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Some Hematological and Serum Biochemical Parameters of European Wild Hogs (*Sus scrofa*)

Michael John Williamson
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Michael John Williamson entitled "Some Hematological and Serum Biochemical Parameters of European Wild Hogs (*Sus scrofa*)." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

Michael R. Pelton, Major Professor

We have read this thesis and recommend its acceptance:

George M. Merriman, R. L. Murphee

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

March 3, 1972

To the Graduate Council:

I am submitting herewith a thesis written by Michael John Williamson entitled "Some Hematological and Serum Biochemical Parameters of European Wild Hogs (Sus scrofa)." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wild Life Management.

Michael R. Pelton
Major Professor

We have read this thesis
amd recommend its acceptance:

George M. Merriman

R. L. Murphree

Accepted for the Council:

Hilton A. Smith
Vice Chancellor for
Graduate Studies and Research

SOME HEMATOLOGICAL AND SERUM BIOCHEMICAL PARAMETERS OF EUROPEAN WILD HOGS (SUS SCROFA)

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Michael John Williamson

June 1972

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ABSTRACT

Blood samples were obtained from 70 European wild hogs (*Sus scrofa*), of which 33 were live-trapped in the Great Smoky Mountains National Park and 37 were reared in captivity on farms which were geographically proximal to the mountains.

Anticoagulated blood was analyzed for erythrocyte sedimentation rate, red blood cell count, white blood cell count (total and differential), packed cell volume, hemoglobin concentration and platelet count. The values for mean corpuscular volume and mean corpuscular hemoglobin were calculated. Sera were analyzed for chloride, potassium, sodium, glucose, blood urea nitrogen, total serum protein, albumin, alpha, beta and gamma globulins. The albumin/globulin ratio was calculated. Statistical analyses in the form of analysis of variance ($P < 0.05$) were performed on the data.

With the exception of serum sodium, significant sex differences were not found. Subadult free-roaming hogs were higher than adults for red blood cell count, white blood cell counts, packed cell volumes, hemoglobins and platelet counts. The ratios of white blood cells in the differential counts were the same, though subadults had slightly fewer neutrophils and slightly more lymphocytes. Among the pen-reared animals, values for the different categories (i.e., age or sex) were more similar to one another with females having slightly higher sedimentation rates, white blood cell counts and platelet counts than males, and adults having somewhat higher values than subadults for all hematological parameters except percentage of neutrophils, mean corpuscular volume and mean corpuscular

hemoglobin. Serum biochemical values for male, free-roaming hoge were slightly higher than females with the exception of glucose. Among adult and subadult, free-roaming hogs, only the total serum protein was significantly higher in the adults. Serum values of male and female pen-reared hogs were similar though the females had somewhat higher levels of total serum protein and albumin. Adult, pen-reared hogs had slightly higher levels of potassium, sodium and beta globulins and significantly higher levels of total serum protein than subadults. Analysis of variance of the data indicated that location (i.e., free-roaming versus pen-reared) had a significant influence on platelet counts, neutrophil and lymphocyte counts, potassium, sodium, glucose, blood urea nitrogen, total serum protein, alpha, beta and gamma globulins. The influence of sex was significant only on sodium levels. Age apparently exerted a significant influence on platelet counts, chloride, sodium, total serum protein, albumin and the gamma globulins.

It is postulated that the differences mentioned above may be largely accounted for by differences in hematopoietic development, differences in reaction to stress and excitement, and differences in locational milieu.

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CHAPTER I

INTRODUCTION

Data for hematological parameters is basic to an understanding of the biology of any species of wild animal. Until recently, however, such information was documented only for domestic and laboratory animals. This dearth of knowledge is being rectified by an ever increasing number of researchers. Less than ten papers were published in journals in the United States regarding hematological values of free-living, North American mammals, between the years of 1951 and 1955. There were slightly more than ten such papers in the years 1961-62 and at least ten in the single year of 1970.

Bats (Lidicker and Davis, 1955), kangaroo rats (Gjonnes and Schmidt-Nielsen, 1952), woodchucks (Faust and Parpart, 1961), deer (Cowan and Bandy, 1969 and Pritchard, Malewitz and Kitchen, 1963) and whales (Ridgeway, Simpson, Patton and Gilmartin, 1970), are some of the wide variety of mammals on which hematological studies have been conducted. However, no report of hematological data for the European wild hog (Sus scrofa) could be found. This animal has come to assume a status of some economic importance as a game species in certain geographical areas and may reasonably be expected to become more significant in the future.

This study was undertaken to establish basic blood and serum parameters for free-roaming European wild hogs. It was intended to differ further from many such studies by examining as many routine blood variables as was feasible and by involving as many samples as could be collected and studied within one year. Rarely does the occasion arise to contrast a wild, exotic game animal with its domestic counterpart of the same genus and species. After this project was initiated, the opportunity developed to obtain samples from allegedly purebred European wild hogs which had been reared in captivity for several generations. It was thought that this latter group of swine might serve as a middle ground of comparison between genuinely wild hogs and the values obtained for various domestic breeds. No assumptions are made regarding the genetic purity of either the free-roaming or the pen-reared wild hogs. Although it has been shown that there is a difference in the chromosome numbers between the domestic and wild swine (Rary, Henry, Matschke and Murphree, 1968), no attempt was made in this study to elucidate the exact genetic makeup of the animals. Presumably the mean racial purities of the free-roaming and the pen-reared hogs were similar enough for the comparative purposes of this project.

The animals designated as free-roaming in this study represent a population which has become established in the Great Smoky Mountains National Park (hereafter called GSMNP). According to Linzey and Linzey (1971), these hogs are descended from 13 young swine imported from Europe in 1912 and which subsequently escaped from a private preserve on which they were kept. They were first reported in the GSMNP in 1959. The GSMNP covers approximately 800 square miles and is roughly bisected by the rugged terrain of the Appalachian Mountain chain.

