Clinical Blood Profiles of Stressed White-tailed Deer: Drop-net versus Harvest

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Abstract: We collected whole blood and serum samples from 50 harvested (unstressed) and 37 live-caught (handling stress in drop-net) adult white-tailed (*Odocoileus virginianus*) does to evaluate the influence of capture method on clinical blood parameters commonly used to assess nutritional condition of deer. Our study found mean values for HCT, MCV, WBC, lymphocytes, neutrophils, creatinine, cholesterol, total protein, albumin, globulin, Na, LDH, and GGTP to be significantly higher in live-caught than harvested does. The concentrations of serum inorganic P and K were lower for live-caught than harvested does. Although the majority of clinical blood parameters were influenced by capture method, their patterns of temporal change (seasonal and annual) were not different, thereby indicating that either method would provide similar conclusions regarding changes in nutritional condition over time. Only serum concentrations of total bilirubin, ALT, BUN and the BUN/creatinine ratio exhibited different temporal changes between capture method. Absolute comparisons of clinical blood profile values derived from samples obtained from drop-net captured deer cannot be compared to those of harvested deer.

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Hematological and serum biochemical profiles have become an increasingly important tool for monitoring white-tailed deer nutrition and health. However, a number of these physiological parameters can be altered by stress from excitement during capture or collection of blood (Blankenship and Varner 1977, Seal and Hoskinson 1978, Wesson et al. 1979*a*, Rehbinder and Edquist 1981, Chapple et al.

1991). Collectively, these studies have strongly recommended that stress-induced alterations in physiology be controlled as much as possible. This has generally been accomplished for free-ranging deer by harvesting with a single rifle-shot to the head/neck region, which is thought to provide actual "normal" physiological values in the unstressed individual, given the animal is unsuspecting and dies immediately (Blankenship and Varner 1977).

Although harvesting may be most reflective of the "normal" physiological state in deer, not all situations are conducive to this collection method. Often, researchers may be interested in monitoring temporal changes in physiological condition of specific individuals over time. Similarly, public safety concerns in urban environments or public opposition to shooting within parks often necessitates the consideration of alternate blood collection methods for clinical analyses.

While a plethora of studies have clearly demonstrated that handling stress and related excitement can alter many physiological parameters, information comparing responses of various clinical indices of nutritional condition between live-caught and harvested free-ranging white-tailed deer are nonexistent. Additionally, examination of how physiological alterations associated with collection method affect clinical interpretations are lacking. The objective of our study was to compare clinical blood profiles of free-ranging deer as influenced by live-capturing with drop-nets and harvesting. Of special concern was assessing if both capture methods provided similar interpretations regarding seasonal and annual changes in nutritional condition of the population. To be clinically useful in nutritional assessment, we hypothesized that stressed deer caught by drop-nets would show temporal trends in clinical blood parameters identical to those of harvested deer (unstressed).

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Methods

Study Area

Deer were collected from Seqouyah State Park in Cherokee County, Oklahoma. The park is a 1,140-ha peninsula that is bound by Fort Gibson Reservoir and is predominantly an oak (*Quercus* spp.) -hickory (*Carya* spp.) forest. The park serves as a recreational retreat, and deer have become accustomed to human activity. The geographical characteristics of the park coupled with the prohibition of hunting have resulted in an overpopulated deer herd. April drive censuses estimated the population in the park at 72 deer/100 ha in 1990, which declined to 39 and 41 in 1991 and 1992, respectively. Prominent browse lines and severely hedged winged elm (*Ulmus alata*) and eastern red cedar (*Juniperus virginiana*) throughout the park suggest deer have been experiencing suboptimal nutrition.

Animal and Blood Collection

Deer were collected during March and September, beginning in September 1989 and ending in March 1992. Harvesting consisted of locating adult does at night from the back of a pickup truck with the aid of spotlights. Deer were shot in the head or neck with a high-powered rifle. Blood was collected via heart puncture within 10 minutes after collapse. Live trapping was accomplished using drop-nets (Ramsey 1968) set over areas prebaited with corn. Prebaiting was limited to a few days (<5) to minimize influence on physiological parameters. Drop-nets were monitored during the early morning and late evening hours.

Blood samples were collected via jugular venipuncture from drop-net deer within 5–45 minutes following capture. Blood samples from each deer consisted of a 3-ml evacuated EDTA-K tube (Monojet; Sherwood Medical, St. Louis, MO 63103) for hematology and a 10-ml evacuated serum-separating tube (SST; Becton Dickinson Vacutainer Systems, Rutheford, NJ 07070) for serum chemistry using 18- or 20-gauge needles.

