EFFECTS OF LONE STAR TICK (ACARINA: IXODIDAE) PARASITISM AND THEILERIASIS ON WHITE-TAILED DEER FAWN SURVIVAL AND HEMATOLOGY

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PREFACE

A review of the literature established the premise that ticks can cause economic losses to the livestock industry and are important in transmitting debilitating diseases to man and his stock. Until recently tick-host interactions and their effect on various physiological parameters of the host were virtually undefined. Reported work on tick-host interactions has dealt primarily with studies on domestic animals and there has been little published information on the effects of tick parasitism or tick transmitted diseases on the well being of game species.

The objective of the present research was to monitor certain physiological parameters of young white-tailed deer fawns infested with ticks in order to more clearly define the effects of ticks on this host. Such findings could possibly be applicable to other wild and domestic animals.

A great deal of indebtedness is owed to my major adviser, Dr. J. A. Hair, Associate Professor of Entomology, who spent numerous hours in guidance and assistance in developing and completing this research. Special thanks are also extended to Dr. Ralph Buckner, Professor of Veterinary Pathology, who contributed a great deal of his unselfish time in guidance and laboratory analysis of blood samples. Appreciation is expressed to Dr. John Sauer, Associate Professor of Entomology, and Dr. W. A. Drew, Professor of Entomology, for serving as members on the graduate committee and for their constructive criticism in the preparation of this manuscript. Acknowledgement of the contributions by Messers Bob Barker, Rick Pickard, Paul Semtner, Joe Fletcher, Foreman Carlile,

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CHAPTER I

INTRODUCTION

The first account of the transmission of a protozoan disease (Texas cattle fever: Babesia bigemina) by ticks was reported by Smith and Kilborne in 1893. Since this important event it has been established that ticks are potential vectors of many pathogenic agents which include bacteria, viruses, rickettsia, and spirochetes.

Although the importance of many disease agents and tick parasitism on wild animal populations is relatively unknown, research investigators have recently observed that survival of white-tailed deer fawns tended to be correlated with tick infestations and/or tick borne diseases (Robinson, et al, 1967; Emerson, 1969; Bolte, et al., 1970; and Barker, et al., 1973).

Recent findings of Oklahoma State University researchers indicate that up to 57% of the annual fawn crop is lost in certain parts of the Ozark region and that such losses are probably due in part to tick-host interaction (Bolte, et al., 1970). More recent laboratory and field research conducted with deer fawns show that a majority of these animals are infected with an intracellular tick-transmitted blood protozoan (Theileria sp.) (Barker, et al., 1973).

The importance of theileriasis in fawn survival and its influences on host physiology have not been established. In order to evaluate the effect of tick parasitism and/or the blood parasite on deer fawn survival

and physiological response, it was deemed necessary to conduct a series of observations under controlled conditions so that certain host blood parameters could be monitored.

CHAPTER II

EFFECTS OF *AMBLYOMMA AMERICANUM* (L.) (ACARINA: IXODIDAE) AND *THEILERIA* SP. (PIROPLASMORIDA: THEILERIIDAE) ON WHITE-TAILED DEER FAWN HEMATOLOGY

Within recent years, Oklahoma tick investigators have observed a significant number of deaths in neo-natal white-tailed deer fawns (*Odocoileus virginianus*) supporting heavy infestations of lone star ticks [*Amblyomma americanum* (L.)] (Bolte, *et al.*, 1970). Although limited by the number of animals and observations, these workers speculated that 57% of the annual fawn crop was lost in their study area as a result of tick-host interaction. Similar observations were also reported by Emerson (1969) in east Texas. Emerson indicated that heavy infestations of ticks and resulting blood loss could kill young fawns.

In more recent work with deer fawns confined to the laboratory, Barker, *et al.* (1973) found that 100% mortality of fawns occurred when test animals were subjected to specified infestations of adult lone star ticks. These infestation levels closely approximated tick populations that normally occurred on fawns in eastern Oklahoma (Bolte, *et al*, 1970). Although no mortality was reported in the lower tick infestation levels established by these workers, marked reductions in packed cell volume and hemoglobin values were observed.

In addition to observed blood losses, Barker, *et al.* (1970) reported

that tick-infested animals under study became infected with a blood protozoan, identified as a species of Theileria. The first report of theileriasis in white-tailed deer in the United States was reported by Krier, et al. (1962). Other reports of theileriasis in white-tailed deer have since been reported by Cook, et al. (1965), Glazener and Knowlton (1967), Kuttler and Robinson (1967), Samuel and Trainer (1970), and Kuttler, et al. (1967). The pathological effects of theileriasis on young white-tailed deer is relatively unknown.

It was the objective of these experiments to monitor certain blood parameters of young fawns in order to determine the effects of tick parasitism and theileriasis on young fawns. It was postulated that such information would be valuable in discerning those factors contributing to hematological alteration and fawn mortality.

Materials and Methods

Experimental Animals

Pregnant adult white-tailed deer, 3-8 years old, were collected at random from the Cookson Hills Wildlife Refuge, Cherokee County, Oklahoma, between January and March, 1971. Following capture, does were confined in a post-oak-hickory woodlot of approximately 1.5 hectares and sustained on an ad libitum artificial diet (French, et al., 1956).

Prior to the fawning season of late May and early June, Gardona^{R} (2-chloro-1(2,4,5-trichlorophenyl) vinyl dimethyl phosphate insecticide dust was applied to the woodlot pen to kill indigenous tick populations. This was necessary to prevent tick infestation of neo-natal fawns prior to initiation of laboratory studies.

During doe fawning the holding pen was examined frequently for

new-born fawns. Within 24 hrs after birth fawns were removed from the mother and pen and relocated to a laboratory in Stillwater, Oklahoma.

Other tick-free fawns were obtained from semi-domesticated deer confined to tick-free enclosures.

