SOME BIOCHEMICAL PARAMETERS OF SERUM OF EUROPEAN WILD HOGS

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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 geographically proximal to the mountains. 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. Data were analyzed for the effects of sex, age, and location by least squares analysis of variance. With the exception of serum sodium, significant sex differences were not found. With the exception of glucose, serum biochemical values for male, free-roaming hogs were slightly higher than females. 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. Location (i.e., free-roaming versus pen-reared) had a significant influence on 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 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.

INTRODUCTION

This study was undertaken to establish basic serum parameters for free-roaming European wild hogs *(Sus scrofa)*. Rarely does the occasion arise to contrast a wild, exotic game animal with its domestic counterpart of the same genus and species. Also, it was hoped that the long range and more practical significance of this work might result in some indices of blood useful for determining animal health and/or habitat condition.

After the project was initiated, the opportunity developed to obtain samples from purebred European wild hogs 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 et al. 1968), no attempt was made in this study to elucidate the exact genetic makeup of the animals.

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STUDY AREA

The animals designated as free-roaming in this study represent a population which has become established in the Great Smoky Mountains National Park. 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. They were first reported in the GSMNP in 1959. The GSMNP covers approximatley 2072 km^2 and is roughly bisected by the rugged terrain of the Appalachian Mountain chain.

All animals used in this project were acquired from the Tennessee area of the GSMNP. 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.

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.

Ages were determined by dental formulae examinations (Matschke 1967) or 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 et al. (1961) reported that serum protein values assumed stable adult levels in hogs between 8 and 11 months.

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

Samples were collected from February to December 1971. Free-roaming hogs were sampled through all seasons with fewer numbers trapped between August and October. Pen-reared pigs were sampled in the late fall of 1971. Wild, free-roaming hogs were held in traps for varying lengths of time before sampling.

The animals were restrained, dorsally recumbent, throughout the sampling procedure; blood was drawn and the animal released as quickly as possible. Blood was drawn from the anterior vena cava (Carle and Dewhirst 1942), using 18 gauge x 10cm hypodermic needles with a Vacutainer-Leur adaptor attached between the needles and the 10ml Vacutainers into which the blood was collected. Serum was obtained after the clot in the vacutainer tube had fully retracted. The serum was removed from the clotted tubes by centrifugation and frozen at $-4°$ Centigrade for later analyses.

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 value for the albumin/globulin ratio was calculated using the following formula (Archer 1965):

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.

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

Statistical analysis consisted of the least squares 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.

RESULTS AND DISCUSSION

For most sera values, there were no statistical differences between males and females (Tables 1 and 3). 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 Tables 2 and 4 which are statistically significant.

The serum electrolyte (chloride, potassium and sodium) values in Tables 1, 2, 3, and 4 agree with those given by Meier (1963) for domestic swine. There were differences between males and females of comparable location categories (Tables 1 and 3). However, some rather unremarkable differences between adults and subadults of comparable categories were apparent (Tables 2 and 4), but there was no general trend. Tumbleson et al. (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 (1958), 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.

Table 1. 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 2. 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 3. 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 4. Values for serum parameters of pen-reared European wild hogs by age.

Determination	Number of adult/subadult	Adult		Subadult	
		Mean	S.D.	Mean	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

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 1, 2, 3, and 4). Teeri et al. (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 at. (1965). The average BUN values which Tegeris et al. (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 controlled 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/100ml for glucose in swine. Tumbleson et al. (1969) report a higher value of 118. Free-roaming hogs in the present study had levels considerably higher than all of the above values (Table 5). 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 the "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 3 and 4) than free-roaming hogs (Tables 1 and 2). Among pen-reared animals the values were higher for females and adults. All were higher than the values of 6.9 g/100ml 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 1, 2, and 6). 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 high (Tables 3 and 4) relative to normal values reported for domestic swine and this, with the low albumin levels, provides albumin/globulin ratios for every category other than subadults (0.65, Table 4) which are lower (0.36, Table 4 and 0.43 and 0.39, Table 3) 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 1, and 0.92 and 0.88, Table 2) are higher than the above value for domestic swine. Vitamin deficiencies (Erwin et al. 1959), dietary protein depletions (Weimar et al. 1959) and other types of nutritional imbalances (Cartwright et al. 1948) have all been linked with changes in the concentrations of albumin and globulins.

The effect of sex is significant for only one parameter, sodium (Table 7). The above is in accord with those studies, previously cited, on domestic swine which revealed no sex differences for blood values. Also, this table reveals there is a significant effect of age 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.

Personal observations revealed that, among these captive wild hogs, the reaction to the stress of handling was far less pronounced that 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 A/G ratio is significantly affected by the interaction between location and age (Table 8). It is likely that the difference arises from the dissimilarity of age comparisons for the two locations. The fact that sodium was significantly affected by all variables is unexplainable.

Table 5. Values for serum parameters of 37 pen-reared and 33 free-roaming European wild hogs.

	Free-roaming		*Pen-reared*	
Determination	*Mean*	*S.D.*	*Mean*	*S.D.*
Chloride (mEq/1)	97.10	4.27	100.18	4.14
Potassium (mEq/1)	6.78	1.78	8.67	0.81
Sodium (mEq/1)	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 6. Normal serum biochemical values for domestic swine.

Determination	*Age and/or weight*	*Mean and/or range*	*Source*
Chloride		104	Tumbleson et al. 1969
(mEq/1)		103	Meier 1963
Potassium		4.7	Tumbleson et al. 1969
(mEq/1)		5.9	Meier 1963
Sodium		146	Tumbleson et al. 1969
(mEq/1)		149	Meier 1963
Glucose		118	Tumbleson et al. 1969
(mg %)		(65-95)	Eveleth & Eveleth 1935
		103	Tegeris et al. 1965
Blood urea		13	Tegeris et al. 1965
nitrogen		9	Tumbleson et al. 1969
(mg %)	3 mos. - adult	(17-20)	McClellan et al. 1965
Total serum		6.9	McClellan et al. 1965
protein		(6.78-7.61)	Miller et al. 1961
(gm/100 ml)			
Albumin (%)		33.9	McClellan et al. 1965
Alpha (%)		29.3	McClellan et al. 1965
Beta (%)		16.8	McClellan et al. 1965
Gamma (%)		20.0	Tumbleson et al. 1969
	6 mos.	6.8	Tumbleson et al. 1969
		48.6	Tumbleson et al. 1969
		19.4	Tumbleson et al. 1969
		12.6	Tumbleson et al. 1969
		19.3	Tumbleson et al. 1969
	12 mos.	7.5	Tumbleson et al. 1969
		52.7	Tumbleson et al. 1969
		18.2	Tumbleson et al. 1969
		12.6	Tumbleson et al. 1969
		16.4	Miller et al. 1961

Table 7. 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 loci and ages*	*Effect of age on comparable loci 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.

Table 8. The effects of sex-age and location of 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; Location 2 includes the pen-reared hogs.
* Denotes significance at the 95% confidence level of F distribution.

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. However, continued studies involving larger sample sizes and more controlled conditions may reveal a blood parameter or combination of parameters that might be useful for monitoring a wild population.

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