Although the GSMNP includes portions of three Tennessee counties and two North Carolina counties, all animals used in this project were acquired from the Tennessee area. The pen-reared hogs came from two Tennessee counties, Monroe and Sevier. According to their owners, these were also direct descendants of the original European swine. These pen-reared animals, ultimately destined for hunting purposes, are closely protected from admixture with free-roaming feral hogs. No attempt is made to domesticate them, however. Rarely is any selective breeding practiced nor are newborn or smaller pigs protected from the aggressions, sometimes fatal, of mature hogs.

Although these data may not represent normal values, having been taken from animals under the stress of handling, animals sampled for this study were apparently healthy, typical specimens. The values herein may prove of interest or worth as a guide to the actual values or as a basis for future research. It would be virtually impossible to obtain blood samples under similar field conditions without introducing stressors. A study of domestic swine by Kornegay (1967) indicates that even tranquilization is of no benefit in the above regard. Also, the necessity for holding samples under refrigeration for varying lengths of time prior to laboratory testing precludes the representation of these values as unchallengable. It is to be expected, however, that other researchers must undoubtedly be faced with much the same difficulties.

CHAPTER II

MATERIALS AND METHODS

The 70 animals used in this study were comprised of 33 wild, free-roaming hogs and 37 wild hogs which were pen-reared. The opportunity to obtain blood from the free-roaming hogs came as an adjunct to another study which necessitated live-trapping the animals within the boundaries of the GSMNP.

Ages were determined by dental formulae examinations (Matschke, 1967) or in some instances, by personal records of owners of pen-reared stock. Ages among the free-roaming hogs ranged from approximately six weeks to greater than 26 months, with the majority between six and 20 months. All of the pen-reared animals were within this latter range. For statistical considerations, the division between adults and subadults was arbitrarily made at 10 months. It was felt that the majority of the parameters under study would be stabilized beyond this age. Miller, Ullrey, Ackerman, Schmidt, Luecke and Hoefer (1961a) reported that various erythrocytic values assumed stable adult levels in hogs between 8-11 months. Miller, Ullrey, Ackerman, Schmidt, Hoefer and Luecke (1961b) noted a similar maturation for serum protein values. Although the arbitrary division made in this study must inevitably introduce some bias, it did allow for the most equitable sample sizes. A preponderance of adults resulted, but increasing the age at which the division was to be made did not seem justifiable.

The numbers of individuals of each sex were more similar than the numbers of adults and subadults. A few (three) free-roaming sows were nursing litters of piglets and at least two others were thought to be in mid-pregnancy. All of the pen-reared females sampled were nulliparous.

The first samples were collected in February 1971 and sampling was terminated in early December of the same year. The times of sampling of the free-roaming hogs extended throughout all climatic seasons of the one year, although a much limited number were trapped in the hotter months (August-October). All of the pen-reared pigs were sampled in the late fall of 1971. Twenty-four of the pen-reared hogs were from one farm. The degree of familial relationship of this group was not known with any accuracy, although it was believed that they were relatively outbred, the herd having been only recently assembled with animals from widely separated localities. Ten of the remaining pen-reared hogs came from another farm and were members of a herd which had been in existence for a much longer time. No historical data were available for the remaining three pen-reared pigs.

Blood was drawn from the anterior vena cava (Carle and Dewhirst, 1942), using 18 gauge X 4 inch hypodermic needles with a Vacutainer-Luer adaptor attached between the needles and the 10 milliliter Vacutainers (Becton-Dickinson) into which the blood was collected. Two of these vacutainer tubes were used for each sampling. One tube contained potassium oxalate anticoagulant for cellular hematology and the other contained no additive, allowing the blood to clot. Serum was obtained after the clot had fully retracted. The animals were restrained, dorsally recumbent, throughout the sampling procedure. Blood film smears for differential enumeration of white blood cells were typically made with a drop of blood from a peripheral ear vein. These smears were stained in the usual manner with Wright's blood stain. As soon as possible after collection, cellular studies were performed. Also at this time, the serum was removed from the clotted tubes by centrifugation and frozen at -4° Centigrade for later analyses.

A Model F Coulter Electronic Cell Counter was used for the red and white blood cell counts (Weide, Trapp, Weaver and Lagace, 1962 and Wisecup and Crouch, 1962). The settings used on the Coulter Counter were: attenuation, 1; aperture, 8; threshold, 11 and APC current, 0.8. Leukocytes were determined from a solution of 20 microliters of blood in 10 milliliters of Isoton (Scientific Products). A 100 microliter aliquot of this solution was then diluted to 10 milliliters with Isoton and used for the erythrocyte counts. Before counting the leukocytes, two drops of Zap-Isoton (Scientific Products) were added to the solution to lyse the red cells.

The standard cyanmethemoglobin technique of Drabkin (1954) was utilized to determine values for red blood cell hemoglobin content. Twenty microliters of blood were added to five milliliters of the prepared reagent (Hycel). Standardization was accomplished using a commercial cyanmethemoglobin standard (Hycel). Samples were analyzed spectrophotometrically using a Model 139 Hitachi UV-VIS Spectrophotometer.

The hematocrits (packed cell volumes) were determined by a micro-method similar to Guest (1934), using capillary tubes, a Microhematocrit Centrifuge (Adams) and a circular reader (International). The average of two determinations was reported as the hematocrit value for each sample.

Platelets were counted by phase microscopy following the method of Brecher (1953). A Bright-Line phase hemacytometer (A/O Spencer) was used. Dilutions were typically made with red blood cell diluting pipettes. Diluent, one percent ammonium oxalate, was added and the pipettes were agitated on a pipette shaker (Yankee) for five minutes. The hemacytometer was then charged and allowed to stand in a pre-moistened Petri dish for 15 minutes before counting.

Erythrocyte sedimentation rates were measured after one hour in disposable Wintrobe Sed-Rate tubes.

Differential white cell counts were made on the Wright's stained slide smears. One hundred cells, under oil immersion, were counted on each slide.

The serum samples were analyzed for sodium, potassium, chloride, blood urea nitrogen and glucose using an Auto-Analyzer, SMA 6/60. Total serum protein was measured with a refractometer (National). Protein electrophoresis was accomplished with cellulose acetate membranes (Beckman) electrophoresed for 20 minutes at a potential of 120 VDC. After staining and clearing, the membranes were scanned utilizing an appropriate densitometer (Beckman) and the percent values were then calculated for albumin and the alpha, beta and gamma globulins. (Beckman Electrophoresis Manual, 1965).