Maintenance and Handling of Fawns

Laboratory fawns were maintained on a formulation of 1:2 Pet Milk^{R}: water for 2 weeks. This formulation was given to each fawn 3 times a day. Following the second week the diet was changed to a dry, powdered milk calf supplement (Lan-o-lake^{R}). Water containers were placed in pens to provide additional water. Experimental treatment groups were maintained in 4 separate but near identical tick-proof areas.

Experimental Grouping of Fawns

At approximately 12 days of age, fawns were placed in one of 4 major treatment categories: (1) control; (2) fawns to be infested with wild *Theileria* infected ticks; (3) fawns to be infested with laboratory reared non-*Theileria* harboring ticks; and (4) fawns to be injected intravenously with 5 ml of infected blood from a *Theileria* infected, splenectomized deer. Treatment groups (2) and (3) were subdivided into 2 groups (high and low infestation) depending on the number of ticks to be placed on each subgroup. Each treatment group had 3 animals with the exception of the control group (6 fawns) and a subgroup of treatment 3 (2 fawns).

Infestation of Fawns

Hoods constructed of muslin cloth and contoured to fit the fawn's head were used as tick cells (Barker, *et al.*, 1973). Adjustable elastic

bands were inserted into the basal portion of the hoods to prevent ticks from escaping. Infestation of fawns with ticks was conducted after their evening feeding, thus allowing approximately 14 hrs for tick attachment before the hoods were removed for the next feeding.

Treatment No. 2 and 3 were subdivided into 2 infestation levels. Those fawns to receive the high level tick infestations received 80 female and 60 male ticks per inoculation, while those in the low infestation treatments received 30 female and 20 male ticks per inoculation. Fawns to be treated were infested with the appropriate number of ticks on Monday, Wednesday, and Friday until the experiment was concluded.

Infected Ticks

Due to the extensive work which has been conducted with the wild population of ticks in the Cookson Hills Wildlife Refuge in eastern Oklahoma, tick investigators of Oklahoma State University have found that a high percentage of the ticks in this area was potential vectors of Theileria sp. (unpublished data). Therefore, infected ticks used in this experiment were taken from this area utilizing CO_2 traps (Wilson, et al., 1972) and a vacuum sweeper (Hair, et al., 1972).

Non-Infected Ticks

Domestic rabbits served as laboratory hosts for propogating non-infected ticks. Previous tick investigators have shown that Theileria sp. are not transmitted to progeny by transovarian means (Levine, 1967).

Blood Samples

Hematological assays were performed on approximately 6 ml of blood

drawn from the jugular of each fawn twice a week (Monday and Wednesday). Two milliliters of each blood sample were transferred to 4 ml vaccutainers containing ethylenediaminetetraacetate (EDTA). The remainder of the blood sample was transferred to 15 ml glass tubes.

After centrifugation of whole blood in test tubes, serum samples were transferred to clean tubes and held at dry ice temperature.

Blood samples collected in vaccutainers were used for the following analysis: blood smear, packed cell volume (PCV), hemoglobin (Hb), and Coutler counter samples.

Determination of PCV, Hb, Wintrobe Erythrocyte Index, Total Erythrocytes and Leukocytes

Packed cell volumes were determined by the microhematocrit technique while hemoglobin measurements were made by light absorption of cyanmethemoglobin by the use of a spectrophotometer (B&L Spectronic 20 Colorimeter). Total erythrocyte and leukocyte cell counts were calculated in the same manner as presented by Schalm (1970). Total erythrocyte counts used in the calculations were determined by the electronic Coulter Counter.

Staining Methods

A cover-slip method was used to prepare blood smears. Smears were stained in a Wright's-Leishman solution (Schalm, 1970).

Results

Fawn Mortality

Longevity data of white-tailed deer fawns which were subjected to

the various treatments are presented in Table I. Fawn survival in the clean ticks-high infestation fawn treatment ranged from 4 to 17 days post tick infestation, and survival of the animals in the infected ticks-high infestation treatment ranged from 10 to 29 days. In the clean ticks-high infestation treatment, the first fawn to die had been infested with 280 adult ticks, while the fawn which lived 17 days had received 1020 adult lone star ticks. In the infected ticks-high infestation treatment group, 2 fawns had been subjected to about 1000 adult ticks before death occurred. One fawn in the clean ticks-low infestation treatment succumbed 12 days post tick infestation, while in 1 fawn, death occurred in the infected ticks-low infestation group 16 days post-treatment.

The 2 fawn deaths occurring in the 2 low infestation treatments occurred before the fawns had been infested with 360 lone star ticks. There was one accidental death in the control group of fawns, while no mortality was recorded for fawns inoculated intravenously with Theileria infected blood.

Blood Composition

Control Fawn Treatment. When comparing the initial erythrocyte and hemoglobin measurements of similar aged fawns in the control treatment, considerable variability was observed (Table II). Early in the study blood readings of some fawns in the control group were approximately twice the magnitude of similar aged fawns in the same treatment. However, by the termination of the experiment the variability in erythrocyte and hemoglobin readings between members of control and treatment members had been reduced. Although the PCV, Hb, and RBC measurements tended to rise and fall together, the normal 3:1 ratio of PCV to Hb (Schalm, 1970)

TABLE I

LONGEVITY OF WHITE-TAILED DEER FAWNS SUBJECTED TO VARIOUS TREATMENTS AND PERCENT OF FEMALE TICKS REPLETING WITHIN EACH TREATMENT

Treatment	Longevity (Days)[1]	Infestation (Accumulated) ♀ + ♂	Repletion (%)
Control	32+, 32+, 32+ 32+, 32+, 9		
Non-Infected Ticks			
High	4, 10, 17	280, 700, 1020	0, 23, 24
Low	12, 32+	250, 700	24, 43
Theileria-Infected Ticks			
High	10, 22, 29	700, 1400, 1680	24, 25, 24
Low	16, 32+, 32+	350, 700, 700	33, 28, 39
Theileria-Infected Blood			
I.V.	32+, 32+, 32+		

[1]Each entry represents data collected on one animal.

