FACTORS AFFECTING HEMATOLOGICAL VALUES OF WHITE-TAILED DEER IN SOUTH TEXAS[a]

LYTLE H. BLANKENSHIP, Texas Agricultural Experiment Station, Uvalde, TX 78801
LARRY W. VARNER, Texas Agricultural Experiment Station, Uvalde, TX 78801

Abstract: Blood samples from white-tailed deer (*Odocoileus virginianus texanus*) were taken in three locations in south Texas to establish metabolic profiles and nutritional status and to determine the correlations of body condition, location, season, sex, age, reproductive status, stress and hemolysis with hematological values for this species. The parameters we measured included glucose, protein, albumin, globulin, A/G ratio, creatinine, cholesterol, phosphorus, calcium, magnesium, iron, copper, uric acid, urea (BUN), total lipids, free fatty acids, triglycerides, alkaline phosphatase, serum glutamic-oxalacetic transaminase, lactic dehydrogenase, serum glutamic-pyruvic transaminase, packed cell volume, hemoglobin, red blood cells and white blood cells. The means of these parameters were related to 17 factors which we felt might have some correlation with the values. Two of the most important factors affecting normal blood values were hemolysis and stress. Many of the blood parameters for struggling and especially drugged animals were highly significant ($P < 0.01$). Certain parameters as cholesterol, free fatty acids and BUN show promise as predictive measures for deer body and range habitat condition.

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Both physical and chemical values of blood have been used to assess condition in various species of ruminants, more so in domestic than wild animals. Work with the latter has included mule (*Odocoileus hemionus*) and white-tailed deer, both penned and free-ranging individuals. Some of the mule deer studies in which blood values were influenced by body condition included those by Rosen and Bischoff (1952), Browman and Sears (1955), Kitts et al. (1956), Bandy et al. (1957), Rohwer et al. (1970), Lesperance et al. 1972, 1973), and Hunter et al. (1973).

In white-tailed deer studies, Wilber and Robinson (1958) could not attribute any variation of blood composition to size or age. Any differences noted seemed more related to shock or the physiological state of the animal prior to collection of blood samples. However, in Michigan, Johnson et al. (1968) found age differences in several blood characteristics of penned deer. Tumbleson et al. (1968) also found age a factor affecting biochemical composition of blood in white-tails. Teeri et al. (1958) indicated a correlation between blood values and malnutrition. Nutritional effects on blood characteristics of white-tailed deer were noted also by Seal et al. (1972b).

Many studies have reported normal blood physical and chemical values for the deer. Where variability was evident attempts were made to relate the values to some factor. The data we present are primarily to establish norms for a population of deer in the Rio Grande Plain of Texas and to emphasize some of those factors which might be correlated with hematological values.

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MATERIALS AND METHODS

Blood analyzed in this study was from 135 free-ranging white-tailed deer collected in connection with a broader nutritional investigation. Some came from hunter-killed deer and some from drug-immobilized animals.

The deer came from 3 localities: (1) Chaparrosa Ranch, Zavala County, (2) Chaparral Wildlife Management Area, Dimmit and La Salle Counties, (3) Rio Grande Plain Experimental Ranch, Maverick County. Chaparrosa Ranch includes approximately 27,530 ha and has a variety of range sites and vegetative types as do the other 2 areas although both are considerably smaller (bout 6,075 ha and 4,050 ha, respectively).

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The period of collection included every season between April 1974 and January 1976. Moisture conditions varied between extremely dry to excessively wet.

Deer collected for the study were shot usually in the neck or head with a rifle. This prevented damage to internal organs and allowed a better blood flow since the heart continued to pump for several minutes. Blood samples were taken also from 12 deer drugged with rompun (oxylazine hydrochloride). Blood was drawn from the jugular vein with vacutainers (Becton-Dickinson). The vein was located and then entered with a 20-gauge needle before inserting the vacutainer. Normally, four 20 ml plain vacutainers were filled for sera samples, one 7 ml vacutainer with EDTA (K_3) for hematology, one 7 ml with sodium heparin for hematology, and one 7 ml with potassium oxalate for analysis of blood glucose. Two blood smears were made at the collection site. Smears were either air-dried and stored or placed in a jar of 70 percent methanol.

