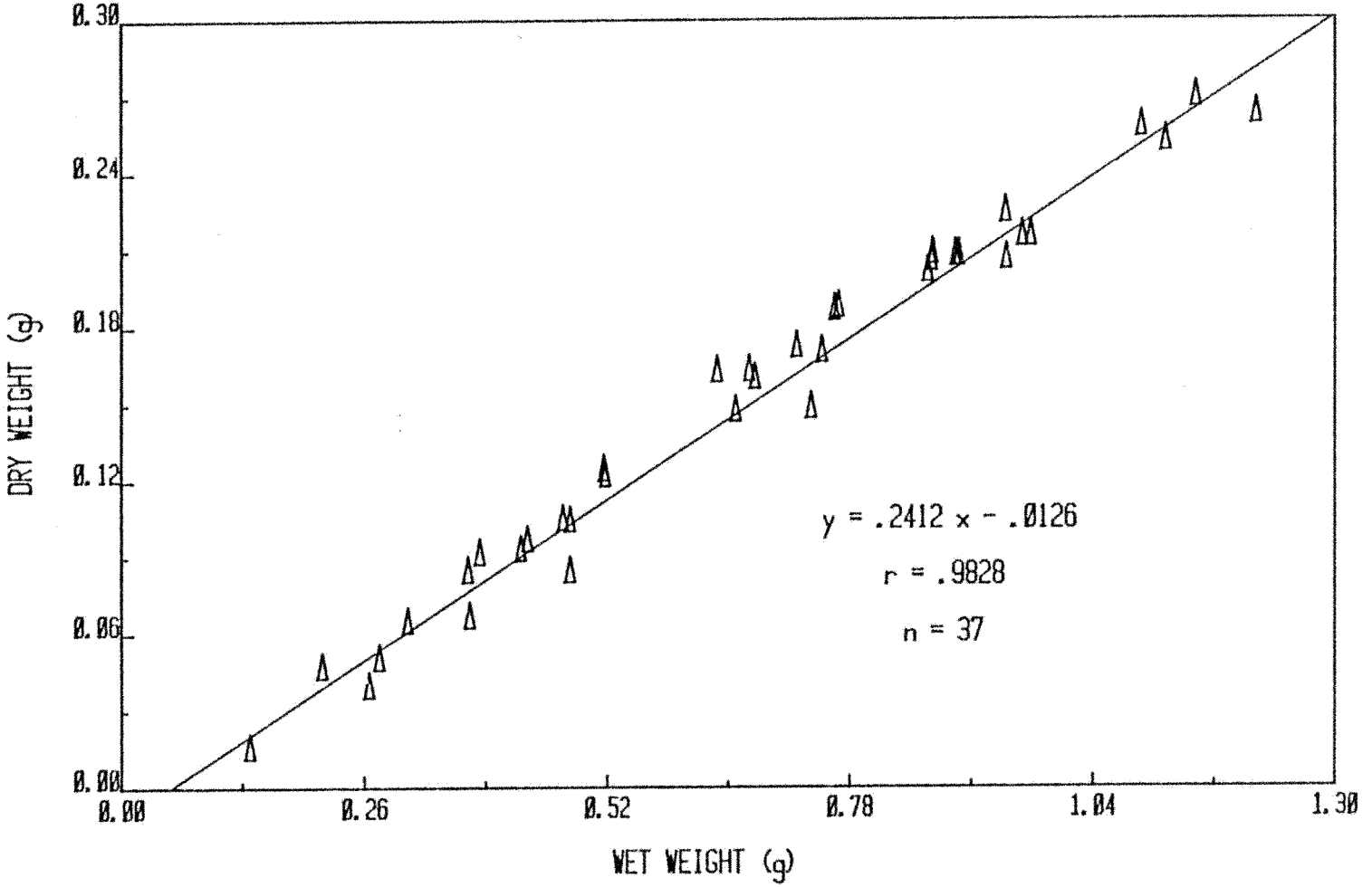

Figure 4. Dry versus wet weight of muscle samples collected from grizzly bears in Alaska.

for evaluating stress than did Franzmann (1972) and Franzmann and Schwartz (1983) who used 5 classes. Handling stress was difficult to assess in this study but nevertheless, I think the classification is useful and could be done with less difficulty as the observer gains experience. The classification provides a means for grouping similarly stressed animals to allow for detection of other influences on physiologic variables.