TABLE II

HEMOGRAM OF WHITE-TAILED DEER FAWNS AS INFLUENCED BY TREATMENT AND AGE

Treatment Group	Age of Fawns (Days)									
	10-12	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
Control										
Fawn #41										
PCV %	23.2	20.4	23.0	25.0	25.4	27.7	26.2	28.4	31.0	27.5
Hb gm%	11.3	7.6	9.4	9.7	11.9	10.4	9.4	10.4	12.9	11.8
RBC x 10^6_3	-	8.5	9.9	9.1	11.9	12.7	12.6	13.0	17.3	16.4
WBC x 10^3	-	9.1	3.6	4.0	4.9	4.5	3.4	3.7	3.8	4.0
Fawn #43										
PCV %	15.1	12.8	14.8	17.5	15.9	16.2	20.6	19.5	24.0	24.5
Hb gm%	6.5	4.7	4.3	6.8	5.8	5.0	7.2	7.2	9.2	10.0
RBC x 10^6_3	-	7.8	6.1	5.5	6.8	7.2	8.1	8.0	10.5	8.3
WBC x 10^3	-	5.6	2.6	2.8	6.5	5.2	2.1	5.9	4.8	3.4
Fawn #44										
PCV %	16.5	18.0	16.9	16.0	15.9	16.5	15.0	16.2	15.6	
Hb gm%	5.3	5.0	6.1	5.8	5.4	5.9	5.0	6.5	8.6	
RBC x 10^6_3	5.1	4.7	4.2	4.2	4.7	5.2	4.4	5.5	5.1	
WBC x 10^3	2.5	2.7	2.4	3.5	8.3	1.9	3.1	1.6	1.9	
Fawn #x-3										
PCV %	24.0	26.0	25.0	22.0	22.5	21.7	29.1			
Hb gm%	10.4	10.3	10.1	8.6	8.5	9.2	11.9			
RBC x 10^6_3	-	10.9	10.5	9.3	9.1	7.8	10.5			
WBC x 10^3	-	2.2	2.6	3.5	3.1	3.1	4.3			
Fawn #x-1										
PCV %	25.4	20.1	25.0	21.0	28.1	29.0	29.3			
Hb gm%	9.9	7.9	10.1	7.9	10.6	11.5	12.9			
RBC x 10^6_3	9.0	8.9	10.3	8.6	13.7	11.6	11.7			
WBC x 10^3	7.3	4.3	2.9	8.9	6.0	3.2	3.6			
Fawn #29										
PCV %	25.3	20.0	22.2	20.3[1]						
Hb gm%	9.4	7.2	7.6	7.2						
RBC x 10^6_3	7.0	7.3	6.9	9.9						
WBC x 10^3	7.1	6.3	8.2	5.9						
I.V.										
Fawn #50										
PCV %	21.0	19.7	18.0	17.4	18.8	17.7	17.7	16.6	16.4	
Hb gm%	8.6	7.6	6.8	6.8	6.8	7.2	6.5	6.8	7.9	
RBC x 10^6_3	8.0	7.5	6.5	6.5	6.4	6.9	6.8	6.1	5.9	
WBC x 10^3	2.2	2.1	4.3	2.4	4.3	3.0	2.7	2.6	2.1	

TABLE II (Continued)

Treatment Group	Age of Fawns (Days)									
	10-12	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
Fawn #47										
PCV %	20.6	18.0	17.6	18.8	20.0	18.7	23.2	19.7	22.9	
Hb mg%	8.1	7.2	7.0	7.9	7.9	7.2	8.5	8.6	9.7	
RBC x 10^6_3	8.3	7.2	6.3	7.9	4.9	7.4	9.2	7.7	9.1	
WBC x 10^3	3.0	2.5	2.2	2.2	1.7	2.0	1.4	2.5	2.1	
Fawn #49										
PCV %	17.4	16.9	16.0	16.5	20.1	21.1	19.0	21.1	24.2	
Hb gm%	5.5	6.1	6.1	6.4	7.6	8.1	8.6	8.4	9.7	
RBC x 10^6_3	6.1	5.1	7.1	7.6	7.6	7.6	6.8	8.3	9.4	
WBC x 10^3	2.8	-	2.0	1.1	1.8	1.2	2.2	2.3	-	
Clean Ticks, High Infestation										
Fawn #46										
PCV %	18.3	19.8	16.01[1]							
Hb gm%	6.7	7.2	5.7							
RBC x 10^6_3	8.0	7.4	4.5							
WBC x 10^3	4.2	7.3	13.2							
Fawn #42										
PCV %	22.7	22.0	20.8	19.0	9.0	6.9[1]				
Hb gm%	8.5	9.0	7.2	6.8	3.9	1.9				
RBC x 10^6_3	-	7.9	8.2	7.6	4.3	2.7				
WBC x 10^3	-	5.6	2.9	2.2	3.6	6.9				
Fawn #30										
PCV %	25.0	22.0	22.4	7.0	6.0[1]					
Hb gm%	9.4	12.9	7.9	2.5	2.5					
RBC x 10^6_3	-	7.8	5.1	5.9	2.2					
WBC x 10^3	-	8.8	8.6	2.9	3.4					
Clean Ticks, Low Infestation										
Fawn #45										
PCV %	19.2	17.7	16.8	17.0	17.9[1]					
Hb gm%	6.6	5.8	7.5	6.4	6.5					
RBC x 10^6_3	6.5	5.8	3.9	6.3	6.0					
WBC x 10^3	2.1	3.5	2.2	1.9	2.5					
Fawn #48										
PCV %	25.1	16.0	21.8	22.0	15.8	16.9	7.2	11.3	13.5	16.8
Hb gm%	11.2	8.3	8.3	8.3	6.4	6.5	2.5	5.4	5.4	6.8
RBC x 10^6_3	-	7.6	8.5	7.4	6.4	6.0	4.1	3.6	4.4	4.6
WBC x 10^3	-	6.2	4.4	2.7	2.6	2.5	5.4	5.2	3.6	5.1