The blood samples for sera were refrigerated until the sera could be decanted or centrifuged. Following separation the sera were frozen until analyzed.

Blood samples for hematology and specific chemical analysis were refrigerated until convenient for processing, preferably within 48 hours. At that time, plasma was extracted from the potassium oxalate vial and frozen for future use. Hematology data including RBC (red blood cell counts), WBC (white blood cell counts), differential cell counts, PCV (packed cell volume) and Hb (hemoglobin) were obtained using EDTA treated blood samples unless hemolyzed and then heparinized samples were used. Excess EDTA and heparin blood samples were centrifuged for plasma which was then frozen.

Blood chemistry analyses included glucose, total protein, albumin, creatinine cholesterol, inorganic phosphorus, direct calcium, direct uric acid, BUN (blood urea nitrogen), alkaline phosphatase, triglycerides, total lipids, SGOT (serum glutamic-oxalacetic transaminase), LDH-L (lactic dehydrogenase), SGPT (serum glutamic-pyruvic transaminase), iron, copper and magnesium.

Most of these analyses were run on a unit arranged by Data Medical Associated (DMA) consisting of a Bausch & Lomb Spectronic 70 base and three instruments manufactured by Medi Conics International (a Chemputer 3, Chemprinter 3 and Chemtimer 3). Reagents were obtained primarily from DMA. Iron and copper were analyzed by the procedure of Yee and Goodwin (1974) and magnesium was determined using reagents manufactured by Pierce Chemical Co.

All data were punched on IBM cards and computer programs developed to provide correlation coefficients, analysis of variance, regression coefficients, means, standard deviations and statistics of fit.

RESULTS

Data on 25 blood chemical and physical parameters were collected and related to 17 factors which might affect these values. Eleven of the factors were body condition characteristics. The remaining 6 were location of kill, age class, month, reproductive status, stress factor and blood condition. Means of the various parameters are shown in Table 1. The overall mean for 111 deer was calculated for each blood parameter but many of the blood samples were hemolyzed to some degree. Hemolysis is known to affect certain blood parameters (Richterich 1969). We noted 4 stages relative to hemolysis: non-hemolyzed, slight, moderate and high. The non-hemolyzed blood samples (73) were used to calculate means for representing normal values. Some of these values could vary from normal because of unknown variables but they should suffice for comparative purposes to illustrate how hematological values may be correlated with different factors.

The mean values of SGOT and LDH were significantly higher than normal ($P < 0.01$) for all degrees of hemolysis as determined by a Chi-square analysis while the mean of the third enzyme SGPT was greater ($P < 0.01$) only at high hemolysis (Table 2). The means of total lipids and triglycerides were significantly lower ($P < 0.10$) and higher ($P < 0.05$) respectively at slight hemolysis, but both were higher ($P < 0.01$) at greater degrees of hemolysis. Free fatty acids mean was higher ($P < 0.01$) only at a level of moderate hemolysis while iron values, though higher at all stages, were significant ($P < 0.01$) at slight and high hemolysis. Serum glucose for some unexplainable reason was significantly lower than normal ($P < 0.05$) at slight hemolysis but not at greater levels of hemolysis. PCV values were generally increased but significant ($P < 0.05$) only at high hemolysis. All other blood parameters showing a highly significant variation ($P < 0.01$) did so only at the greatest hemolysis (protein, globulin, cholesterol, Ca, uric acid, urea, alkaline phosphatase, RBC, Mg, Cu).

Table 1. Means of various blood parameters for a total of 111 white-tailed deer examined and for 73 non-hemolyzed blood samples.