The values for mean corpuscular volume, mean corpuscular hemoglobin and albumin/globulin ration were calculated using the following formulae (Archer, 1965):

Mean Corpuscular Volume (MCV) - The average volume of a red blood cell expressed in cubic microns.

$$= \frac{\text{(Hematocrit percent)}}{\text{(red blood cell count-million per cu mm)}} \text{ X 10 cu microns}$$

Mean Corpuscular Hemoglobin (MCH) - The average hemoglobin content of a single erythrocyte expressed as micromicrograms.

$$= \frac{\text{(Hemoglobin-gm per 100 ml)}}{\text{(red blood cell count-million per cu mm)}} \text{ X 10 micrimicrograms}$$

Albumin/Globulin Ratio (A/G Ratio) - The ratio of the percent serum albumin to the sum of the percents of the alpha, beta and gamma globulins.

$$= \frac{\text{(Percent albumin)}}{\text{(Percent alpha + beta + gamma globulins)}}$$

The formal method of statistical analysis was the standard analysis of variance for the effects of locations (free-roaming vs. pen-reared), age (adult vs. subadult) and sex (male vs. female). Significance was noted at the 95 percent level of F based upon the appropriate degrees of freedom. Similarly, the significance of interactions between location and age, location and sex, and sex and age were determined. It was felt that a more detailed statistical analysis would be unreliable due to the small size of certain sample cells.

CHAPTER III

RESULTS AND DISCUSSION

General Comments

The results of cellular hematological and serum analyses for the free-roaming hogs are presented in Tables 1, 2, 3 and 4. The first two tables categorize the animals according to sex and the last two according to age. Tables 5, 6, 7 and 8 present the same data for the pen-reared hogs in a similar manner. In Tables 9 and 10 are contained the overall values for all sexes and ages of free-roaming and pen-reared hogs. In Tables 11 and 12, the normal hematological and serum biochemical values for domestic swine, as reported by various researchers, are presented. The numbers of animals comprising each category are shown in the first eight tables to emphasize the sample size upon which the statistical analyses were made.

Examination of Tables 1 through 8 reveals that, for most values, there were no marked differences between males and females. This will later be shown to be statistically verified. Studies on domestic swine have likewise indicated a general absence of sex differences for similar data (Calhoun and Smith, 1970; Craft and Moe, 1932). On the other hand, there are several observable differences between age categories in these tables which are statistically significant.

TABLE 1

VALUES FOR CELLULAR BLOOD PARAMETERS OF FREE-ROAMING EUROPEAN WILD HOGS BY SEX

Determination	Number of male/female	MALE		FEMALE	
		Mean	S.D.	Mean	S.D.
Erythrocyte sedimentation rate (mm/hr)	26/16	4.73	4.22	7.56	12.39
Erythrocyte count (mill/cu mm)	26/16	7.21	1.52	7.36	1.48
Leukocyte count (thous/cu mm)	26/16	11.48	4.45	13.48	4.55
Packed cell volume	26/16	38.88	6.69	39.25	7.86
Hemoglobin (gm/100 ml)	26/16	14.73	2.57	14.96	2.58
Platelet count (thous/cu mm)	26/16	310.81	271.81	343.25	335.04
Differential (%)					
Neutrophils	26/16	53.27	19.64	57.25	16.87
Lymphocytes	26/16	42.19	19.73	38.56	14.39
Monocytes	26/16	3.12	2.99	2.69	2.57
Eosinophils	26/16	1.38	2.06	1.75	3.13
Basophils	26/16	0.12	0.43	0.0	0.0
Mean corpuscular volume	26/16	54.85	7.78	53.88	7.00
Mean corpuscular hemoglobin	26/16	20.96	3.23	20.56	2.53

TABLE 2

VALUES FOR SERUM PARAMETERS OF FREE-ROAMING EUROPEAN WILD HOGS BY SEX

Determination	Number of male/female	MALE		FEMALE	
		Mean	S.D.	Mean	S.D.
Chloride (mEq/l)	19/12	97.10	4.88	97.08	3.29
Potassium (mEq/l)	15/12	7.02	1.92	6.48	1.64
Sodium (mEq/l)	19/12	142.11	4.71	141.83	3.27
Glucose (mg %)	19/12	129.89	53.80	156.75	45.50
Blood urea nitrogen (mg %)	19/12	10.42	5.81	10.67	3.08
Total serum protein (gm/100 ml)	25/16	7.23	1.36	7.01	0.72
Albumin (%)	25/16	48.38	3.62	48.49	4.96
Alpha globulins (%)	25/16	16.52	2.56	16.70	1.52
Beta globulins (%)	25/16	22.60	4.50	22.64	2.81
Gamma globulins (%)	25/16	12.48	3.03	12.18	3.29
Albumin/Globulin ratio	25/16	0.86	0.25	0.97	0.20

TABLE 3

VALUES FOR CELLULAR BLOOD PARAMETERS OF FREE-ROAMING EUROPEAN WILD HOGS BY AGE

Determination	Number of adult/subadult	ADULT		SUBADULT	
		Mean	S.D.	Mean	S.D.
Erythrocyte sedimentation rate (mm/hr)	28/14	6.93	9.56	3.57	4.43
Erythrocyte count (mill/cu mm)	28/14	6.72	1.34	8.36	1.16
Leukocyte count (thous/cu mm)	28/14	11.64	3.89	13.42	5.59
Packed cell volume	28/14	36.61	6.24	43.86	6.24
Hemoglobin (gm/100 ml)	28/14	14.17	2.61	16.11	1.91
Platelet count (thous/cu mm)	28/14	267.68	268.71	434.14	320.22
Differential (%)					
Neutrophils	28/14	56.04	19.23	52.28	17.44
Lymphocytes	28/14	39.75	19.21	42.93	14.98
Monocytes	28/14	2.93	2.99	3.00	2.54
Eosinophils	28/14	1.32	1.98	1.93	3.34
Basophils	28/14	0.11	0.42	0.0	0.0
Mean corpuscular volume	28/14	55.32	7.88	52.78	6.34
Mean corpuscular hemoglobin	28/14	21.46	3.21	19.50	1.83