Blood Analysis

Whole blood samples for hematological analysis were refrigerated (4° C) until convenient for processing, within 24 hours. Serum samples were kept on ice until they could be centrifuged, within 6 hours after collection. Serum samples were centrifuged at 3,000 rpm for 10 minutes and stored in aliquotes at -80° C.

All hematological analyses were done manually with the exception of the March 1992 harvest collection when counts of erythrocytes (RBC), leucocytes (WBC), and hematocrits (HCT) were measured on a Serono System 9000 Automated Cell Counter (Serono-Abaker Diagnostics, Allentown, PA 18103), which had been calibrated using manual counts. Manual counts of RBC and WBC were completed using a Reichert Bright-line hemocytometer. Hematrocrit was determined by the microcapillary tube method (Ravel 1989) using centrifugation for 5 minutes in an International micro-capillary centrifuge. Differential WBC counts were determined by identifying 100 cells from an air-dried blood smear stained with Diff-Quick stain (American Scientific Products, McGaw Park, IL 60085).

Serum samples collected from September 1989 to September 1990 were submitted to SmithKline Beecham Laboratory (Dallas, TX 75247) where they were analyzed on an Olympus AU5000 (Olympus Clinical Instrument Div., New York City, NY 11042). Samples collected from March 1991 through March 1992 were submitted to The Family Medical Laboratory (Enid, OK 73701) where they were analyzed on an Abbott EPX (Abbott Laboratories, Abbott Park, IL 60064).

Data Analysis

Only adult does (≥1.5 years of age) were used for statistical analysis to minimize variability in clinical blood parameters due to gender and age. Blood samples graded higher than slightly hemolytic or lipemic and harvested animals that were known to have struggled excessively before death were omitted. Remaining data were subjected to Levene's Test (Snedecor and Cochran 1980) for homogeneity of

variances; heterogeneous variables were corrected by transformation prior to further analysis. Differences in clinical blood parameters attributable to method of capture were examined by 2-way analysis of variance for unequal sample sizes with method and collection period (month/year) as main factor effects. The interactive effect of method and collection period was specifically used to determine if the 2 capture methods showed similar temporal trends with regard to herd condition. All data analyses were completed using the Statistical Analysis System (SAS; SAS Inst. Inc. 1982).

Results

Hematology

We collected 86 whole blood samples from 49 harvested and 37 live-caught does (Table 1). Of the 3 erythrocyte parameters measured, RBC count was the only parameter not influenced ($P > 0.05$) by method of collection. Mean values of HCT ($P = 0.0014$) and mean corpuscular volume (MCV; $P = 0.0003$) were greater for live-caught than harvested deer. Counts of WBC ($P = 0.0001$) also were increased in live-caught deer due to increases in the number of circulating lymphocytes ($P = 0.0001$) and neutrophils ($P = 0.0252$) compared to harvested does. The number of eosinophils, basophils, and monocytes were unaffected ($P > 0.05$) by method of capture. No hematological parameters were shown to be significant ($P > 0.05$) with regard to a method-collection period interaction.

Serum Biochemistries

Of the 19 serum constituents measured, only glucose, chloride (Cl), calcium (Ca), alkaline phosphates (AP), aspartate aminotransferase (AST), creatinine phosphokinase (CPK), and the ratio of albumin/globulin were not significantly ($P >0.05$) affected by collection method (Table 2). Of the constituents that were altered by method of capture, inorganic P ($P = 0.0001$) and K ($P = 0.0001$) were the only parameters that were lower in live-caught than harvested deer. Concentration of total bilirubin ($P = 0.0034$), alanine aminotransferase (ALT; $P = 0.0138$), blood urea nitrogen (BUN; $P = 0.0211$) and the BUN/creatinine ratio ($P = 0.0334$) were the only serum constituents that had a significant method-collection period interaction (Fig. 1). All other serum constituents showed similar temporal changes, regardless of method of capture (Fig. 2).

Discussion

The level of excitement or stress induced by capture and subsequent handling differed greatly both within and between sampling techniques. Deer captured in drop-nets experienced prolonged periods of exertion (5–45 minutes) trying to escape. Length of this period was dependent upon number of deer trapped per occasion. Although harvested deer typically fell dead with little evidence of struggling, some of these individuals required several minutes of searching to locate

Table 1. Selected hematological parameters of adult white-tailed does harvested with a rifle (N = 49) or live-caught with a drop-net (N = 37) during different seasons in northeastern Oklahoma, 1989–1992.