		Total deer examined (111)		*Non-hemolyzed blood (73)*
	Unit	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$
Glucose	mg/dl	125.52	7.02	132.33
Albumin	g/dl	2.75	0.09	2.70
Protein	g/dl	5.86	0.20	5.72
Globulin	g/dl	3.12	0.16	3.04
A/G ratio		1.12	0.10	1.07
Creatinine	mg/dl	1.60	0.11	1.47
Cholesterol	mg/dl	67.86	1.95	64.58
Phosphorus	mg/dl	8.98	0.37	8.25
Calcium	mg/dl	9.24	0.37	8.96
Uric acid	mg/dl	6.47	0.37	5.15
Urea	mg/dl	22.32	0.98	22.22
Alk. phosphatase	1U/L	27.47	2.54	24.58
Total lipids	mg/dl	317.23	15.14	313.44
SGOT	1U/L	234.35	21.91	177.36
LDH	mU/ml	255.71	19.20	215.07
SGPT	m_{μ}/ml	24.41	1.50	24.96
PCV	%	43.80	0.95	42.96
Hemoglobin	g/dl	14.42	0.31	14.39
RBC	$10^6/mm^3$	17.57	1.25	15.65
WBC	$10^3/mm^3$	3.79	0.23	4.08
Magnesium	mg/dl	24.80	0.92	25.05
Copper	mcg/dl	69.12	2.49	67.51
Iron	mcg/dl	208.15	10.92	191.38
Free fatty acids	mg/dl	12.75	0.80	11.24
Triglycerides	mg/dl	53.25	4.14	46.30

Uric acid values were high, especially considering that this substance usually occurs in small quantities in mammals (Dukes 1955). The high values probably resulted from nonspecific blood constituents analyzed as uric acid by the phosphotungstate method used.

Location had no significant effect on most of the blood parameters. Of 75 possible means only 9 were significantly different from normal ($P < 0.01$ to < 0.10). The means of SGOT and LDH were significantly higher than normal on Chaparrosa ($P < 0.01$) and the Rio Grande Plain Experimental Ranch. The SGPT mean was significantly higher ($P < 0.05$) on the Experimental Ranch. For the Chaparral area means of alkaline phosphatase ($P < 0.10$), copper ($P < 0.10$), total lipids ($P < 0.05$), and iron ($P < 0.05$) were significantly higher than the expected mean.

Certain of the mean blood values were significantly different from each other among locations according to Duncan's Multiple Range Test. Cholesterol values from the three locations were all different ($P < 0.05$) from each other. Phosphorus, uric acid and SGPT mean serum values were not different between the Chaparrosa and Chaparral areas but were significantly different ($P < 0.05$) from those obtained on the Rio Grande Plain Experimental Ranch. The mean blood values of urea and RBC counts were significantly different ($P < 0.05$) between Chaparrosa and the Experimental Ranch but not between Chaparrosa and Chaparral or the latter and the Experimentl Ranch. For LDH and copper mean serum values the significant ($P < 0.05$) difference occurred between Chaparral and the other 2 locations but not between Chaparrosa and the Experimental Ranch. Serum protein differences approached significance ($P < 0.05$) between Chaparrosa and the Experimental Ranch.

Most of the significant variations in mean blood parameters related to age classes occurred after 8 years of age. Fourteen of 50 means were significantly different from the expected for this age class. Glucose, SGOT, LDH and iron values were greater ($P < 0.01$) as were cholesterol ($P < 0.01$), magnesium ($P < 0.05$) and creatinine ($P < 0.10$). Significantly smaller mean values occurred for total lipids ($P < 0.01$), triglycerides ($P < 0.01$) and alkaline phosphatase and SGPT ($P < 0.05$).

Table 2. Relationship of blood condition to mean values of various blood parameters.

	Degree of hemolysis			
Blood parameter	*Non-hemolyzed*	*Slight*	*Moderate*	*High*
Glucose	132.33	106.39[b]	128.78	135.00
Protein	5.72	5.73	6.08	17.70[c]
Globulin	3.04	2.95	3.24	12.86[c]
Cholesterol	64.58	73.07	74.67	101.00[c]
Calcium	8.96	9.75	8.84	19.40[c]
Uric acid	5.15	8.39	9.10	25.60[c]
Urea	22.22	22.39	21.11	39.00[c]
Alkaline phosphatase	24.58	31.93	32.00	73.00[c]
Total lipids	313.44	284.04[a]	443.00[c]	392.00[c]
SGOT	177.36	294.50[c]	474.00[c]	554.00[c]
LDH	215.07	270.24[c]	523.39[c]	406.00[c]
SGPT	24.96	20.16	28.73	64.10[b]
PCV	42.96	45.29	44.33	59.00[b]
RBC	15.65	20.67	21.24	38.31[c]
Magnesium	25.05	23.63	24.20	45.20[c]
Copper	67.51	71.07	68.22	140.00[c]
Iron	191.38	244.93[c]	205.11	430.00[c]
Free fatty acids	11.24	13.52	22.42[c]	14.90
Triglycerides	46.30	63.07[b]	71.78[c]	119.00[c]