TABLE 4

VALUES FOR SERUM PARAMETERS OF FREE-ROAMING EUROPEAN WILD HOGS BY AGE

Determination	Number of adult/subadult	ADULT		SUBADULT	
		Mean	S.D.	Mean	S.D.
Chloride (mEq/l)	25/6	96.40	4.18	100.00	3.58
Potassium (mEq/l)	21/6	6.77	1.87	6.83	1.62
Sodium (mEq/l)	25/6	141.36	3.70	144.67	5.24
Glucose (mg %)	25/6	139.88	55.97	142.00	31.52
Blood urea nitrogen (mg %)	25/6	10.40	5.19	11.00	3.63
Total serum protein (gm/100 ml)	27/14	7.28	1.35	6.88	0.54
Albumin (%)	27/14	47.45	3.44	50.31	4.80
Alpha globulins (%)	27/14	16.28	2.17	17.18	2.18
Beta globulins (%)	27/14	22.88	3.64	22.10	4.42
Gamma globulins (%)	27/14	13.38	1.73	10.39	4.14
Albumin/Globulin ratio	27/14	0.92	0.12	0.88	0.37

TABLE 5

VALUES FOR CELLULAR BLOOD PARAMETERS OF PEN-REARED EUROPEAN WILD HOGS BY SEX

Determination	Number of male/female	MALE Mean	MALE S.D.	FEMALE Mean	FEMALE S.D.
Erythrocyte sedimentation rate (mm/hr)	18/19	3.00	3.16	4.84	3.30
Erythrocyte count (mill/cu mm)	18/19	7.78	0.68	7.66	1.07
Leukocyte count (thous/cu mm)	18/19	17.73	4.10	19.85	14.35
Packed cell volume	18/19	42.33	3.60	42.00	4.15
Hemoglobin (gm/100 ml)	18/19	15.34	0.96	15.11	1.46
Platelet count (thous/cu mm)	18/19	385.94	255.23	448.42	302.78
Differential (%)					
Neutrophils	18/19	37.72	7.46	37.05	8.44
Lymphocytes	18/19	55.94	5.96	55.47	9.25
Monocytes	18/19	3.17	2.66	3.26	2.13
Eosinophils	18/19	3.17	3.28	4.05	4.89
Basophils	18/19	0.06	0.24	0.05	0.23
Mean corpuscular volume	18/19	54.67	3.96	55.37	5.02
Mean corpuscular hemoglobin	18/19	19.89	1.41	19.95	1.75

TABLE 6

VALUES FOR SERUM PARAMETERS OF PEN-REARED EUROPEAN WILD HOGS BY SEX

Determination	Number of male/female	MALE		FEMALE	
		Mean	S.D.	Mean	S.D.
Chloride (mEq/l)	15/18	100.27	3.84	100.11	4.48
Potassium (mEq/l)	15/18	8.75	0.68	8.61	0.92
Sodium (mEq/l)	15/18	142.07	3.73	140.72	3.16
Glucose (mg %)	15/18	92.73	17.75	89.17	17.13
Blood urea nitrogen (mg %)	15/18	15.87	2.72	12.56	2.73
Total serum protein (gm/100 ml)	17/19	8.84	1.23	9.12	1.29
Albumin (%)	17/19	28.89	9.83	26.83	8.20
Alpha globulins (%)	17/19	14.07	2.89	13.85	2.82
Beta globulins (%)	17/19	39.99	11.42	43.82	8.83
Gamma globulins (%)	17/19	17.04	3.51	15.52	3.66
Albumin/Globulin ratio	17/19	0.43	0.24	0.39	0.19

TABLE 7

VALUES FOR CELLULAR BLOOD PARAMETERS OF PEN-REARED EUROPEAN WILD HOGS BY AGE

Determination	Number of adult/subadult	ADULT		SUBADULT	
		Mean	S.D.	Mean	S.D.
Erythrocyte sedimentation rate (mm/hr)	31/6	4.35	3.39	1.83	2.04
Erythrocyte count (mill/cu mm)	31/6	7.84	0.90	7.12	0.63
Leukocyte count (thous/cu mm)	31/6	19.43	11.25	15.67	5.76
Packed cell volume	31/6	42.77	3.72	39.00	2.97
Hemoglobin (gm/100 ml)	31/6	15.36	1.29	14.52	0.54
Platelet count (thous/cu mm)	31/6	432.64	299.77	342.50	106.85
Differential (%)					
Neutrophils	31/6	36.35	7.67	42.67	7.31
Lymphocytes	31/6	56.06	8.24	53.83	4.07
Monocytes	31/6	3.45	2.32	2.00	2.45
Eosinophils	31/6	4.03	4.23	1.50	3.21
Basophils	31/6	0.06	0.25	0.0	0.0
Mean corpuscular volume	31/6	55.00	4.79	55.17	2.71
Mean corpuscular hemoglobin	31/6	19.77	1.56	20.67	1.51

TABLE 8

VALUES FOR SERUM PARAMETERS OF PEN-REARED
EUROPEAN WILD HOGS BY AGE

Determination	Number of adult/subadult	ADULT Mean	ADULT S.D.	SUBADULT Mean	SUBADULT S.D.
Chloride (mEq/l)	29/4	99.90	4.13	102.25	4.19
Potassium (mEq/l)	29/4	8.67	0.79	8.65	1.10
Sodium (mEq/l)	29/4	141.55	3.60	139.75	1.26
Glucose (mg %)	29/4	89.45	16.97	100.50	18.38
Blood urea nitrogen (mg %)	29/4	13.76	3.12	16.25	2.87
Total serum protein (gm/100 ml)	30/6	9.20	0.98	7.93	1.95
Albumin (%)	30/6	26.18	5.92	35.92	16.14
Alpha globulins (%)	30/6	13.68	2.41	15.32	4.40
Beta globulins (%)	30,6	43.80	7.80	33.07	16.02
Gamma globulins (%)	30/6	16.34	3.22	15.70	5.58
Albumin/Globulin ratio	30/6	0.36	0.11	0.65	0.41