TABLE II (Continued)

Treatment Group	Age of Fawns (Days)									
	10-12	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
Infected Ticks, High Infestation										
Fawn #34										
PCV %	29.3	29.9	28.0	25.9	16.0	15.5	8.7	10.2	7.7[1]	
Hb gm%	11.3	10.0	10.8	10.2	6.5	5.8	2.9	3.1	2.5	
RBC x 10^6_3	-	10.2	9.1	8.7	7.5	5.5	3.3	2.2	1.9	
WBC x 10^3	-	2.3	3.4	1.8	2.4	2.0	2.6	3.5	1.9	
Fawn #33										
PCV %	31.4	28.5	27.0	13.9	10.9	11.0	5.3[1]			
Hb gm%	13.6	11.2	10.8	6.0	3.6	3.9	1.9			
RBC x 10^6_3	-	8.3	9.0	3.9	3.1	2.9	3.6			
WBC x 10^3	-	2.1	2.3	2.9	2.7	2.5	2.8			
Fawn #31										
PCV %	26.1	22.4	15.2	5.9[1]						
Hb gm%	10.3	7.2	6.1	2.5						
RBC x 10^6_3	-	7.8	7.9	6.3						
WBC x 10^3	-	2.9	3.1	-						
Infected Ticks, Low Infestation										
Fawn #36										
PCV %	30.3	27.7	24.2	23.1	18.5	20.0	16.3	19.0	14.7	12.6
Hb gm%	10.3	11.5	9.0	9.0	7.2	6.8	6.1	6.5	5.8	4.7
RBC x 10^6_3	-	7.3	8.3	6.8	5.7	5.1	4.9	4.0	4.1	3.0
WBC x 10^3	-	2.5	3.5	4.0	5.2	4.3	2.7	2.9	3.7	5.1
Fawn #32										
PCV %	15.2	13.1	14.6	16.5	7.8	5.9[1]				
Hb gm%	5.6	4.7	5.4	6.0	2.9	1.9				
RBC x 10^6_3	-	5.9	6.9	6.7	4.7	-				
WBC x 10^3	-	2.8	3.5	2,1	6.9	-				
Fawn #35										
PCV %	27.9	28.5	27.2	17.1	13.0	19.3	14.1	19.0	17.5	16.4
Hb gm%	11.4	10.8	10.1	7.9	5.4	6.5	5.0	6.9	7.2	7.6
RBC x 10^6_3	-	9.8	10.1	6.0	5.4	5.2	5.7	5.6	6.3	6.1
WBC x 10^3	-	-	4.3	4.5	8.8	2.9	5.4	3.9	6.7	4.9

[1]Fawn died.

was not always exhibited. Control fawns demonstrated a slight reduction of the PCV, Hb, and RBC values for the first 2 to 3 weeks. This reduction was followed by a steady increase in magnitude of blood values until the experiment was concluded.

Clean Ticks and Infected Ticks-Low Infestation Fawn Treatments. In the fawns receiving the clean ticks-low infestation treatment, the PCV and Hb values of fawn #48 exhibited a reduction in excess of 55% of the initial blood levels by day 29-30 (Table II). A 50% reduction of the initial erythrocyte count was observed by day 35-36. Succeeding these significant reductions in blood levels, the PCV, Hb and erythrocyte counts were observed to increase steadily until the conclusion of the experiment. The total leukocyte values for fawn #48 ranged from 6.2 x 10^3 to 2.5 x 10^3 with a majority of the counts above 3.5 x 10^3 WBC. Only slight variations in these blood values were recorded for fawn #45 which died approximately 2 weeks post-treatment.

In the infected ticks-low infestation treatment, fawn #36 showed a terminal PCV reduction by 56% (30.0 to 13.0%) and fawn #35 exhibited a 54% (28.0 to 13.0%) decline by day 26-27. A two fold reduction of Hb and RBC was recorded for fawn #36 on day 41-44, while a similar decline in these blood values for fawn #35 was observed approximately one and a half weeks before the conclusion of the experiment. The total leukocyte counts for fawn #36 ranged from 2.7 to 5.1 x 10^3 WBC, while fawn #35 showed a high of 8.8 x 10^3 WBC and a low of 2.9 x 10^3 WBC. Prior to the death of fawn #32 on day 29-30, the initial PCV and Hb of 15.0% and 5.6 gm%, respectively, had been reduced by approximately 50%. Moderate variations were observed for the erythrocyte counts.

Although the PCV, Hb and erythrocytes of the 2 low infestation

treatments tended to rise and fall together throughout the testing period, the expected 3:1 ratio of PCV to Hb was not always evident.

Clean Ticks-High Infestation. Few hematological values were obtained from the clean ticks-high infestation treatment due to early mortality. However, significant reductions of PCV, Hb and RBC were recorded prior to death. The most marked decrease in these blood parameters was exhibited by fawns #42 and #30. The initial PCV and Hb values of fawn #42 were reduced from 22.7% and 8.5 gm%, respectively, to a terminal reading of 6.9% and 1.9 gm% on day 29-30 (Table II). Comparable blood measurements and reduction were also reported for fawn #30. The terminal measurements were recorded on day 26-27 for this fawn. A 50% decline in the initial RBC for animals #30 and #40 occurred approximately one week and 2 weeks, respectively, post infestation. The total leukocyte counts for fawn #30 ranged from 2.0 to 7 x 10^3 WBC while the range for fawn #40 was from 2.9 x 10^3 to 8.8 x 10^3 WBC. Moderate variations of PCV and Hb measurements were recorded for fawn #46 prior to death. The terminal RBC reading for this animal was approximately 50% of the initial level, while the terminal total leukocyte count showed a noticeable elevation when compared to the initial value.