[a]–$P < 0.10$
[b]–$P < 0.05$
[c]–$P < 0.01$

Insufficient sample size prevented a thorough analysis of blood parameters on a monthly basis. The largest number of significant variations of mean values from the expected occurred in those months with 5 or less samples. Generally, glucose, total lipids, SGOT, LDH, iron and triglycerides showed the greatest number of significant variations among months.

We examined reproductive status on basis of the following categories: pregnant female—1 fetus, pregnant female—2 fetuses, open female, open female—lactating, and male. An analysis by these categories did not reveal any clear-cut differences. In almost every one the mean values of total lipids, SGOT and LDH were significantly different ($P < 0.05$ to < 0.01), either higher or lower, from the expected values. When the mean values of all female categories were averaged and compared to values for males, serum glucose, LDH and iron were significantly higher ($P < 0.01$) in males. Also higher ($P < 0.10$) were values for alkaline phosphatase and copper. Significantly lower mean values for blood parameters of males included SGOT ($P < 0.01$), total lipids and SGPT ($P < 0.05$) and triglycerides ($P < 0.10$). Mean values which were greater for male than female blood parameters but not significant ($P < 0.05$) included albumin, protein, creatinine, urea, WBC and fatty acids. Lower values were cholesterol, phosphorus, uric acid and RBC. All other values were similar.

The stress factor (Table 3) affecting mean blood values the most in our study was rompun. Blood taken from 12 drugged deer showed a significant elevation in mean serum values of glucose ($P < 0.01$), urea ($P < 0.05$), alkaline phosphatase ($P < 0.05$), SGOT ($P < 0.01$), LDH ($P < 0.01$), copper ($P < 0.10$), iron ($P < 0.01$) and fatty acids ($P < 0.10$) with a significant decrease in serum values of total lipids ($P < 0.05$), SGPT ($P < 0.01$) and triglycerides ($P < 0.10$).

Blood taken from animals which struggled considerably before dying had mean serum values for glucose ($P < 0.01$), cholesterol ($P < 0.05$), SGOT ($P < 0.01$), and LDH ($P < 0.01$) significantly lower than expected. Mean serum values for iron and triglycerides were significantly greater ($P < 0.01$).

Table 3. Relationship of stress factors to mean values of various blood parameters. Normals in Table 1.

Parameter	*Neck shot (Downed)*	*Body shot*	*Struggling animal*	*Drugged*
Glucose	114.78	115.94	95.67[c]	217.42[c]
Cholesterol	70.41	58.81	46.00[b]	68.42
Urea	20.81	20.94	21.33	34.50[b]
Alkaline phosphatase	26.45	26.88	25.00	35.67[b]
Total lipids	332.06	283.19[a]	285.33	271.75[b]
SGOT	217.35[c]	323.13[c]	125.67[c]	256.50[c]
LDH	225.84	303.18[c]	120.87[c]	425.24[c]
SGPT	27.35	22.56	20.90	8.12[c]
Copper	69.15	60.63	60.67	82.33[a]
Iron	190.34	185.25	236.67[c]	350.33[c]
Free fatty acids	11.84	14.07	10.20	17.76[a]
Triglycerides	51.48	69.00[c]	95.33[c]	33.58[c]

[a]—$P < 0.10$
[b]—$P < 0.05$
[c]—$P < 0.01$

Deer with body shots compared to neck or head shots had elevated mean serum values for triglycerides, SGOT and LDH, significant at $P < 0.01$. The mean value for total lipids was lowered significantly ($P < 0.10$).