	HCT (%)[ab]			RBC (10^6/mm^3)[b]			MCV (μm^3)[a]			WBC (10^3/mm^3)[a]			Lymphocytes (10^3/mm^3)[a]		
Month (Year)	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE
Shot															
Sep (89)	6	40.2	1.9	6	14.4	1.1	6	28.4	1.4	6	2.07	0.29	6	1.18	0.11
Mar (90)	9	49.7	3.4	9	16.3	0.7	9	30.5	1.1	9	3.64	0.91	9	1.66	0.52
Sep (90)	10	33.5	3.8	10	12.6	1.3	10	26.6	1.7	10	2.82	0.60	10	2.13	0.50
Mar (91)	8	42.9	2.0	8	13.6	0.8	8	31.7	1.1	8	2.95	0.33	8	1.72	0.24
Sep (91)	8	37.5	2.2	8	12.2	1.5	8	33.3	3.2	8	2.83	0.89	8	1.60	0.41
Mar (92)	8	51.5	1.0	8	17.9	0.4	8	28.9	0.8	8	2.75	0.48	8	1.24	0.30
Drop-net															
Sep (89)	12	47.0	2.0	12	14.3	1.0	12	33.7	1.7	12	6.43	0.95	12	3.38	0.45
Mar (90)	7	52.1	0.9	7	15.4	0.7	7	34.2	1.3	7	4.61	0.69	7	3.23	0.48
Sep (90)	5	43.4	2.1	5	12.6	1.5	5	36.2	4.1	5	4.77	1.19	5	3.25	0.92
Mar (91)	3	49.0	4.4	3	14.1	2.5	3	35.8	3.1	3	4.04	0.66	3	2.74	0.55
Sep (91)	5	42.7	0.7	5	13.2	0.4	5	32.5	0.5	5	6.00	1.26	5	3.59	0.80
Mar (92)	5	53.0	1.1	5	15.5	1.5	5	35.5	3.7	5	4.27	0.58	5	2.20	0.32

	Neutrophils (10^3/mm^3)[a]			Eosinophils (10^3/mm^3)			Monocytes (cells/mm^3)[b]			Basophils (cells/mm^3)		
Month (Year)	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE
Shot												
Sep (89)	6	0.68	0.28	6	0.22	0.05	6	0	0	6	0	0
Mar (90)	9	1.01	0.21	9	0.91	0.26	9	0.01	0.01	9	0	0
Sep (90)	10	0.34	0.12	10	0.34	0.10	10	0.02	0.01	10	0	0
Mar (91)	8	0.84	0.12	8	0.38	0.06	8	0	0	8	0.01	0.01
Sep (91)	8	0.69	0.18	8	0.52	0.36	8	0.02	0.01	8	0	0
Mar (92)	8	1.03	0.24	8	0.46	0.10	8	0.02	0.01	8	0	0
Shot												
Sep (89)	12	2.62	0.74	12	0.44	0.13	12	0	0	12	0	0
Mar (90)	7	1.06	0.32	7	0.32	0.06	7	0	0	7	0.01	0.01
Sep (90)	5	0.90	0.17	5	0.61	0.13	5	0	0	5	0	0
Mar (91)	3	1.00	0.11	3	0.29	0.04	3	0.01	0.01	3	0	0
Sep (91)	5	1.17	0.13	5	1.15	0.44	5	0.04	0.02	5	0	0
Mar (92)	5	1.32	0.14	5	0.72	0.26	5	0.03	0.01	5	0	0

[a] Significant ($P < 0.05$) with regard to method of sampling.
[b] Significant ($P < 0.05$) with regard to collection period (month and year) samples were taken.
[c] Significant ($P < 0.05$) method-collection period interaction.

Table 2. Selected serum constituents of adult white-tailed does harvested with a rifle ($N = 50$) and live-caught with a drop-net ($N = 37$) during different seasons in northeastern Oklahoma, 1989–1992.