TABLE 9

VALUES FOR CELLULAR BLOOD PARAMETERS OF ALL CLASSES OF EUROPEAN WILD HOGS

Determination	FREE-ROAMING		PEN-REARED	
	Mean	S.D.	Mean	S.D.
Erythrocyte sedimentation rate (mm/hr)	5.81	8.31	3.94	3.32
Erythrocyte count (mill/cu mm)	7.26	1.49	7.72	0.89
Leukocyte count (thous/cu mm)	12.24	4.54	18.82	10.59
Packed cell volume	39.02	7.06	42.16	3.84
Hemoglobin (gm/100 ml)	14.82	2.55	15.22	1.24
Platelet count (thous/cu mm)	323.17	293.89	418.03	278.57
Differential (%)				
Neutrophils	54.78	18.53	37.38	7.87
Lymphocytes	40.81	17.79	55.70	7.72
Monocytes	2.95	2.82	3.22	2.37
Eosinophils	1.52	2.49	3.62	4.15
Basophils	0.07	0.34	0.05	0.23
Mean corpuscular volume	54.48	7.42	55.03	4.49
Mean corpuscular hemoglobin	20.81	2.96	19.92	1.57

TABLE 10

VALUES FOR SERUM PARAMETERS OF ALL CLASSES
OF EUROPEAN WILD HOGS

Determination	FREE-ROAMING		PEN-REARED	
	Mean	S.D.	Mean	S.D.
Chloride (mEq/l)	97.10	4.27	100.18	4.14
Potassium (mEq/l)	6.78	1.78	8.67	0.81
Sodium (mEq/l)	142.00	4.16	141.33	3.44
Glucose (mg %)	140.29	51.70	90.79	17.24
Blood urea nitrogen (mg %)	10.52	4.88	14.06	3.16
Total serum protein (gm/100 ml)	7.14	1.15	8.99	1.25
Albumin (%)	48.42	4.13	27.80	8.94
Alpha globulins (%)	16.59	2.19	13.96	2.82
Beta globulins (%)	22.62	3.89	42.01	10.17
Gamma globulins (%)	12.36	3.10	16.24	3.62
Albumin/Globulin ratio	0.90	0.24	0.41	0.22

TABLE 11

NORMAL HEMATOLOGICAL VALUES FOR DOMESTIC SWINE

Determination	Age and/or Weight	Mean and/or Range	Source
Erythrocyte		5.0	Zott, 1931
sedimentation		5.35	Schappes, 1937
rate (mm/hr)	10-94 da.	1.72	Weide & Twiehaus, 1959
Erythrocyte		6.7	Scarborough, 1931-32
count		7.9	Wintrobe, 1951
(mill/cu mm)		7.4	Dukes, 1955
Leukocyte		8-20	Scarborough, 1931-32
count		7-20	Wintrobe, 1951
(thous/cu mm)	ad. sows	15.9	
	bacon pigs	13.7	Luke, 1953
Packed cell		39.0	Wintrobe, 1934
volume		46.0	Tegeris, 1965
	10-94 da.	(20.4-32.9)	Weide & Twiehaus, 1959
Hemoglobin	180 da.	12.6	Craft & Hoe, 1932
(gm/100 ml)		15.0	Wintrobe, 1951
	adult	(14-15)	McClellan, 1965
Platelet		404	Tegeris, 1965
count	6 mos.	330	
(thous/cu mm)	18 mos.	(200-250)	McClellan, 1965
		403	Hokmet, 1927
Differential			
Neutrophils (%)		39.0	
Lymphocytes (%)		52.1	
Monocytes (%)		3.3	
Eosinophils (%)		4.5	
Basophils (%)		1.2	Scarborough, 1931-32
	180 da.	30.6	
		64.9	
		--	
		4.4	
		--	Craft & Moe, 1932

TABLE 11 (continued)

Determination	Age and/or Weight	Mean and/or Range	Source
		41.0	
		47.0	
		8.0	
		2.5	
		<1.0	Dukes, 1955
Mean Corpuscular volume		(51.4 ± 4.6)	Tumbleson, 1969
		(59-63)	Wintrobe, 1934
	10 mos.	(60.5 ± 1.4)	Miller, 1961
Mean Corpuscular hemoglobin		(16.8 ± 1.6)	Tumbleson, 1969
		(21-22)	Wintrobe, 1934
	10 mos.	(19.9 ± 0.5)	Miller, 1961

TABLE 12

NORMAL SERUM BIOCHEMICAL VALUES FOR DOMESTIC SWINE

Determination	Age and/or Weight	Mean and/or Range	Source
Chloride (mEq/l)		104	Tumbleson, 1969
		103	Meier, 1963
Potassium (mEq/l)		4.7	Tumbleson, 1969
		5.9	Meier, 1963
Sodium (mEq/l)		146	Tumbleson, 1969
		149	Meier, 1963
Glucose (mg %)		118	Tumbleson, 1969
		(65-95)	Eveleth & Eveleth, 1935
		103	Tegeris, 1965
Blood urea nitrogen (mg %)		13	Tegeris, 1965
		9	Tumbleson, 1969
	3 mos. -ad.	(17-20)	McClellan, 1965
Total serum protein (gm/100 ml)		6.9	
Albumin (%)		33.9	
Alpha (%)		29.3	
Beta (%)		16.8	
Gamma (%)		20.0	Tumbleson, 1969
	6 mos.	6.8	
		48.6	
		19.4	
		12.6	
		19.3	
	12 mos.	7.5	
		52.7	
		18.2	
		12.6	
		16.4	Miller, 1961

Hematological Parameters

The sedimentation rates of erythrocytes for animals in this study were generally higher than rates reported for domestic pigs. Bunce (1954) states that hogs have a faster sedimentation rate than most other domestic animals and she gives an average rate of 3.7 millimeters after eight hours. Her results, however, seemed to be based upon tests involving only six animals. The lowest value obtained for the wild hogs was 1.83 mm after only one hour for the subadult, pen-reared pigs (Table 7) and the highest was 7.56 mm/hour for free-roaming females (Table 1). There appeared to be a trend for female rates to be higher than male and for adults to have higher rates than young. The validity of this trend may be questionable, however, in view of the relatively wide range of values as reported by other authors studying domestic swine. (Table 11). Sedimentation rates for wild hogs could reasonably be executed to exhibit a similar degree of variation.