Of the 11 body condition characteristics measured only 6 are discussed. These 6 were more highly correlated with more blood parameters than the remaining ones (Table 4). The percentage fat in femur bone marrow and external body condition primarily were negatively correlated with the blood parameters. SGPT was the only parameter positively correlated with these 2 body condition indices. Almost all other blood parameters were positively correlated at high probabilities with body condition indices except LDH. This enzyme was negatively correlated with three indices ($P < 0.05$), i.e., kidney fat, fat at base of tail and kidney-fat index.

DISCUSSION

Browman and Sears (1955) believed that the physiological condition of mule deer is revealed considerably by the blood picture. Considering the results we have obtained and some of the variances such as hemolysis which can be corrected we feel the same about blood parameters of white-tailed deer. These parameters can be useful means for evaluating the health or condition of deer. When used in combination with plant nutritional data we feel blood values can be extremely important in recognizing changes in range conditions. Ultimately, it is our desire to be able to determine not only animal condition but changes in range condition by measuring certain blood parameters from animals in the area.

Blood values may vary depending on age, sex, location or a variety of other factors; however, there are two variables which are the greatest sources of variation and can mask true or expected values. These variables, which must be eliminated or reduced as much as possible, are hemolysis and stress conditions.

Hemolyzed blood affected the mean value of many of the blood parameters in our study. Almost all values were affected by the greatest degree of hemolysis we recorded, i.e., "high" or apparent complete breakdown of most red blood cell structures. At least 5 parameters (total lipids, SGOT, LDH, Fe and triglycerides) were affected significantly ($P < 0.10$) by slight hemolysis. Values of SGOT, LDH and Fe were significantly higher ($P < 0.01$) at this level of hemolysis.

White and Cook (1974) felt that hemolysis could affect the values of such electrolytes as sodium and potassium. We found, however, that the mean value of calcium was not affected except at our greatest degree of hemolysis. To remove any possible effects of hemolysis all hemolyzed samples probably should be discarded or at least not used for

Table 4. The correlation of various body condition indices to certain blood parameters of white-tailed deer.

	% Fat in femur bone marrow			Carcass weight			Body condition[a]		
	R	*Prob.*	*N*	*R*	*Prob.*	*N*	*R*	*Prob.*	*N*
Cholesterol	−0.306	0.033	92	0.174	0.076	102	−0.376	0.0003	102
Phosphorus	−0.393	0.0003	92				−0.261	0.008	102
Uric acid	−0.443	0.0001	92	0.226	0.021	102	−0.349	0.0006	102
LDH									
SGPT	0.272	0.009	92	−0.255	0.010	102	0.221	0.024	102
PCV	−0.221	0.032	92				−0.348	0.0006	102
Copper	−0.272	0.009	90	0.187	0.059	100	−0.265	0.008	100
Iron	−0.232	0.026	90	0.281	0.005	100			
Free fatty acids	−0.285	0.006	91	0.219	0.026	101	−0.314	0.002	101
	Kidney fat			*Fat-base of tail*			*Kidney-fat index*		
	R	*Prob.*	*N*	*R*	*Prob.*	*N*	*R*	*Prob.*	*N*
Cholesterol	0.265	0.006	105	0.352	0.0005	102	0.204	0.035	105
Phosphorus	0.199	0.040	105	0.225	0.022	102	0.241	0.013	105
Uric acid	0.155	0.109	105				0.267	0.006	105
LDH	−0.197	0.042	105	−0.209	0.033	102	−0.199	0.040	105
SGPT									
PCV				0.190	0.053	102	0.160	0.099	105
Copper							0.178	0.069	103
Iron	0.219	0.025	103	0.188	0.058	100	0.206	0.034	103
Free fatty acids	0.257	0.008	104	0.263	0.008	101	0.288	0.003	104

[a]External body conditions: 1—Excellent, 2—Good, 3—Fair, 4—Poor.

most chemical analyses. For correlative purposes we have retained the 10 samples of greatest hemolysis. In most cases deleting these samples did not change the overall mean significantly (Table 1). As we refine and collect more data, hemolyzed samples will be deleted except where hemolysis is the main correlation being studied.