I.V. Treatment (Theileria-Infected Blood). The PCV and Hb readings in the I.V. treatment group ranged from 16.0% to 24% and from 5.5 gm% to 9.7 gm%, respectively (Table II). Fawn #50 was the only animal in this treatment group which failed to exhibit elevated terminal measurements when compared to the initial blood values. The same trend was also noted in erythrocyte counts. The total leukocyte counts for the I.V. group ranged from 1.1 x 10^3 to 4.0 x 10^3 WBC, with no noticeable trend established between or within treatment animals.

Parasitism of Red Blood Cells

The results of the microscopic examinations of blood smears indicated that there were no intracellular blood parasites present in the peripheral blood of the following fawn treatments: clean ticks-low infestation; clean ticks-high infestation and control fawns (Table III). In the I.V. treatment animals, the first appearance of infected red blood cells in the peripheral circulation occurred approximately 9 days following inoculation with infected blood. The highest percent of infected erythrocytes observed in the I.V. group was 3.0%.

The parasitemia in the infected ticks-low infestation fawn treatment was observed in fawns #35 and #36 within 1 week following tick infestation. The percent of infected red blood cells for both fawns in this group was observed to moderately increase to day 33-34 (14.8%) and a general decline was then noted in infected blood cell numbers.

In the infected ticks-high infestation fawn group, infected blood cells were demonstrated within 4 days after the animals had been subjected to Theileria harboring ticks. The percent parasitemia in fawn #34 was less than 3.0% for approximately 4 weeks and then rose sharply to 60.0% on day 33-34. A major reduction to less than 9.0% was observed on day 38-40. The percent infected red blood cells for fawns #31 and #33 did not exceed 15%.

Fawn Weight Gains

Individual fawn weights as influenced by treatment and age are reported in Table IV. The weight gains in the I.V. and control fawn groups generally demonstrated a two fold increase in fawn weight from day 15 until the last recorded measurements.

TABLE III

PERCENT OF ERYTHROCYTES INFECTED BY THEILERIA SP.

Treatment Group	Age of Fawns (Days)									
	10-12	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
	Parasitemia %									
I.V.										
Fawn #50	0	0	0		3.0	1.3	1.4	1.6	1.3	
Fawn #49	0	0	0	0.5	1.0	0.7	0.3	0.3	0.3	
Fawn #47	0	0	0	0	0	0.1	0.1	0.2	0.5	
Infected Ticks, Low Infestation										
Fawn #35	0	0	0.2	3.1	11.4	6.9	5.3	2.3	1.5	2.6
Fawn #32	0	0	0	0	0	0.6[1]				
Fawn #36	0	0	1.9	2.3	3.8	5.0	14.8	8.4	7.3	6.5
Infected Ticks, High Infestation										
Fawn #31	0	0	0	15.0[1]						
Fawn #33	0	0	1.1	4.6	7.5	3.5	4.0[1]			
Fawn #34	0	0.5	1.4	0.8	1.5	2.5	59.9	39.0	8.8[1]	

[1]Fawn died.

TABLE IV

WEIGHT CHANGES OF WHITE-TAILED DEER FAWNS AS INFLUENCED BY TREATMENT AND AGE

Treatment Group	Approximate Age of Fawns (Days)						
	15	19	24	29	34	40	44
	Weight Gains (Pounds)						
Control							
41	7.0	8.0	10.5	11.0	12.5	14.0	16.0
43	5.0	6.5	7.0	8.5	10.0	11.5	13.0
44	4.0	5.0	6.0	6.5	9.5	11.0	
X-1	6.5	8.0	11.5	11.0	13.0		
X-3	8.0	9.0	10.5	12.0	14.0		
29	9.0	10.5	11.0[1]				
I.V.							
47	6.0	7.5	10.0	11.5	10.0		
49	5.0	4.5	6.0	8.5	11.5		
50	7.5	9.0	10.5	11.5	15.0		
Clean Ticks, High Infestation							
42	6.5	8.0	10.0	7.5[1]			
46	7.5	7.0	5.0[1]				
30	7.0	9.5	7.0[1]				
Clean Ticks, Low Infestation							
45	5.0	6.0	5.5[1]				
48	8.0	10.0	13.0	15.5	13.0	12.0	14.0
Infected Ticks, High Infestation							
31	5.5	7.5[1]					
33	9.0	9.5	11.0	10.0	9.5[1]		
34	8.0	10.0	11.5	10.0	11.5	10.0	7.0
Infected Ticks, Low Infestation							
32	6.0	8.0	7.5	4.5[1]			
35	6.0	6.0	7.0	10.0	12.5	14.0	11.0
36	6.5	5.0	7.0	7.0	9.5	11.0	9.0

[1]Fawn died.

In the clean ticks-high infestation and infected ticks-high infestation fawn groups, the post-treatment weight gains exhibited moderate elevations succeeded by a general decline in animal weights prior to death.

The initial weight increases in the clean ticks-low infestation and infected ticks-low infestation fawn groups exhibited a comparable increase with that of the control and I.V. fawn treatments. However, weight gains were suppressed in these groups during the latter portion of the experiment.

Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Hemoglobin Concentration (MCHC) and Leukocyte Differential of Fawn Treatment Groups

In the clean ticks-high infestation and infected ticks-high infestation fawn treatments, the MCV measurements generally fell within the control fawn treatment range of 31.0 μ^3 - 23.3 μ^3 (Table V). However, there were some measurements of the clean ticks-high infestation treatment animals which exceeded or fell below the values established for the control animal group. In the infected ticks-high infestation animal treatment, a prominent elevation in the MCV was observed in the terminal readings (33.0 μ^3 to 42.7 μ^3), while no appreciable trend was noted in the clean ticks-high infestation animals. The MCH values for both of these groups generally ranged from one to 2 micrograms above the control animal values. While the MCHC values for the control animal group remained fairly constant, the MCHC for the 2 high tick infestation fawn treatments showed a definite reduction.

The percent of neutrophils and lympocytes in the clean ticks-high

TABLE V

HEMATOLOGICAL VALUES OF WHITE-TAILED DEER FAWNS AS INFLUENCED BY TREATMENT AND AGE

Age of Fawns (Days)	MCV μ^3	MCH $\mu\mu g$	MCHC %	Differential Leukocyte Count (Percent)				
				Neutro.	Lympho.	Mono.	Eosino.	Baso.
			Control Group[1]					
10-12	31.2	11.1	39.3	64.9	30.7	3.6	0.80	0
14-16	24.6	8.8	36.1	63.6	31.7	4.3	0.33	0
17-19	28.7	10.5	36.7	55.6	38.6	3.3	2.3	0
21-24	25.7	9.8	37.7	74.3	23.3	1.8	0.33	0.17
26-27	25.5	9.7	38.7	64.2	30.5	4.6	0.25	0.25
29-30	25.6	9.6	37.1	59.6	38.0	0	2.0	0.33
33-34	26.1	9.8	38.1	66.4	30.8	1.4	1.4	0
35-36	21.8	9.4	39.3	67.3	29.3	2.3	0.66	0.33
38-40	23.6	10.9	45.0	59.0	39.3	0	1.7	0
41-44	23.3	9.6	41.3	61.5	35.5	1.5	1.5	0
			I.V. Group[2]					
10-12	29.7	10.1	34.4	58.3	39.0	0.8	1.8	0
14-16	25.6	10.1	38.2	53.0	42.3	2.3	2.3	0
17-19	28.9	11.1	38.5	67.0	31.0	2.5	0	0
21-24	24.6	10.1	40.0					
26-27	29.1	12.1	37.8	62.6	34.3	1.6	0.7	0
29-30	26.0	10.4	39.4	50.0	48.0	1.3	0	0.7
33-34	25.9	10.8	41.5	79.5	18.0	2.0	0	0.5
35-36	26.5	16.7	44.2	62.6	33.6	2.6	0	1.0
38-40				39.5	57.0	2.5	0.5	0.5
41-44								
			Clean Ticks - High Infestation[3]					
10-12	24.3	8.1	36.7	55.3	39.6	3.3	1.7	0
14-16	26.8	12.7	45.4	49.0	46.0	2.0	3.0	0
17-19	34.5	12.2	35.9	46.0	44.0	9.0	1.0	0
21-24	18.5	6.6	35.7	46.5	45.0	7.5	0.5	0.5
26-27	24.0	10.2	42.6					
29-30[4]	25.5	7.3	28.4					
33-34								
35-36								
38-40								
41-44								
			Clean Ticks - Low Infestation[5]					
10-12	32.2	10.5	36.1	62.5	33.6	1.3	2.0	0.33
14-16	25.7	10.4	42.1	63.5	32.0	4.5	0	0
17-19	39.5	14.5	41.2	51.5	46.0	2.0	0.5	0
21-24	28.0	10.6	37.5	69.0	26.5	3.0	1.5	0
26-27	26.2	10.4	38.2					
29-30	27.9	10.7	38.3	67.0	31.0	2.0	0	0
33-34			35.0	75.0	20.0	3.0	0	2.0
35-36	31.3	15.0	47.7	77.0	20.0	1.0	0	2.0
38-40	30.8	12.3	40.0	72.0	26.0	2.0	0	0
41-44	36.2	14.7	40.7	59.0	29.0	0	4.0	8.0

TABLE V (Continued)

Age of Fawns (Days)	MCVμ³	MCHμμg	MCHC %	Differential Leukocyte Count (Percent)				
				Neutro.	Lympho.	Mono.	Eosino.	Baso.
			Infected Ticks - High Infestation[3]					
10-12			38.8	50.7	41.0	6.0	1.6	0.6
14-16	30.8	11.0	35.8	38.6	54.3	4.6	2.3	0
17-19	26.6	10.5	38.7	46.6	49.0	4.3	0	0
21-24	24.9	10.3	41.4	37.7	59.6	3.0	1.3	0
26-27	28.2	10.1	36.0	40.0	56.0	2.0	2.0	0
29-30	33.0	11.8	36.0	42.5	51.0	4.0	2.5	0
33-34			33.9	54.0	39.5	5.0	0.5	0.5
35-36	46.3	13.6	29.4	17.0	60.0	4.0	19.0	0
38-40[4]	42.7	13.4	32.4	61.0	30.0	9.0	0	0
41-44								
			Infected Ticks - Low Infestation[6]					
10-12			41.4	66.6	27.9	3.7	1.3	2.2
14-16	29.7	11.5	41.8	61.0	33.5	2.5	3.0	0
17-19	25.9	9.6	36.9	52.6	43.3	3.6	0.3	0
21-24	29.0	11.8	40.9	42.6	55.3	0.6	1.3	0
26-27	25.6	9.6	38.8	56.6	39.0	2.7	1.7	0
29-30	38.2	12.8	34.5	84.0	15.0	1.0	0	0
33-34	29.3	10.6	36.2	39.5	50.0	7.0	2.0	1.5
35-36	41.0	14.2	34.9	34.0	56.0	4.5	5.0	0.5
38-40	32.2	12.8	39.9	46.0	39.5	7.0	7.5	0
41-44	35.3	14.1	41.1	47.0	39.0	9.0	5.0	0

[1]Sample size - range from 5 to 6 fawns.