	BUN (mg/dl)[c]			Creatinine (mg/dl)[ab]			BUN/Creatinine ratio[c]			Total Protein (g/dl)[ab]			Albumin (g/dl)[ab]			Globulin (g/dl)[ab]		
Month (Year)	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE
Shot																		
Sep (89)	6	12.2	3.6	6	1.48	0.05	6	8.6	2.7	6	5.93	0.23	6	2.30	0.08	6	3.63	0.17
Mar (90)	9	28.2	1.0	9	2.30	0.14	9	12.7	0.9	9	5.94	0.59	9	2.44	0.06	9	4.06	0.17
Sep (90)	10	8.4	1.2	10	1.83	0.06	10	4.6	0.6	10	6.22	0.15	10	2.42	0.06	10	3.80	0.18
Mar (91)	9	24.9	1.6	9	1.74	0.08	9	14.2	0.7	9	6.37	0.32	9	2.77	0.11	9	3.60	0.29
Sep (91)	8	11.8	2.7	8	1.48	0.03	8	8.0	1.8	8	6.39	0.17	8	2.84	0.07	8	3.55	0.18
Mar (92)	8	25.3	3.1	8	1.83	0.05	8	13.9	1.7	8	6.83	0.21	8	3.13	0.12	8	3.69	0.28
Drop-net																		
Sep (89)	12	9.5	1.9	12	1.79	0.07	12	5.4	1.1	12	6.67	0.13	12	2.48	0.08	12	4.19	0.09
Mar (90)	7	23.7	4.3	7	2.36	0.08	7	9.9	1.8	7	7.41	0.28	7	2.90	0.09	7	4.51	0.28
Sep (90)	5	21.2	4.6	5	1.98	0.06	5	10.6	2.1	5	7.30	0.13	5	2.70	0.12	5	4.60	0.21
Mar (91)	3	23.7	3.2	3	1.93	0.18	3	12.6	2.2	3	7.27	0.32	3	3.63	0.17	3	3.63	0.29
Sep (91)	5	9.0	2.3	5	1.54	0.05	5	5.8	1.4	5	7.66	0.36	5	3.28	0.10	5	4.38	0.24
Mar (92)	5	25.4	1.2	5	1.90	0.12	5	13.6	1.2	5	7.80	0.20	5	4.08	0.24	5	3.72	0.04

	Alb/Glob. ratio[b]			Cholesterol (mg/dl)[ab]			Glucose (mg/dl)			Ca (mg/dl)[b]			Inorganic P (md/dl)[ab]			Ca/P ratio[ab]		
Month (Year)	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE
Shot																		
Sep (89)	6	0.63	0.02	6	52.0	6.4	6	138	24.0	6	9.08	0.61	6	9.58	0.89	6	0.98	0.10
Mar (90)	9	0.60	0.03	9	40.3	1.5	9	143	22.2	9	9.56	0.17	9	8.74	0.55	9	1.12	0.07
Sep (90)	10	0.65	0.04	10	49.6	3.8	10	109	17.9	10	10.76	0.25	10	8.70	0.59	10	1.28	0.09
Mar (91)	9	0.80	0.08	9	38.9	2.8	9	181	26.0	9	7.91	0.27	9	6.37	0.37	9	1.26	0.06
Sep (91)	8	0.83	0.05	8	57.4	3.6	8	170	23.0	8	9.96	0.12	8	9.51	0.88	8	1.10	0.09
Mar (92)	8	0.91	0.09	8	46.9	1.2	8	150	25.4	8	8.69	0.18	8	7.38	0.35	8	1.19	0.05
Drop-net																		
Sep (89)	12	0.59	0.03	12	56.0	3.7	12	166	9.6	12	9.28	0.25	12	6.58	0.43	12	1.47	0.09
Mar (90)	7	0.67	0.06	7	46.9	3.1	7	142	15.3	7	9.49	0.13	7	6.77	0.77	7	1.53	0.21
Sep (90)	5	0.60	0.05	5	65.2	6.8	5	144	29.7	5	10.44	0.51	5	8.16	1.07	5	1.32	0.09
Mar (91)	3	1.00	0.10	3	44.3	5.8	3	142	14.3	3	8.93	0.26	3	4.70	0.93	3	2.09	0.49
Sep (91)	5	0.74	0.02	5	62.2	7.1	5	187	39.9	5	9.50	0.27	5	5.70	0.77	5	1.78	0.23
Mar (92)	5	1.20	0.24	5	57.8	2.3	5	152	14.3	5	8.82	0.31	5	5.96	0.35	5	1.49	0.05

(table continues)