Stress conditions can affect blood values significantly. To study the effect of stress we divided our blood samples into 4 categories: neck-shot deer, body-shot deer, struggling animal, drugged animal (Table 3). Usually our best non-hemolyzed samples came from neck-shot deer although occasionally good blood serum was obtained from body-shot animals.

Blood from any animal which struggled intensively or ran any distance before succumbing was frequently hemolyzed. Also many of the blood parameter values of these deer were significantly different ($P < 0.05$ to < 0.01) from the expected. White and Cook (1974) emphasized that blood samples obtained from shot deer, particularly individuals that did not die instantly, might show deviations from normal values just as samples from animals restrained or excessively handled would (Seal et al. 1972a). Relatively high values for certain blood constituents are explainable by the physiological state of deer immediately before blood samples are taken (Wilber and Robinson 1958).

The mean value of glucose, which is supposed to be affected by excitement, was lowered significantly ($P < .01$) in blood samples we took from struggling deer. However, high glucose values have been reported for blood from deer severely stressed prior to shooting (Seal and Erickson 1969). Cholesterol, which according to Coblentz (1975) is definitely influenced by excitability, was also lowered ($P < 0.05$) in these same samples. With the other parameters already mentioned being significantly different from the expected, mean values of blood from struggling or resisting animals should be used with caution.

Although Seal et al. (1972a) and White and Cook (1974) indicated that immobilization of deer with drugs can result in hemodilution or expansion of plasma volume, we cannot confirm this for drugs in general. Phenocyclidine and promazine affected blood parameters in serum from deer in northern Michigan (Seal et al. 1972a), and we found a considerable effect from the use of the tranquilizer, rompun. Our results showed this drug significantly affected 11 of 25 blood parameters. Several of the blood parameters (e.g. protein, albumin, creatinine) although not significantly different tended to be elevated. None of the physical properties were significantly different, contrary to the findings of Seal et al. (1972a) who found statistically significant decreases in hemoglobin, red blood cells and PCV. Extreme caution should be used in interpreting any blood data acquired from drugged animals.

Our data thus far seem to indicate that the best deer blood sample comes from an unsuspecting animal that drops immediately from a shot in the neck wihout any subsequent struggle. This may not always hold true since some physiological alterations may occur due to fatal trauma or shock.

The effects of location on deer blood values were not as evident as anticipated possibly because the 3 areas considered were probably not greatly different in terms of food quantity and quality. However, this aspect is being studied in more detail within and between areas since one of our major objectives is to detect such differences if they do exist. As suggested by Seal et al. (1972b), such studies must be controlled in such a way that we can quantify the role of nutrition as influenced by animal and range condition. White and Cook (1974) reported that most data are not sufficient to detect small changes in health and condition and other possible variation. Data need to be more refined and in greater quantity to detect these subtle differences. We are working on both aspects. We have noticed some mean blood value differences between areas with such parameters as cholesterol, phosphorus, BUN, LDH, SGPT, and copper. Coblentz (1975) reported that serum cholesterol in deer may reflect dietary status. Based upon the highly significant correlations of serum cholesterol and body condition measurements observed in our study, we would support this hypothesis. We have found also that digestible energy may be a limiting factor for deer in south Texas, particularly in summer and fall (Varner et al. 1977). Therefore, the differences between locations in serum cholesterol may be a reflection of energy content of forages from the various areas.

In some areas, BUN levels may be a reflection of protein intake in deer (Seal et al. 1972b and Kirkpatrick et al. 1975). This may be the case in our study, but we have found in normal years that protein is not a limiting nutrient in south Texas forages, at least on the Chaparral Wildlife Management Area (Varner et al. 1977). Although BUN levels varied between locations, differences were not significant ($P < 0.05$). The apparent differences could be a result of diurnal variation in BUN (Laird 1972) or the forage from the 3 areas may actually differ in protein content.

With improved quality and quantity of blood and a closer correlation to plant nutrition information currently being collected, we anticipate identifying the critical parameters in the near future.