Due to their obvious interrelationships, erythrocyte counts, packed cell volumes and hemoglobin concentrations may be considered as a composite group of factors. Thus, this group varies as a whole in the same manner as each component varies. That is, for example, among the data in Table 3, RBC counts for subadults are higher than for the adults. Similarly, the subadult values for packed cell volumes and hemoglobin concentrations are also higher than adult values. This concurrence among the three erythrocytic parameters is emphasized because it is believed that such agreement aids in validating the accuracy of the data.

Although the RBC counts, packed cell volumes (PCV) and hemoglobin concentrations in Tables 1, 3 and 7 (pages 10, 12 and 16, respectively) are quite similar, it may be noted that there is a striking difference between adult and subadult free-roaming hogs for these values (Table 3). That the subadult values are higher is not, in itself, surprising as McClellan, Vogt and Ragan (1965) report from their study of miniature swine that these values increased from weaning to 9-12 months of age and then began to steadily decline, reaching a stable plateau at about three years. It is difficult to explain why this relationship is not seen in the data for adult and subadult pen-reared, wild hogs. Hackett, Seigneur and Bustad (1956), working with Palouse pigs, found a slight difference (15.00 ± 0.79 vs. 15.29 ± 0.74) in hemoglobin levels between those individuals receiving "full-feed" and those receiving only 70 percent full-feed, with the full-fed hogs having the higher values. Nevertheless, although differences in diet or other environmental factors between free-roaming and pen-reared animals might alter the erythrocytic values, the effect of the alteration should be seen in the values for both young and old hogs to a similar degree without masking age-dependent differences. Examination of Table 7 reveals that such is not the case, rather the mean values differ by only 720,000 cells and the adults have the higher value.

Since mean corpuscular volume and mean corpuscular hemoglobin values were calculated from RBC counts, packed cell volumes and hemoglobin concentration, it is to be expected that they should vary consistently with one another and in a definite relationship with the erythrocyte parameters. It is interesting to note that, within comparative categories, those individuals having higher RBC, PVC and hemoglobin levels will conversely have erythrocytes with lower mean corpuscular volumes and lower mean corpuscular hemoglobin values.

The total leukocyte numbers for wild hogs follow the same comparative ratios as erythrocyte values with the exception of male and female pen-reared animals (Table 5, page 14). In this comparison, the males had slightly higher RBC counts, but lower white blood cell (WBC) counts. It is doubtful that this variation can be accurately interpreted, as normal domestic pigs are known to be highly variable for total leukocyte values, according to studies by Eikmeier and Mayer (1965). Luke (1953) found the total WBC count to vary considerably within the same individual pig from day to day and even from hour to hour. It is likely that any apparent relationship between RBC and WBC counts is spurious. Of greater interest is the comparison of differential white blood cell counts between pen-reared and free-roaming hogs. It may be seen in Tables 5 and 7 (page 16) that the pen-reared animals exhibited a definite lymphocytosis. Wirth, Rosmann and Benndorf (1939) stated that the white blood cell picture of young and growing hogs was lymphocytic. Luke (1953) found a relative lymphocytosis to be normal among domestic swine. Eikmeier and Mayer (1965) also reported a lymphocytic picture as normal for domestic pigs. The data in Tables 1 and 3 (pages 10 and 12, respectively), for free-roaming wild swine, indicates a reversal, with neutrophilic white cells in preponderance, regardless of sex or age. The pen-reared hogs follow the lymphocytic state typical of domestic swine and the values in

Tables 5 and 7 (pages 14 and 16, respectively) are almost a perfect numerical inversion of neutrophil and lymphocyte numbers for free-roaming pigs. Gardiner, Sippel and McCormick (1953) studied the effects of concrete floors, dirt and pasture on white blood cells and failed to find a relationship. Regner (1923) found that the normally lymphocytic state was temporarily reversed 2-5 hours after pigs were fed, but returned in 12-17 hours. The struggling and concomitant excitement of the wild hogs during the blood sampling operation might afford an explanation. Palmer (1917) found that exercising normal pigs changed the white blood cell picture from lymphocytic to neutrophilic. Eikmeier and Mayer (1965) found that transporting hogs in trucks had a similar effect. Although the pen-reared animals were somewhat excited at the time of sampling, the amount of struggling was less, as was the amount of stress prior to handling. This explanation loses some validity, though, in that Palmer also found an increase in total white cell counts always followed the exercise and in this study, the wild, free-roaming hogs routinely exhibited lower total WBC counts in all sex and age categories. It is possible, though not yet verified, that a difference in microbial environments of free-roaming and captive swine could account for most of the observed differences in leukocyte pictures. Obviously the pen-reared animals are more crowded into close contact with every other member of the herd and forced to occupy a much smaller territory than the free-roaming hogs. These latter are usually observed in the wild state as solitary animals or in groups seldom larger than a family unit. This would presumably prevent facile communication of low grade infections (especially respiratory) to a large number of animals from a single or few individuals. Similarly, wild hogs at large are free to wander and seem to move throughout a large home range. Again this reduces the tendency for infectious microorganisms to become concentrated in a small area thereby leading to inevitable dissemination throughout a herd inhabiting that area.

Examination of the stained blood smears at the time the differential white blood cell counts were made indicated that polychromatophilia of erythrocytes was common among wild hogs. Wirth (1938) found polychromatic erythrocytes to be characteristic of domestic pig blood and Musacchia, Wilber and Gorski (1955) suggest that polychromatophilia is a characteristic feature of animals of the order Rodentia.