Table 2. *(continued)*

Month (Year)	Na (mEq/dl)[ab]			K (mEq/dl)[ab]			Na/K ratio[ab]			Total Bilirubin (mg/dl)[c]			Cl (mEq/dl)[b]			LDH (IU/l)[ab]		
	N	$\bar{x}$	SE	*N*	$\bar{x}$	SE	*N*	$\bar{x}$	SE	*N*	$\bar{x}$	SE	*N*	$\bar{x}$	SE	*N*	$\bar{x}$	SE
Shot																		
Sep (89)	6	136	1.8	6	7.9	0.7	6	17.9	1.9	6	0.20	0.08	6	100	1.4	6	633	67
Mar (90)	9	143	1.3	9	9.1	0.8	9	16.6	1.1	9	0.58	0.05	9	104	1.2	9	297	31
Sep (90)	10	142	0.6	10	11.4	0.8	10	13.0	0.8	10	0.28	0.06	10	105	0.7	10	220	11
Mar (91)	9	135	4.1	9	8.1	0.6	9	17.2	0.9	9	0.37	0.06	9	103	3.3	9	335	27
Sep (91)	8	143	0.6	8	9.6	0.6	8	15.3	1.0	8	0.35	0.04	8	106	0.8	8	691	39
Mar (92)	8	146	0.8	8	8.1	0.5	8	18.7	1.6	8	0.29	0.04	8	112	0.6	8	363	23
Drop-net																		
Sep (89)	12	140	2.1	12	4.9	0.5	12	30.3	2.0	12	0.24	0.04	12	99	1.6	12	658	77
Mar (90)	7	146	0.5	7	4.1	0.2	7	35.8	1.4	7	0.61	0.07	7	101	0.7	7	445	10
Sep (90)	5	147	3.1	5	5.2	0.6	5	29.6	3.2	5	0.18	0.06	5	101	2.6	5	304	34
Mar (91)	3	141	1.0	3	4.1	0.4	3	34.6	2.7	3	1.23	0.50	3	105	0.9	3	519	50
Sep (91)	5	149	2.1	5	4.4	0.2	5	33.7	1.1	5	0.42	0.05	5	107	1.8	5	812	57
Mar (92)	5	151	2.4	5	5.2	0.5	5	29.7	2.2	5	0.38	0.04	5	110	0.8	5	585	80

Month (Year)	AP (IU/l)[b]			GGTP (IU/l)[a]			AST (IU/l)[b]			ALT (IU/l)[c]			CPK (IU/l)		
	N	$\bar{x}$	SE	*N*	$\bar{x}$	SE	*N*	$\bar{x}$	SE	*N*	$\bar{x}$	SE	*N*	$\bar{x}$	SE
Shot															
Sep (89)	6	123	16	6	46.3	2.5	6	152	25	6	50	2.9	—	—	—
Mar (90)	9	58	10	9	36.4	2.4	9	79	11	9	28	1.6	—	—	—
Sep (90)	10	102	21	10	43.8	3.2	10	110	19	10	34	1.2	10	346	220
Mar (91)	9	44	6	9	52.2	12.7	9	91	12	9	39	2.5	9	104	21
Sep (91)	8	131	24	8	37.5	2.4	8	157	17	8	58	4.8	8	456	174
Mar (92)	8	43	6	8	50.4	5.7	8	123	21	8	33	2.7	8	716	367
Drop-net															
Sep (89)	12	146	17	12	54.1	4.7	12	127	12	12	49	3.7	—	—	—
Mar (90)	7	77	21	7	48.3	3.8	7	88	9	7	38	5.0	—	—	—
Sep (90)	5	83	16	5	63.0	8.9	5	100	10	5	32	1.0	5	720	279
Mar (91)	3	84	29	3	59.7	4.9	3	112	6	3	52	5.5	3	532	191
Sep (91)	5	118	10	5	49.6	2.5	5	134	11	5	63	5.0	5	698	261
Mar (92)	5	61	18	5	65.0	19.1	5	127	12	5	56	8.1	5	1027	347

[a] Significant ($P < 0.05$) with regard to method of sampling.
[b] Significant ($P < 0.05$) with regard to collection period (month and year) samples were taken.
[c] Significant ($P < 0.05$) method-collection period interaction.