Several workers have documented variations in several blood parameters of deer due to age (Kitts et al. 1956, Bandy et al. 1957, Johnson et al. 1968, Tumbleson et al. 1968, Anderson et al. 1972, White and Cook 1974, and others). Most of these studies compared animals of 1 year or less to older animals. Our most evident changes occurred after 8 years of age but we had only a few fawns in our sample.

Glucose levels, which were significantly higher ($P < 0.05$) in young animals as anticipated (Johnson et al. 1968), dropped considerably with age but increased momentarily with 8-year olds before dropping again. Some other factor may have masked the expected stabilization with maturation.

Alkaline phosphatase was considerably higher ($P < 0.01$) in the earliest age class than in all others, and the decline was continual with age except again for the 8-year olds. Tumbleson et al. (1968) too found this negative correlation. Growing animals evidently require more in bone development, and deer should be no different than other ruminants.

As animals mature, fatty substances become more of a part of physiological processes. This was evidenced in the deer blood parameters by significant increases in total lipids, free fatty acids and triglycerides up to the 8-year old group. Older deer frequently have smaller quantities of fat deposits.

Some variation in certain deer blood parameters should be expected with changes in reproductive status as well as between sexes. As pregnant does near parturition and especially commence lactation a greater stress is placed upon them. Unless these animals compensate with an increased intake of certain nutrients, changes must occur in body and blood composition. Such changes have not been very well-documented in literature. Sikes et al. (1969) did show a decrease in serum protein in captive white-tailed deer during summer months (lactation). Implications elsewhere are that decreases in serum protein may be due to lactation and pregnancy.

The significant decrease ($P < 0.01$) in the mean value of glucose in does pregnant with twin fetuses, but not with one, could indicate a stressed condition in which more glucose was being utilized for fetal development. Total lipids were lower in pregnant females than in open or lactating females. This phenomenon should not occur with lactating females unless in the mobilization of fat deposits for synthesis into milk fat it is reflected in higher lipid levels in the blood serum.

Certain body condition indices, all related directly or indirectly to the degree of fat present, were significantly correlated with several of the blood parameters. It would be desirable to be able to select a few seemingly critical blood parameters to use in screening live animals for evidence of general condition as well as some specific condition as a liver disease. For the latter we have noted an elevation in alkaline phosphatase and LDH.

At this phase of our study we hesitate to select specific parameters as screening or predictive factors for deer body condition but certainly cholesterol and free fatty acids are two worth considering. Seal et al. (1972b) showed some indication of the possible use of cholesterol in detecting seasonal and diet differences and also suggested that BUN might serve as an index for the recent nutritional status of the pregnant white-tailed deer. In a study by Kirkpatrick et al (1975) conclusions based on work of others as well as their own, show that BUN may be an indicator of nutritional status in deer as well as useful in evaluating range conditions. Thus far we cannot be that conclusive concerning BUN. Other parameters in Table 4 as well as some not included show promise and will be investigated more thoroughly in subsequent studies.

LITERATURE CITED

Anderson, A. E., D. E. Medin, and D. C. Bowden. 1972. Total serum protein in a population of mule deer. J. Mammal. 53(2):384-387.

Bandy, P. J., W. D. Kitts, A. J. Wood, and I. McT. Cowan. 1957. The effect of age and the plane of nutrition on the blood chemistry of the Columbian black-tailed deer (*Odocoileus hemionus columbianus*) B. blood glucose, non-protein nitrogen, total plasma protein, plasma albumin, globulin, and fibrinogen. Can. J. Zool. 35:283-289.

Browman, L. G., and H. S. Sears. 1955. Erythrocyte values, and alimentary canal pH values in the mule deer. J. Mammal. 36(3):474-476.

Coblentz, B. D. 1975. Serum cholesterol level changes in George Reserve deer. J. Wildl. Manage. 39(2):342-345.

Dukes, H. H. 1955. The Physiology of Domestic Animals. Comstock Publishing Assoc. Ithaca. 1,020 pp.