The following physiological variables showed significant stress classification effect for at least one sex and location class: glucose, BUN, sodium, potassium, chloride, carbon dioxide, SGOT, SGPT, triglycerides, albumin-globulin ratio, total protein, alpha-globulin, weight, temperature, and pulse rate. The reader should refer to the discussion of each variable under the appropriate section for an interpretation of the results.

I used the following stress related variables to attempt to explain the variation in the physiological characteristics included in Table 29: number of darts fired (NODART), number of darts injected (NOINJ), number of helicopter passes at a bear (NOPASS), pulse rate (PRT), respiration rate (RRT) and time between darting and immobilization (TBDADO). The characteristics in Table 29 are the only ones which exhibited significant correlation (see page 36) with the stress related variables.

NODART, NOINJ, NOPASS, and TBDADO were considered stress related variables because they affect the amount of stress imposed on each bear and the length of time each bear was stressed before immobilization. PRT was used for reasons outlined previously (see Pulse Rate). Although

Table 29. Multiple correlation analysis of physiological characteristics and stress-related variables. F-multiple is the F statistic for significance of the multiple correlation.

CHARACTERISTIC	VARIABLE††	MULTIPLE R	MULTIPLE RSQ	INCREASE IN RSQ	F-TO-ENTER	F-MULTIPLE	# OF IND. VARIABLES
Potassium (Alaska Range bears)	PRT	0.5425	0.2943	0.2943	6.26°	6.26°	1
	NODART	0.7423	0.5510	0.2567	8.00†	8.59†	2
	RRT	0.8040	0.6464	0.0954	3.51*	7.92†	3
Phosphorous (ANWR bears)	TBDADO	0.5490	0.3014	0.3014	6.90°	6.90°	1
	RRT	0.7302	0.5332	0.2318	7.45°	8.57†	2
Total Protein+ (Alaska Range bears)	RRT	0.6716	0.4510	0.4510	12.33†	12.33†	1
	PRT	0.8210	0.6740	0.2230	9.58†	14.47†	2
Albumin+ (Alaska Range bears)	RRT	0.8055	0.6488	0.6488	27.71†	27.71†	1
	PRT	0.8506	0.7235	0.0747	3.78*	18.31†	2
Total Protein++ (Alaska Range bears)	RRT	0.6966	0.4894	0.4894	14.38†	14.38†	1
	PRT	0.8574	0.7351	0.2457	12.98†	19.42†	2
Albumin++ (Alaska Range bears)	RRT	0.8222	0.6760	0.6760	31.29†	31.29†	1
	NOINJ	0.8488	0.7205	0.0444	2.23	18.04†	2
	NOPASS	0.8813	0.7767	0.0562	3.27*	15.07†	3

†† - NODART-number of darts fired; NOINJ-number of darts injected; NOPASS-number of helicopter passes at a bear; PRT-pulse rate; RRT-respiration rate; TBDADO-time between darted and down.
† - ($p<0.01$)
° - ($p<0.05$)
* - ($p<0.10$)
+ - Determined by autoanalyzer.
++ - Determined by electrophoresis.

RRT did not show a statistically significant influence from stress classification (see Respiration Rate), it seemed logical that it would increase with exercise and excitability. Therefore, I used it in the multiple correlation analyses. Its relationship with the characteristics in Table 29 though, may be more drug (see Respiration Rate) than stress related.

Drug Effect

The drug effect classification I used (see METHODS) was developed by Reynolds (1974). It appeared to be a useful evaluation in terms of deciding the need for administering additional drug dosages. However, when relating physiologic variables to this classification, significance was indicated, but inconsistencies between related variables and between studies for the same variable made interpretation difficult. For each physiologic measurement, means for each class were not ranked in decreasing or increasing order but in an unexplainable fashion. This situation was also apparent for the condition and stress classifications but for drug effect it was the most evident.

The following is a list of the variables significantly affected by drug effect classification: hemoglobin, MCV, MCH, creatinine, carbon dioxide, uric acid, bilirubin, phosphorous, alkaline phosphatase, triglycerides, albumin, albumin-globulin ratio, cortisol, total protein, temperature, pulse rate, respiration rate, and weight. Again, the reader should consult the appropriate section of this thesis for a discussion of these results.