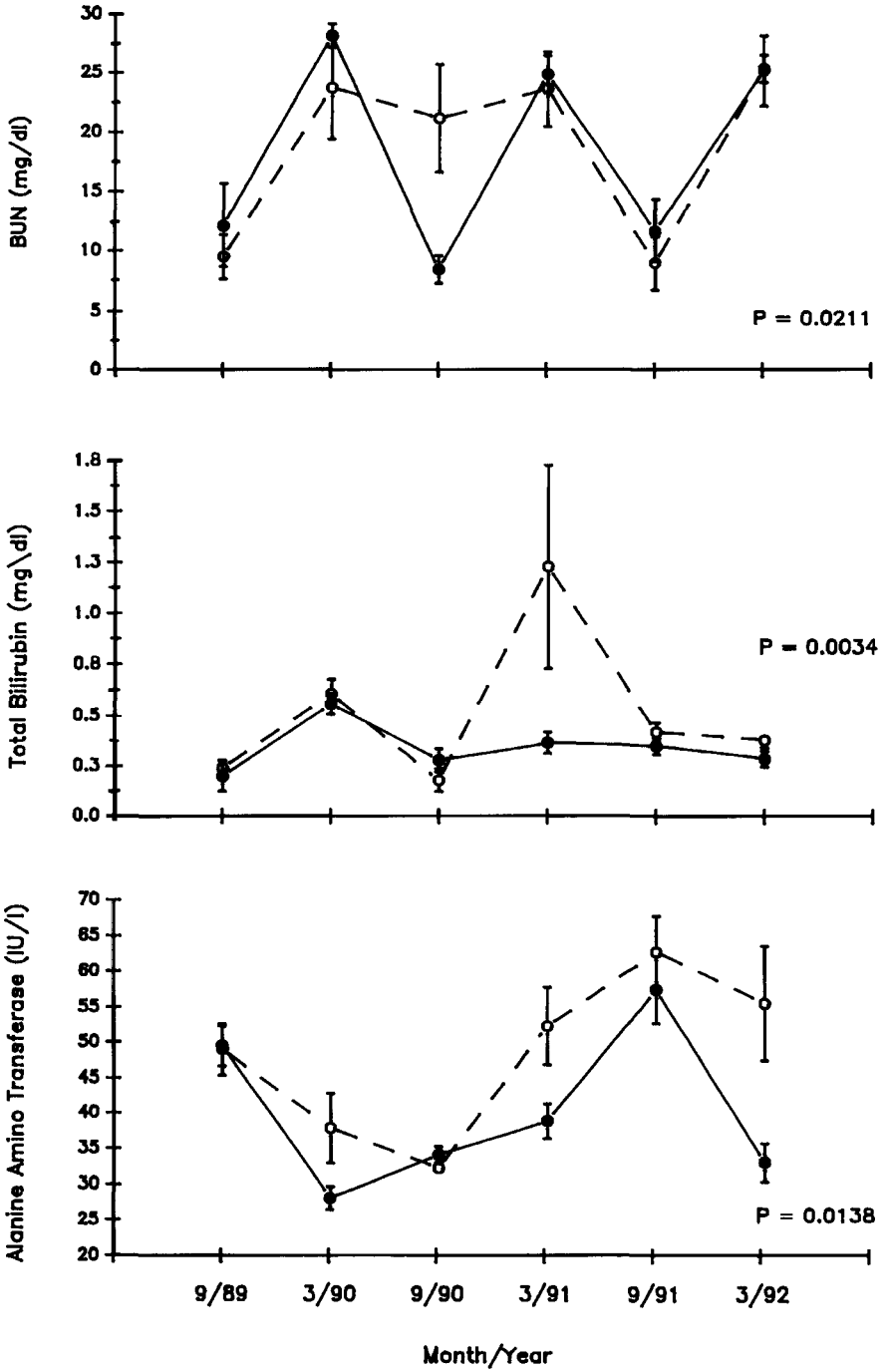

Figure 1. Temporal changes in mean (Se bars) serum concentrations of BUN, total bilirubin, and ALT in adult white-tailed does as influenced by capture technique (harvested or live-caught using a drop-net).