[2]Sample size - 3 fawns.

[3]Sample size - range from 1 to 3 fawns.

[4]Terminal measurement due to death of fawn.

[5]Sample size - range from 1 to 2 fawns.

[6]Sample size - range from 2 to 3 fawns.

infestation fawn treatment were observed to be approximately equal throughout the test period. In the infected ticks-high infestation fawn treatment the percent of lymphocytes generally exceeded the neutrophils. The percent of basophils and eosinophils for this fawn group was slightly elevated above the control animal treatment readings.

The initial MCV readings of the clean ticks-low infestation and infected ticks-low infestation treatments closely approximated the early measurements established for the control animal group of 32.2 μ^3 by day 26-37. Following this early trend, the MCV of the 2 low infestation animal treatments began to increase until the conclusion of the experiment.

The terminal MCV measurements of the above groups exceeded the last recorded reading of the control fawn group by 12 μ^3. The MCH of clean ticks and infected ticks-low infestation treatments consistently read 1 to 2 micromicrograms higher than the control treatment. The MCHC for the clean ticks-low infestation fawn treatment ranged from 35.0% to 47.0% while the same factor for the infected ticks-low infestation animal group ranged from 34.0% to 42.0%.

The percent neutrophils ranged from 77.0% to 51.0% in the clean ticks-low infestation fawn group while the percent neutrophils ranged from 34.0% to 66.6% in the infected ticks-low infestation fawn group. During the terminal phase of the experiment the latter group of fawns demonstrated a 25.0% to 60.0% higher lymphocyte count than that reported for the clean ticks-low infestation fawn treatment.

Blood Smear Erythrocyte Form

A composite of erythrocyte forms are summarized in Table VI. From

TABLE VI

COMPOSITE OF BLOOD VALUES IN WHITE-TAILED DEER FAWNS AS INFLUENCED BY TREATMENT AND AGE

Treatment Group	Age of Fawns (Days)									
	10-12	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
Control[1]										
H-J Bodies	O-S[2,3]	O-S	O-S	O-S	O-M[4]	O-M	O-S		O-S	O-S
Basophilic Stippling	O-S	O-S	O	O-S	O	O	O-S	O-S	O-S	O
Anisocytosis	O-P[5]	O-P	O-P	O-P	O-P	O-P	P	P	P	P
Poikilocytosis	O-P	O-P	O-P	O-P	O-P	O-P	P	P	P	P
Polychromasia	O-S	O-M	O-S	O-S	O-S	O-S	O-S	O-S	O	O
Sickle Cells			0-2/3	0-3/3	0-3/3	0-2/3	0-3/3	1/3-2/3	1/3-3/3	2/3-3/3
I.V. Group[6]										
H-J Bodies	S	O-S	S-N[7]	S	O	O-S	S	O	S	
Basophilic Stippling	S	O-S	S-M	O-S	O	O	O-S	O	O	
Anisocytosis	O-P	P	P	P	O	P	P	P	O	
Poikilocytosis	O-P	P	P	P	O	P	P	P	O	
Polychromasia	O-S	O-S	S	O-S	O	O-S	O	O	O	
Sickle Cells	0-1/3	0-1/3	1/3-2/3	0-2/3	O	0-3/3	0-3/3	2/3-3/3	0-3/3	
Clean Ticks - High Infestation[8]										
H-J Bodies	O-S	O-S	O-N	O	O-S	O[9]				
Basophilic Stippling	O-M	O-S	O-M	O-S	O	O				
Anisocytosis	P	P	O-P	P	O	O				
Poikilocytosis	P	P	O-P	P	O	O				
Polychromasia	O-M	O-S	O-N	O-M	O-M	O				
Sickle Cells	O	O	0-2/3	0-2/3	0-1/3	O				
Clean Ticks - Low Infestation[10]										
H-J Bodies	S	S	S	O-S	O	O	S	O	S	O
Basophilic Stippling	S	S	O	O	O	O	O	O	O	O
Anisocytosis	O-P	O	O-P	O	O	O	O-P	P	P	O
Poikilocytosis	O-P	O	O-P	O-P	O	O	O-P	P	P	O
Polychromasia	O-S	O-S	O-S	S	O	O	S	S	M	S
Sickle Cells	O	O	O	O	O	O	O	O	O	O
Infected Ticks - High Infestation[8]										
H-J Bodies	S	O-S	O-S	O-S	O-S	O	O-N	M	S	
Basophilic Stippling	S	O	O	O-S	O-S	O	O-S	S	O	
Anisocytosis	P	O-P	O-P	P	O-P	O	O	O	O	
Poikilocytosis	P	P	O-P	P	O-P	O	O	O	O	
Polychromasia	O-S	O	O	S-N	O-S	O	M	M	S	
Sickle Cells	O	O	O	O	O	O	O	O	O	

TABLE VI (Continued)

Treatment Group	Age of Fawns (Days)									
	10-12	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
	Infected Ticks - Low Infestation[11]									
H-J Bodies	0-S	0-S	0-S	0-M	0-S	0	S-M	0-M	0-N	S-M
Basophilic Stippling	0-S	0	0-M	0-S	0-S	0	S-M	S-M	0-S	0-M
Anisocytosis	P	0-P	P	P	P	0-P	0-P	P	P	P
Poikilocytosis	P	0-P	P	P	P	0-P	P	P	P	P
Polychromasia	0	0	P-N	0-S	S-N	0	M-N	0-N	M-S	S-M
Sickle Cells	0	0-1/3	0-1/3	0-2/3	0-3/3	0	1/3-2/3	0-1/3	0-3/3	0-2/3

[1]Sample size - range from 5 to 6 fawns.