For the multiple correlation analysis, I considered two variables (NODART and NOINJ) to be drug related which I also used as stress related. My justification for using these was that although they affected the amount of stress imposed on a bear, they also determined the amount of drug administered. S1 is the total amount of Sernylan administered to each bear. Table 30 shows the significant results of the multiple correlation analysis for influence of drug related variables.

Table 30. Multiple correlation analysis of physiological characteristics and drug-related variables. F-multiple is the F statistic for significance of the multiple correlation.

CHARACTERISTIC	VARIABLE††	MULTIPLE R	MULTIPLE RSQ	INCREASE IN RSQ	F-TO-ENTER	F-MULTIPLE	# OF IND. VARIABLES
Hemoglobin (Alaska Range bears)	S1	0.5967	0.3561	0.3561	14.37†	14.37†	1
	NODART	0.6961	0.4846	0.1285	6.24°	11.75†	2
Sodium (Alaska Range bears)	S1	0.5118	0.2619	0.2619	9.58†	9.58†	1
	NODART	0.5499	0.3024	0.0405	1.51	5.64†	2
	NOINJ	0.6294	0.3961	0.0938	3.88*	5.47†	3
Alk. Phosph. (ANWR bears)	NODART	0.4048	0.1639	0.1639	7.45†	7.45†	1
	NOINJ	0.4901	0.2402	0.0763	3.71*	5.85†	2
	S1	0.5445	0.2965	0.0563	2.88*	5.06†	3

†† - NODART-number of darts fired; NOINJ-number of darts injected; S1-Sernylan dosage.
† - ($p<0.01$)
° - ($p<0.05$)
* - ($p<0.10$)

SUMMARY AND CONCLUSIONS

In the spring of 1981 and 1982, 85 grizzly bears were captured, sampled, and released. In the Alaska Range, 5 bears were captured between 17 May and 19 June 1981 and 30 between 24 May and 13 July 1982. Fifty bears were captured in the ANWR between 23 June and 3 July 1982. Blood samples were collected from each bear to be analyzed for 7 hematological, 23 serum chemistry, 6 protein electrophoretic assays, and serum cortisol. Included with this blood were 21 serum samples from 20 bears captured from the Ivishak River drainage, Alaska, and 55 samples from 46 bears captured in the western Brooks Range between 1973 and 1980.

Differences between sexes in some of the blood characteristics are contradictory. For some (total erythrocytes, hematocrit, glucose, and cholesterol), males have higher values indicating they may have been more stressed by the capture effort while others, such as glutamic-oxalacetic transaminase and glutamic-pyruvic transaminase are higher in females indicating they may have been more heavily stressed. Creatinine was higher in males than females and positively correlated with age and weight due to a relationship of creatinine production to muscle mass. Alkaline phosphatase was higher in males because of greater skeletal mass. Females exhibited lower values of calcium and phosphorous due to an increased demand in lactating sows for milk production. As expected males weighed more than females.

The most apparent and consistent location difference was between

the Alaska Range and the ANWR. Total leukocytes, total erythrocytes, hemoglobin, hematocrit, and cortisol were all higher in Alaska Range bears, which may indicate that they were more heavily stressed by the capture effort. The fact that on average more attempts were made at immobilizing each bear in the Alaska Range supports this suggestion. Location differences in creatinine reflected renal dysfunction. Bears in the Alaska Range were captured earlier in the spring than were bears in any other location and the higher values for these bears indicates that renal function had not been completely regained at the time of capture. Urea nitrogen, uric acid, total protein, and its fractions exhibited location differences which were probably dietary in nature. Since serum enzymes are unstable for long periods of storage unless the serum is properly stored, and since serum from bears from the Ivishak River and western Brooks Range was initially improperly stored, the apparent difference between these locations and the Alaska Range and ANWR is probably not physiologically based.

Calcium, phosphorous, and alkaline phosphatase were all negatively correlated with age which reflected increased osteoblast activity and bone formation in young bears. Lactic dehydrogenase was also negatively correlated with age possibly because older animals were less stressed by their capture. Total protein and its fractions were positively correlated with age, which may indicate dietary changes. The correlation of body weight and skinfold thickness with age is expected.