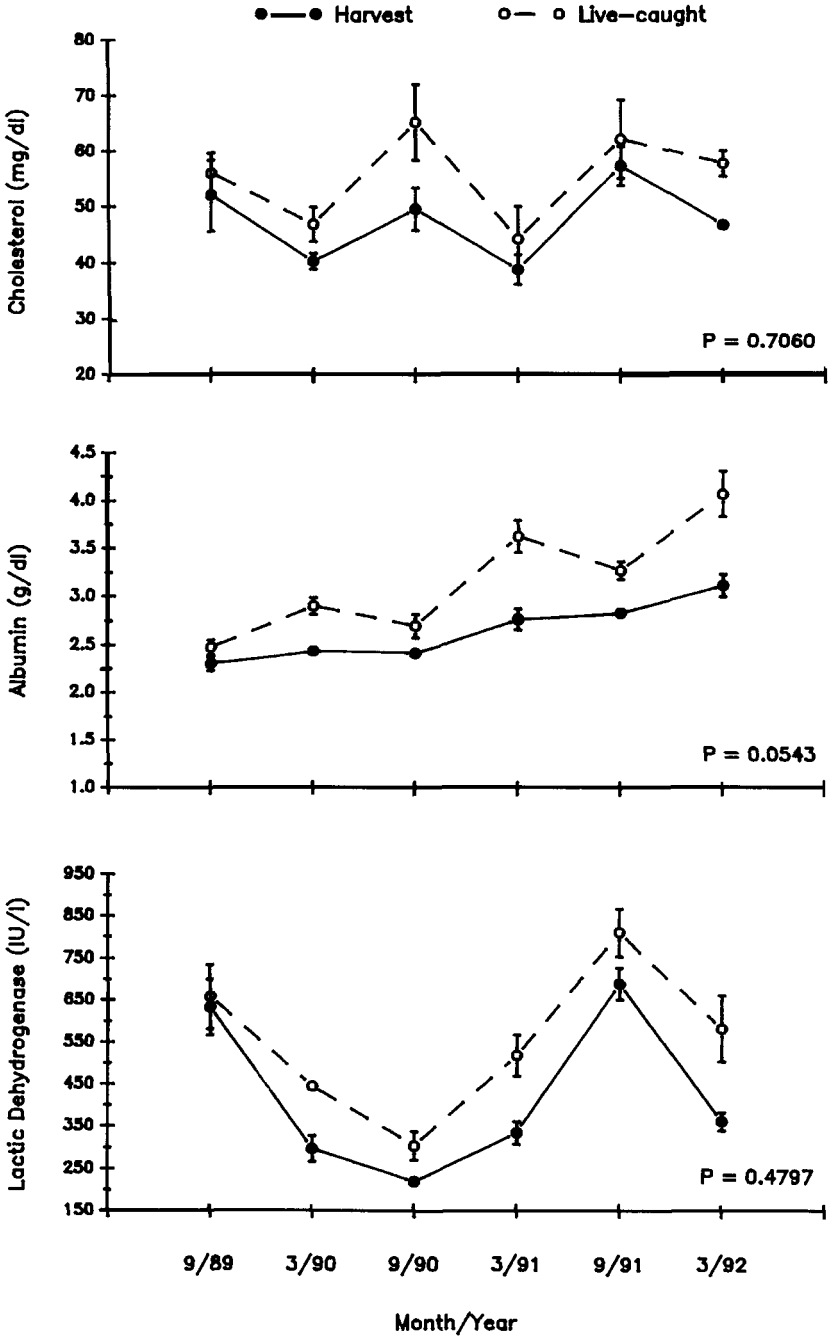

Figure 2. Selected blood serum constituents of adult white-tailed does as influenced by method of capture (harvested and live-caught using a drop-net). Temporal alterations in blood parameters displayed similar trends between capture methods as indicated by a non-significant interaction (method-collection period) using 2-way ANOVA for unequal sample sizes.

carcasses in thick vegetation; for these individuals, immediate death was assumed. Most blood parameters of nutritional condition showed considerable fluctuations between seasons and years of collection. These temporal variations were indicative of changing nutritional conditions, with does collected during September and at peak population density exhibiting the poorest condition (low levels of BUN, albumin, and HCT).

As expected, additional handling stress associated with the drop-net approach to obtaining samples from white-tailed deer for physiological monitoring induced considerable change in the clinical profile of blood. However, it is especially noteworthy that the degree of statistical variation (as indicated by Levene's Test of homogeneity of variances) among individuals was not increased by capture with drop-nets. Heterogeneity of variances between capture techniques was indicated for 6 blood parameters, with variation greater for harvested deer on 3 of those occasions. This observation indicated that although a shift in the "normal" baseline value for a particular blood parameter occurred with the use of drop-nets, sampling intensity or number of individuals required in a sample to achieve a given level of statistical confidence, did not differ from harvested deer.

Responses of hematological parameters of drop-netted deer indicated that this capture technique does not provoke the classical splenic contraction response when compared to harvested deer (Gartner et al. 1965, 1969; Jacobson et al. 1978; Seal and Hoskinson 1978). This excitement response typically is associated with elevated increases in HCT as RBC and WBC are released from the spleen into circulation without any change in MCV (Seal and Hoskinson 1978). In our study, the higher HCT values from live-captured animals were due solely to increased MCV with no noticeable alteration in RBC numbers. Increases in MCV due to excitement have been found in intact and splenectomized cattle and attributed to decreased blood pH (Gartner et al. 1965, 1969). For example, increases in plasma lactate concentration have been observed in manually restrained impala (*A melampus*) (Hattingh et al. 1988) and cattle subjected to differing handling stressors (Mitchell et al. 1988). The resulting increases of organic phosphates as well as uptake of H ions in erythrocytes results in the extrusion of Na and movement of water into the cell, thereby elevating MCV (Karns and Crichton 1978). This conclusion is further supported by increased concentrations of Na in serum of drop-netted deer compared to harvested deer in our study.

Corticosteroid release from the adrenals during capture or handling, as demonstrated in a variety of wild animal species (Franzmann et al. 1975, Jacobson et al. 1978, Hattingh 1988), has been found to alter WBC populations in blood. Among the more notable alterations from corticosteroid release are increases in immature neutrophils and a decline in the number or circulating lymphocytes and eosinophils (Schalm 1965, Jacobson et al. 1978, Tizard 1987). Increased proportions of neutrophils to lymphocytes during handling-related stress have been documented in reindeer (*Rangiferi tarandus*) (Rehbinder and Edquist 1981), cattle (Gartner et al. 1969), cottontail rabbits (*Sylvilagus floridanus*) (Jacobson et al. 1978), and male chital deer (*Axix axis*) (Chapple et al. 1991). White neutrophil numbers were increased in live-caught animals in our study, lymphocyte numbers

also increased with no overall change in their proportions. We suspect this was the result of an increase in lymphatic circulation from increased muscular activity within drop-nets (Schalm 1965, Wesson et al. 1979*a*).