Serum Biochemical Parameters

The serum electrolyte (chloride, potassium and sodium) values in Tables 2, 4, 6 and 8 (pages 11, 13, 15 and 17, respectively) agree with those given by Meier (1963) for domestic swine. No differences between males and females of comparable location categories are seen in Tables 2 and 6. Some rather unremarkable differences between adults and subadults of comparable categories are apparent in Tables 4 and 8, although there is no general trend. Tumbleson, Middleton, Tinsley and Hutcheson (1969) found that serum electrolyte concentrations in miniature swine were variable, but did not change as a function of change in age. The mean overall sodium values are similar to those reported by Widdowson and McCance (1956), although the potassium values are slightly higher for the pen-reared pigs. It is doubtful that these three electrolytes would be significantly influenced by differences in diet, being parameters which must be maintained within rather limited ranges in a normal, healthy animal.

Glucose and blood urea nitrogen values in this study were variable, and although no general trend is evident, there does appear to be a positive relationship between the two parameters (Tables 2, 4, 6 and 8, pages 11, 13, 15 and 17, respectively). Teeri, Virchow, Colovos and Greeley (1958) found this same correlation in studies of white-tailed deer and suggested that it could be the result of gluconeogenesis from protein. Blood urea nitrogen (BUN) values for all classes were slightly higher than those reported by Tumbleson et al. (1969) and lower than those of McClellan et al. (1965). The average BUN values which Tegeris, Earl and Curtis (1965) obtained were within the range of wild hog values. Blood glucose levels are dependent upon several variables, of which diet is likely to be the most important. Although glucose determinations are best done with fasting subjects, this was not feasible in the course of this study. The glucose values reported herein must necessarily, then, be regarded with caution and considered to be only random, uncontrolled indices, the sum of which possibly furnishes a guideline. Kaneko (1961) gives a range of 65-95 mg/100 ml for glucose in swine. Tumbleson et al. (1969) report a higher value of 118. It may be seen in Table 9 (page 18) that free-roaming hogs had levels considerably higher than all of the above values. The value by Tumbleson is a fasting value as is the level of 103 reported by Tegeris et al. (1965).

The results of serum protein determinations for free-roaming and pen-reared wild hogs will have been influenced by diet and age differences and possibly by histories of trauma, infection or other physiological disturbance among certain hogs. Garner, Crawley and Goddard (1957) found that total serum protein and globulin concentrations in swine increase with advancing age, although albumin concentration decreases. Serum or plasma proteins appear to be directly influenced by nutritional levels according to Dimopoullos (1963). Specifically, he states that "vitamins, growth factors and related substances which affect protein, lipid and carbohydrate metabolism would consequently be expected to make their influence felt in the plasma protein profile."

Pen-reared hogs had higher total serum protein concentrations (Tables 6 and 8, pages 15 and 17, respectively) than free-roaming hogs. Among pen-reared animals, values were higher for females and adults. All were higher than the values of 6.9 g/100 ml. reported by Tumbleson et al. (1969), 6.78-7.61 reported by Miller et al. (1961b) and 7.0 given by McClellan et al. (1965). The free-roaming wild hogs had concentrations which were closer to the domestic swine values (Tables 2, 4 and 12, pages 11, 13 and 22, respectively). There was no marked sex difference in this group and adults had higher values than subadults. The above agrees with the study by Garner et al. (1957), as are the lower albumin concentrations for adult, free-roaming hogs compared to free-roaming subadults. The albumin and alpha globulin fractions for pen-reared hogs were considerably lower than those for free-roaming or domestic swine (Tumbleson et al., 1969 and

Miller et al., 1961b). The beta globulin concentrations are relatively high (Tables 6 and 8, pages 15 and 17, respectively) and this, with the low albumin levels, provides albumin/globulin ratios for every category other than subadults (0.65, Table 8) which are lower (0.36, Table 8 and 0.43 and 0.39, Table 6) than Tumbleson's figure of 0.52 for domestic swine. The A/G ratios for the free-roaming hogs (0.86 and 0.97, Table 2, page 11 and 0.92 and 0.88, Table 4, page 13) are higher than the above value for domestic swine. Vitamin deficiencies (Erwin, Varnell and Page, 1959), dietary protein depletions (Weimer, Bell and Nishihara, 1959) and other types of nutritional imbalances (Cartwright, Smith, Brown and Wintrobe, 1948) have all been linked with changes in the concentrations of albumin and globulins.

Statistical Treatment of Data

Examination of Tables 13 and 14 indicates that the effect of sex is significant for only one parameter (sodium). This is in accord with those studies, previously cited, on domestic swine which revealed no sex differences for blood values. Also in Tables 13 and 14, there is a significant age effect on several parameters. This is believed to be due, in large part, to the differences in the stages of development and levels of activity of the hematopoietic systems of young and older hogs. Clearly, the influence of location is profound. This is not surprising when the environmental contrast between the two locations is considered. Although the pen-reared hogs were in no manner "tame," they were at least accustomed to the sight of humans.

TABLE 13

THE RELATIONSHIP OF SEX-AGE AND LOCATION TO CELLULAR BLOOD VALUES

Determination	Effect of Loca[a] on Comparable Sexes and Ages	Effect of Sex on Comparable Locas and Ages	Effect of Age on Comparable Locas and Ages
Erythrocyte sedimentation rate	n.s.	n.s.	n.s.
Erythrocyte count	n.s.	n.s.	n.s.
Leukocyte count	n.s.	n.s.	n.s.
Packed cell volume	n.s.	n.s.	n.s.
Hemoglobin	n.s.	n.s.	n.s.
Platelet counts	*	n.s.	*
Differential[b]			
Neutrophils	*	n.s.	n.s.
Lymphocytes	*	n.s.	n.s.
Monocytes	n.s.	n.s.	n.s.
Eosinophils	n.s.	n.s.	n.s.
Mean corpuscular volume	n.s.	n.s.	n.s.
Mean corpuscular hemoglobin	n.s.	n.s.	n.s.

[a]Loca = Location, i.e. Location 1 includes all of the free-roaming animals and Location 2 includes the pen-reared hogs.

[b]Due to their extremely low frequency of occurrence, basophils were not included in the statistical analyses.

*Denotes significance at the 95% confidence level of F distribution.