Sodium, creatinine, and urea nitrogen were all negatively correlated with date of capture indicating varied diet reinstatement and

regained renal function as time from den emergence increased.

Several results were indicative of a relationship with physical condition. Hemoglobin was positively correlated with body weight which would increase with improving condition. Uric acid, carbon dioxide, bilirubin, body weight, and body temperature all increased with improving condition classification. Multiple correlation analysis showed that creatinine, alkaline phosphatase, lactic dehydrogenase, total protein, albumin, and gamma globulin were all positively correlated with condition related body measurements.

Testing of the first and replicate samples collected from each bear revealed a difference for all but mean corpuscular hemoglobin, glucose, sodium, potassium, bilirubin, calcium, cholesterol, triglycerides, and albumin. In most cases the difference was consistent with a response to stress imposed by the capture effort. This indicates that although individual variability may occur, the influence of the capture effort was significant enough that it overshadowed any variability. The higher total leukocytes of replicate samples may have been influenced more by tissue damage caused by darting and by extraction of muscle samples than by excitability. For total erythrocytes and erythrocyte indices in grizzly bears, the response to stress appears to be a release of more and larger erythrocytes with no change in mean corpuscular hemoglobin concentration but absolutely more hemoglobin in the blood. These changes provide for a greater oxygen carrying capacity for replenishing oxygen depleted tissues. There was no difference between the first and replicate samples for sodium and potassium, probably because both are so

closely regulated by the body. However, both were higher in more stressed individuals. Lactating females had a higher creatinine and uric acid levels than did all other bears probably because females with cubs were more stressed by the capture effort. Chloride was lower in the more stressed bears probably because of an increase in gastric secretions (HCl). Carbon dioxide was greater in stress class 3 individuals perhaps due to a more rapid respiration rate, returning carbon dioxide to normal following respiratory alkalosis. For protein, the response to stress in grizzly bears appears to be an increase in total protein and a decrease in the albumin-globulin ratio, both caused by an increase in globulin. Heavier bears were less stressed than others, probably because of the relationship between weight and condition. The better condition an animal is in the better it is able to cope, physiologically, with the influences of stress. As expected, pulse rate was highest in the most stressed individuals. Potassium, phosphorous, total protein, and albumin were positively correlated with the stress related variables pulse rate, respiration rate, number of darts fired, number of darts injected, and time between darted and immobilized.

Hemoglobin and mean corpuscular volume were positively correlated and pulse rate was negatively correlated with dosages of Sernylan and acepromazine maleate. Hemoglobin, sodium, and alkaline phosphatase increased with the drug related variables dosages, number of darts fired, and number of darts injected, used in the multiple correlation analysis.

The classifications for condition, stress, and drug effect were somewhat useful in assessing the influences on physiological charac-

teristics but are too inconclusive to make recommendations concerning which physiological variables might be most likely to reflect the influences of condition, stress, and drug effect. More research is necessary to establish baseline physiological values for each category in these classifications before they should be used for determining individual or population status. Perhaps broader classifications should be used with more precisely definable criteria for categorizing. However, when the evaluations are subjective precise definition is not always possible.

In the present study, the use of muscle fat content to determine body condition did not prove useful. With a larger sample size though, the method may be useful. The use of a back fat depth guage for measuring back fat in this study indicates that the method should not be used on bears in other than at least average condition. Bears in worse condition have so little, if any, fat that it is difficult to determine whether the guage is contacting fat or muscle tissue. The method should be used, however, on bears of at least average condition, as determined by subjective evaluation, to provide a means of objectively assessing condition.

Serum cortisol provided, to some extent, a means of determining the level of stress a bear was exposed to. However, further research is needed before it should be used for establishing levels of excitability for comparisons.

Finally, studies of this nature provide information that can be used for determining the health, condition, and status of individuals

and populations, as well as establishing and evaluating the many influences on blood and other physiological values. Although studies of this kind may be logistically or financially infeasible on their own, they are certainly justifiable when collaborated with other studies, as was the case for this research project. Data of the sort collected here are necessary for managers to make comparisons between individuals and between populations.

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APPENDIX

Table A. Numbers of grizzly bears from which whole blood and serum samples were analyzed for each location* by sex, and classifications for stress, condition, drug effect, and lactation†.