Hunter, V. E., A. L. Lesperance, and N. J. Papez. 1973. Total plasma protein, lipid and related compound levels in Nevada mule deer. Proc. West. Sec. Amer. Soc. Animal Sci. 24:213-216.

Johnson, H. E., W. G. Youatt, L. D. Fay, H. D. Harte, and D. E. Ullrey. 1968. Hematological values of Michigan white-tailed deer. J. Mammal. 49(4):749-754.

Kirkpatrick, R. L., D. E. Buckland, W. A. Abler, P. F. Scanlon, J. B. Whelan, and H. C. Burkhart. 1975. Energy and protein influences on blood urea nitrogen of white-tailed deer fawns. J. Wildl. Manage. 39(4):692-698.

Kitts, W. D., P. J. Bandy, A. J. Wood, and I. McT. Cowan. 1956. Effect of age and plane of nutrition on the blood chemistry of the Columbian black-tailed deer (*Odocoileus hemionus columbianus*). A. packed-cell volume, sedimentation rate, and hemoglobin. Can. J. Zool. 34:477-484.

Laird, C. W. 1972. Representative values for animal and veterinary populations and their clinical significances. Hycel, Inc. Houston. 34 pp.

Lesperance, A. L., G. L. Rohwer, and N. J. Papez. 1972. Lipid and related plasma levels of northeastern Nevada mule deer. Proc. West. Sec. Amer. Soc. Animal Sci. 23:180.

----------, V. E. Hunter, G. L. Rohwer, and N. J. Papez. 1973. Relationship of weight and plasma mineral indexes of mature female deer. Proc. W. Sec., Amer. Soc. Animal Sci. 24:209-212.

Richterich, R. 1969. Clinical Chemistry. Theory and Practice. S. Karger, Basel (Switzerland) Academic Press. 542 pp.

Rohwer, G. L., A. L. Lesperance, and N. J. Papez. 1970. Blood protein indexes of northeastern Nevada mule deer. Proc. West. Sec. Amer. Soc. Animal Sci. 21:315.

Rosen, M. N., and A. I. Bischoff. 1952. The relation of hematology to condition in California deer. Trans. N. Amer. Wildl. Conf. 17:482-495.

Seal, U. S., and A. W. Erickson. 1969. Hematology, blood chemistry and protein polymorphisms in the white-tailed deer (*Odocoileus virginianus*). Comp. Biochem. and Physiol. 30(4):695-713.

----------, J. J. Ozoga, A. W. Erickson, and L. J. Verme. 1972a. Effects of immobilization on blood analysis of white-tailed deer. J. Wildl. Manage. 36(4)1034-1040.

----------, L. J. Verme, J. J. Ozoga, and A. W. Erickson. 1972b. Nutritional effects on thyroid activity and blood of white-tailed deer. J. Wildl. Manage. 36(4):1041-1052.

Sikes, D., F. A. Hayes, and A. K. Prestwood. 1969. Electrophoretic distribution of serum proteins of normal and of arthritic white-tailed deer. Amer. J. Vet. Res. 30:143-148.

Terri, A. E., W. Virchow, N. F. Colovos, and F. Greeley. 1958. Blood composition of white-tailed deer. J. Mammal. 39(2):269-274.

Tumbleson, M. E., M. G. Wood, A. R. Dommert, D. A. Murphy, and L. J. Korschgen. 1968. Biochemic studies on serum from white-tailed deer in Missouri. Am. J. Vet. Clin. Path. 2:121-125.

Varner, L. W., L. H. Blankenship, and G. W. Lynch. 1977. Seasonal changes in nutritive value of deer food plants in south Texas. (In Press).

White, Marshall, and R. S. Cook. 1974. Blood characteristics of free-ranging white-tailed deer in southern Texas. J. Wildl. Dis. 10(1):18-24.

Wilbur, C. G., and P. F. Robinson. 1958. Aspects of blood chemistry in the white-tailed deer. J. Mammal. 39(2):309-310.

Yee, H. Y., and J. F. Goodwin. 1974. Simultaneous determination of copper and iron in a single aliquot of serum. Clin. Chem. 20(2):188-191.