A variety of acute handling stressors can induce excitement capable of altering homeostatic protein levels by causing the release of proteins from liver and other reservoirs into circulation (Carlson 1989). Similar responses of serum protein constituents of deer to drop-netting were observed in our study. Concentrations of albumin and globulin protein fractions increased about 13% in response to drop-netting, which was similar to the 13% elevation in HCT, implicating hemoconcentration in live-caught deer. However, protein concentration typically increases to a greater extent than does HCT values during hemoconcentration (Carlson 1989). Furthermore, since hemoconcentration is the reduction of water in the blood plasma, increases in concentration of most serum constituents would be expected, but were not observed. Therefore, release of proteins into circulation appears to be a more important response than hemoconcentration in deer collected by drop-net. Gartner et al. (1965) likewise failed to find a correlation of protein concentration to HCT levels in excited cattle and attributed their increase to movement of protein in and out of circulation.

The literature is inconsistent with regard to effects of handling stress on serum cholesterol concentrations, with decreases (Blankenship and Varner 1977) and increases (Franzmann 1972) reported. We observed a remarkable elevation in cholesterol levels among drop-netted deer. Several stress-induced alterations in physiology undoubtedly contributed to this elevation, including increased lymphatic circulation (Wesson et al. 1979*a*), increased muscle cell permeability (Chapple et al. 1991), and increased circulation through cholesterol-rich tissues such as the liver and adrenal cortex (Bartley 1989).

Increases in levels of enzymes in circulation have been associated with muscle cell damage (capture myopathy) and increased cell permeability during manual restraint (Franzmann 1972, Blankenship and Varner 1977, Seal et al. 1981, Chapple et al. 1991). Blood samples derived from drop-netted deer had elevated levels of gamma glutamyl transpeptidase (GGTP) and lactic dehydrogenase (LDH). In addition to investigator handling, struggling of deer in drop-nets undoubtedly resulted in release of enzymes from stress, shock, and capture myopathy. Serum levels of CPK and AST were not significantly affected by the method of capture, which probably reflected the fact that blood samples were taken from the heart (where levels are suspected to be higher than venous blood) of harvested deer (Seal et al. 1981). This may likewise explain the elevated levels of serum inorganic P in harvested does (Seal et al. 1981). Serum K also is suspected of being higher when taken from the heart (Seal et al. 1981). However, the 93% elevation of K in harvested does is most probably due to the immediate release of K from cells following death (Coe 1974), compared with corticosteroid-induced hypokalemia in drop-netted deer (Carlson 1989).

Mean values for most parameters reported above rendered significantly different results in absolute terms between capture techniques, but temporal (seasonal

and annual) changes were very similar. The lack of significant statistical interactions (capture method-collection period) indicated that either of the 2 techniques of collecting deer for blood sampling can provide a sensitive means of monitoring nutritional status. Total bilirubin, ALT, and BUN were the only blood parameters where temporal patterns of change differed among capture techniques as indicated by a significant interaction. A plot of temporal patterns of change in BUN revealed that the interaction was attributable to a single collection period. We suspect that the deer responsible for the high BUN values during this trapping period were associated with a family group that frequently visited a supplemental feeding area operated by park employees. Temporal changes in BUN values were similar over all other collection periods. Given this and the tendency for BUN values to be unaffected by method of collection in other studies (Franzmann 1972, Wesson et al. 1979*a, b*), we believe BUN concentration remains a valuable diagnostic index for assessing nutritional status, regardless of capture technique. A plot of temporal changes in total bilirubin showed a similar result with the interaction being attributable to a single collection period.

It was apparent that the physiological environment of deer is capable of reacting quickly to stressors associated with capture, as well as long-term changes associated with changing nutritional status. Although the majority of clinical indices of nutritional status measured in our study were influenced by the stress of capture using drop-nets, temporal fluctuations and patterns remained largely unaffected, as did sample variability. This is strong supporting evidence that either capture technique can be used with equal sensitivity to monitor temporal changes in nutritional status of white-tailed deer using blood parameters. Because method of capture influenced clinical profiles, it is important to reiterate the caution against comparing profiles of individuals sampled using different capture techniques.

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