GROUP		ALASKA RANGE	ANWR	IVISHAK RIVER	W. BROOKS RANGE	TOTAL
Males		11	28	11	31	81
Females		19	21	10	24	74
Stress Class	1	4	4	--	--	8
	2	18	23	--	--	41
	3	8	16	--	--	24
Condition Class	1	2	0	--	--	2
	2	22	36	--	--	58
	3	3	6	--	--	9
	4	3	1	--	--	4
	5	0	0	--	--	0
Drug Effect Class	1	3	11	6	9	29
	2	4	5	0	0	9
	3	18	14	13	19	64
	4	5	10	1	13	29
Lactating Females+		9	7	4	10	30
Nonlactating Females+		5	11	5	10	31
Nonlactating Bears+		12	29	14	35	90

* - Whole blood was not available for bears from the Ivishak River and western Brooks Range.

† - Bears from the Ivishak River and western Brooks Range were not classified as to stress and condition, as they were captured before this study began.

+ - Reproductive aged bears (i.e. at least 4.5 years of age).

Table B. Whole blood characteristics of grizzly bears
National Wildlife Refuge.

CHARACTERISTIC	N
Total Leukocytes ($10^3/mm^3$)	74
Total Erythrocytes ($10^6/mm^3$)	78
Hemoglobin (g/dl)	78
Hematocrit (%)	78
Mean Cell Volume (u^3)	78
Mean Cell Hemoglobin (uug)	78
Mean Cell Hemoglobin Conc. (%)	78

in the eastern Alaska Range and Arctic

MEAN	S.E.	RANGE
8.0	0.35	2.6 - 16.5
6.08	0.06	4.95 - 7.24
15.4	0.17	10.9 - 19.5
49.0	0.50	37.4 - 61.8
81.6	0.50	70 - 90
25.5	0.19	21.5 - 32.5
31.3	0.20	28.7 - 36.5

Table C. Blood characteristics of grizzly bears in the eastern Alaska Range and Arctic National Wildlife Refuge which exhibited significant sampling time differences.

CHARACTERISTIC		N	MEAN	S.E.	RANGE
Total Leukocytes ($10^3/mm^3$)					
	First	62	8.0	0.35	2.6 - 16.5
	Second	62	9.0	0.44	3.8 - 19.8
Total Erythrocytes ($10^6/mm^3$)					
	First	62	6.1	0.07	4.95 - 7.24
	Second	62	5.89	0.07	4.91 - 7.21
Hemoglobin (g/dl)					
	First	62	15.7	0.16	10.9 - 19.5
	Second	62	15.0	0.16	13.1 - 19.0
Hematocrit (%)					
	First	62	70.8	0.30	37.4 - 61.8
	Second	62	69.0	0.40	40.8 - 56.4
Mean Cell Volume (u^3)					
	First	62	82.0	0.44	70.0 - 90.0
	Second	62	81.8	0.43	73.0 - 88.0
Urea Nitrogen (mg/dl)					
	First	62	37	1.66	8 - 91
	Second	62	35	1.52	11 - 76
Creatinine (mg/dl)					
	First	62	1.0	0.03	0.3 - 2.2
	Second	62	0.9	0.03	0.6 - 1.6
Chloride (mEq/L)					
	First	62	99	0.58	38 - 126
	Second	62	100	0.60	86 - 112

Table C. Continued.

CHARACTERISTIC		N
Carbon Dioxide (mEq/L)		
	First	61
	Second	61
Uric Acid (mg/dl)		
	First	62
	Second	62
Phosphorous (mg/dl)		
	First	62
	Second	62
Glutamic-Pyruvic Transaminase (U/L)		
	First	62
	Second	62

MEAN	S.E.	RANGE
13	0.77	1 - 39
17	0.58	8 - 27
2.5	0.15	0.8 - 7.4
1.7	0.07	0.9 - 4.2
4.8	0.16	1.3 - 8.7
4.4	0.15	2.2 - 6.9
58	9.03	2 - 680
57	9.17	10 - 515

Table D. Blood characteristics of grizzly bears in the Arctic National Wildlife Refuge which exhibited significant sex differences.