TABLE 14

THE RELATIONSHIP OF SEX-AGE AND LOCATION TO SERUM PARAMETERS

Determination	Effect of Loca[a] on Comparable Sexes and Ages	Effect of Sex on Comparable Locas and Ages	Effect of Age on Comparable Locas and Sexes
Chloride	n.s.	n.s.	*
Potassium	*	n.s.	n.s.
Sodium	*	*	*
Glucose	*	n.s.	n.s.
Blood urea nitrogen	*	n.s.	n.s.
Total serum protein	*	n.s.	*
Albumin	*	n.s.	*
Alpha globulins	*	n.s.	n.s.
Beta globulins	*	n.s.	n.s.
Gamma globulins	*	n.s.	*
Albumin/Globulin ratio	*	n.s.	n.s.

[a]Loca = Location, i.e. Location 1 includes all of the free-roaming animals and Location 2 includes the pen-reared hogs.

*Denotes significance at the 95% confidence level of F distribution.

Personal observations revealed that, among these captive wild hogs, the reaction to the shock of handling was far less pronounced than that exhibited by their free-roaming counterparts. The other, no less important, contrast exists in the nutritional types and levels of diets of animals in the two locations. Although all of the pen-reared hogs in this study had access to pasture (usually very poor quality), the principal feed was a commercial hog ration, in some instances supplemented by corn. The pen-reared pigs' diet may be described as adequate without fluctuations, as opposed to the diet of free-roaming hogs with its greater seasonal variations depending upon maturation of mast and its much wider variety including practically everything available from wild fruits and nuts to earthworms and salamanders.

The disparate erythrocytic values for different ages of pen-reared and free-roaming hogs are evident in the interactions of location and age (Table 15). The A/G ratio is significantly affected by the interaction between location and age (Table 16). In both cases, it is likely that the differences arise from the dissimilarity of age comparisons for the two locations. The fact that sodium was significantly affected by all variables is unexplainable.

Due to the extreme lability of hematological values, both among individuals and among different racial populations of swine, it is believed that they may not serve as reliable indications of health or state of condition when based upon a single random sampling procedure as was used in this study.

TABLE 15

THE EFFECTS OF SEX-AGE AND LOCATION ON BLOOD VALUES

Determination	Interactions Between Loca[a] and Age	Interactions Between Loca and Sex	Interactions Between Sex and Age
Erythrocyte sedimentation rate	n.s.	n.s.	n.s.
Erythrocyte count	*	n.s.	n.s.
Leukocyte count	n.s.	n.s.	n.s.
Packed cell volume	*	n.s.	n.s.
Hemoglobin	*	n.s.	n.s.
Platelet count	n.s.	n.s.	n.s.
Differential			
Neutrophils	n.s.	n.s.	n.s.
Lymphocytes	n.s.	n.s.	n.s.
Monocytes	n.s.	n.s.	n.s.
Eosinophils	n.s.	n.s.	n.s.
Mean corpuscular volume	n.s.	n.s.	n.s.
Mean corpuscular hemoglobin	n.s.	n.s.	n.s.

[a]Loca = Location, i.e. Location 1 includes all of the free-roaming animals and Location 2 includes the pen-reared hogs.

*Denotes significance at the 95% confidence level of F distribution.

TABLE 16

THE EFFECTS OF SEX-AGE AND LOCATION ON SERUM PARAMETERS

Determination	Interactions Between Loca[a] and Age	Interactions Between Loca and Sex	Interactions Between Sex and Age
Chloride	n.s.	n.s.	n.s.
Potassium	n.s.	n.s.	n.s.
Sodium	*	*	*
Glucose	n.s.	n.s.	n.s.
Blood urea nitrogen	n.s.	n.s.	n.s.
Total serum protein	n.s.	n.s.	n.s.
Albumin	n.s.	n.s.	n.s.
Alpha globulins	n.s.	n.s.	n.s.
Beta globulins	n.s.	n.s.	n.s.
Gamma globulins	n.s.	n.s.	n.s.
Albumin/Globulin ratio	*	n.s.	n.s.

[a]Loca = Location, i.e. Location 1 includes all of the free-roaming animals and Location 2 includes the pen-reared hogs.

*Denotes significance at the 95% confidence level of F distribution.

CHAPTER IV

SUMMARY

Some parameters of cellular hematology and serum biochemistry were measured in free-roaming and pen-reared European wild hogs. Mean values for most parameters were similar to those reported in studies of domestic swine. Except for serum sodium, no significant sex differences were noted. Age-related differences in erythrocyte counts, packed cell volumes and hemoglobin concentrations for the free-roaming animals were similar in trend to those reported for domestic pigs, but this trend was absent among pen-reared wild hogs. The neutrophil/lymphocyte ratio among pen-reared hogs was similar to that typically found in domestic breeds (i.e. lymphocytosis), but this ratio was inverted (neutrophilia) among the free-roaming animals. Serum chloride, potassium, blood urea nitrogen and total serum protein values were higher for pen-reared hogs, while the free-roaming hogs exhibited higher levels of sodium, glucose, albumin and alpha globulins.

In general, values for hogs from both locations were similar to those reported for domestic swine by various authors.

It is suggested that the stress associated with trapping and handling the free-roaming hogs and the differing types and nutritional levels of diets were the principal factors influencing the results of this study.

CHAPTER V

RECOMMENDATIONS

The principal limitations of this study were the small sample sizes, the stress and excitement to which the animals were subjected, the inability to fast the hogs before blood samples were taken and the fact that samples were entirely random. If this research is to be pursued, it is believed that the following recommendations would lead to a more accurate evaluation of the wild hog's normal hematological picture.

1. Hogs caught in other areas of the GSMNP could be utilized to obtain more samples from each age class.

2. Immediately after being trapped, hogs could be removed to larger holding pens, allowed to rest without molestation, fasted and sampled. If one person quietly tranquilized the hogs to be sampled from a distance, it is likely that stress and excitement would be minimal.

3. Using the data in this study as a guide, those animals which exhibited significantly atypical values could be resampled.

4. To assess the role of nutrition, those animals mentioned in 2 and 3 above could then be removed to large enclosures and maintained on various rations with accompanying sampling at regular intervals.

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