CHARACTERISTIC		N	MEAN	S.E.	RANGE
Total Leukocytes ($10^3/mm^3$)					
	Males	28	6.0	0.09	5.06 - 6.95
	Females	21	5.7	0.41	5.11 - 6.34
Hematocrit (%)					
	Males	28	78.0	0.90	66.0 - 87.0
	Females	21	76.0	0.60	72.0 - 82.0
Mean Cell Hemoglobin Conc. (%)					
	Males	28	58.6	0.20	56.5 - 60.8
	Females	21	59.1	0.20	57.0 - 61.4
Total Bilirubin (mg/dl)					
	Males	28	0.09	0.006	0.0 - 0.2
	Females	21	0.07	0.008	0.0 - 0.1
Ionized Calcium (mg/dl)					
	Males	28	4.2	0.07	3.6 - 5.1
	Females	21	3.9	0.07	3.5 - 4.8
Calcium (mg/dl)					
	Males	28	8.7	0.11	7.35 - 10.00
	Females	21	8.23	0.13	7.30 - 9.30
Alkaline Phosphatase (U/L)					
	Males	28	101	8.14	33 - 179
	Females	21	65	9.13	29 - 183
Albumin† (g/dl)					
	Males	28	3.38	0.05	2.70 - 3.80
	Females	21	3.18	0.06	2.55 - 3.75

Table D. Continued.

CHARACTERISTIC		N
Albumin:Globulin Ratio†		
	Males	28
	Females	21
Albumin†† (g/dl)		
	Males	27
	Females	21
Gamma (g/dl)		
	Males	27
	Females	21
Albumin:Globulin Ratio††		
	Males	27
	Females	21

† - Determined by SMAC autoanalyzer.
†† - Determined by electrophoresis.

MEAN	S.E.	RANGE
1.28	0.03	0.90 - 1.70
1.1	0.05	0.65 - 1.60
3.4	0.05	2.8 - 3.9
3.2	0.07	2.5 - 3.8
0.6	0.04	0.4 - 1.1
0.7	0.05	0.3 - 1.2
1.3	0.05	0.9 - 2.0
1.19	0.06	0.7 - 2.0

Table E. Serum characteristics of grizzly bears in central and northern Alaska.

CHARACTERISTIC	N	MEAN	S.E.	RANGE
Glucose (mg/dl)	149	97	2.98	32 - 244
Urea Nitrogen (mg/dl)	155	37	1.26	8 - 91
Creatinine (mg/dl)	155	0.93	0.02	0.3 - 2.2
Sodium (mEq/L)	143	135	0.97	87 - 160
Potassium (mEq/L)	153	4.37	0.06	2.0 - 6.6
Chloride (mEq/L)	153	98	1.03	38 - 126
Carbon Dioxide (mEq/L)	153	14	0.55	1 - 39
Uric Acid (mg/dl)	138	2.0	0.09	0.8 - 7.4
Total Bilirubin (mg/dl)	155	0.1	0.005	0.0 - 0.3
Direct Bilirubin (mg/dl)	155	0.09	0.004	0.0 - 0.2
Ionized Calcium (mg/dl)	154	3.87	0.05	1.1 - 6.5
Calcium (mg/dl)	153	8.4	0.24	2.5 - 13.2

Table E. Continued.

CHARACTERISTIC	N
Phosphorous (mg/dl)	152
Alkaline Phosphatase (U/L)	143
Lactic Dehydrogenase (U/L)	154
Glutamic-Oxalacetic Transaminase (U/L)	154
Glutamic-Pyruvic Transaminase (U/L)	153
Cholesterol (mg/dl)	154
Triglycerides (mg/dl)	155
Total Protein (g/dl)	152
Albumin (g/dl)	153
Globulin (g/dl)	154
Albumin-Globulin Ratio	154
Cortisol (ug/dl)	78

MEAN	S.E.	RANGE
4.5	0.12	1.3 - 8.7
69.9	3.82	10 - 233
628	20.30	88 - 1456
149	12.27	14 - 1310
60	6.80	2 - 680
209	5.35	23 - 423
168	5.12	24 - 415
5.99	0.09	1.1 - 9.8
3.26	0.05	1.1 - 5.2
2.79	0.06	0.4 - 6.7
1.23	0.03	0.6 - 2.6
17.7	0.47	6.4 - 28.1