[2]Erythrocytic form not present.

[3]Scanty (1 cell type/600 RBC).

[4]Moderate (2-4 cell types/600 RBC).

[5]Cell type present.

[6]Sample size - 3 fawns.

[7]Numerous (5 or more cell types/600 RBC).

[8]Sample size - range from 1 to 3 fawns.

[9]Terminal measurements due to death of fawn.

[10]Sample size - range from 1 to 2 fawns.

[11]Sample size - range from 2 to 3 fawns.

this information the results indicate that irregular red blood cell morphology (poikilocytosis) and variable erythrocyte size (anisocytosis) are a common factor to all fawn groups. In those animals where anisocytosis was prevalent, an approximate two-fold increase in size was noted for some RBC. Other erythrocyte forms which were present in each test group were Howell-Jolly bodies, basophilic stippling, and polychromasia. Based on the information presented in this table, the data does not seem to exhibit any interpretable trends within or between the specific fawn treatments.

Discussion

As a result of the information obtained in the present investigation (Table I), it appears that mortality in white-tailed deer fawns may be induced when young animals are subjected to 150 to 540 adult lone star ticks per week for ca 4 weeks. Results in Table I show that all fawns in treatments receiving high numbers of clean or infected ticks succumbed within 30 days post tick infestation, while only 1 fawn death occurred in each of the 2 low tick infestation treatments. Observations by other workers under field conditions (Bolte, et al., 1970 and Emerson, 1969) and laboratory conditions (Barker, et al., 1973) have also noted a definite correlation between tick infestation level and fawn mortality.

Although not stated in the reports of other researchers (Bolte, et al., 1970, and Barker, et al., 1973) it is evident from the present findings that young fawns may vary in susceptibility to similar numbers of ticks. This premise is most evident when reviewing the length of fawn survival in the different fawn treatments (Table I) and the hematological data in Table II.

Prior to the present experiment, the effects of theileriasis in white-tailed deer has been relatively undefined. However, due to the results of the present investigation, it would appear that the blood parasite (Theileria sp.) was not a significant factor in contributing to fawn mortality, in the different experimental fawn treatments. This is supported in part by the findings presented in Table I which show the same number of fawn losses between the Theileria infected tick fawn treatments and clean tick fawn treatments. In the infected ticks-low infestation fawn treatment 1 fawn died with a parasitemia level of less than 1.0%, while the surviving fawns of this group exhibited a parasitemia level of up to 15.0%. Similar studies conducted by other workers (Barker, et al., 1973) have reported that a parasitemia by Theileria of 10.0% in young fawns moderately parasitized by lone star ticks did not cause animal mortality.

Moreover, no fawn mortality or fawn activity change was noted in the fawns which received Theileria infected blood intravenously. The parasitemia in this fawn group did not exceed 3.0% within the limits of these experiments. Comparable findings were also reported by Robinson, et al. (1967), in which young fawns were inoculated with Theileria infected blood. The parasitemia level in these animals did not exceed 4.0% and no fawn mortality was obtained. Thus, it would seem reasonable to conclude that low levels of Theileria-infected red blood cells are not an etiological factor in predisposing fawn mortality.

However, in experiments conducted with Theileria-infected deer which have been splenectomized, the results seem to be more variable. While investigating Theileria cervi infections in Missouri white-tailed deer, Schaeffler (1962) described this intracellular blood organism as being

highly pathogenic to deer. In his study all infected deer died. Comparable findings with Theileria-infected splenectomized deer were reported by Krier, et al. (1962). In contrast to these workers, Robinson, et al. (1967) reported one death in an expermental group of six fawns which had been splenectomized and inoculated with Theileria sp. infected blood. In the present study the parasitemia of a splenectomized fawn was observed to be in excess of 50% and no demonstrable suppression of fawn activity was noted.

These findings tend to suggest that the pathogenicity of Theileria sp. which exists in the different geographical areas may vary in its ability to produce pathological symptoms and deer mortality. Furthermore, when comparing the percent of Theileria-infected red blood cells of intact deer with that of splenectomized deer, it is evident that intact deer are much more effective in maintaining a low blood parasite level. This was expected, since the spleen is a major organ in an animal's defense system (Schalm, 1970).

When reviewing the results of Barker, et al. (1973) and Table III, there appears to be a discernible relationship between the number of infective ticks parasitizing a host and the percent of Theileria-infected red blood cells. It is plausible that this correlation may be predisposed by 2 principal factors: (1) an increased number of infective blood parasites being injected into an animal due to a larger number of infected feeding ticks or (2) the depression of an animal's physical stamina and defense system due to tick-associated factors (Van Volkenberg and Nicholson, 1943; Neitz, 1962) or (3) both. Therefore, if one assumes that a correlation of these factors does exist, it would seem logical that the specific effects of tick parasitism and theileriasis may act as

an additive or in a synergistic manner in causing fawn mortality.

The findings presented in Table II show that severe anemic conditions were developed in those fawns infested with high levels of Theileria-infected and non-infected ticks, while a subacute anemia was developed in the infested animals with low tick numbers. In the 2 high tick infestation treatments, the PCV, Hb and RBC were reduced below 65% of the initial blood measurements while the same factors for the animals recovery low tick numbers were reduced by approximately half of their starting values. Similar hematological reductions of tick infested fawns have also been reported by previous investigators (Bolte, et al., 1970 and Barker, et al., 1973). The previously reported reduction in blood parameters may be due in part to exsanguination of fawns by ticks. In addition to the lowering of the PCV, Hb and RBC by blood removal, it has also been speculated by other workers (Jellison and Kohls, 1937, Springell, et al., 1970) that the hemopoetic system of an animal host may be suppressed due to toxic compounds received during tick feeding. However, the toxic nature and identification of such a tick induced compound(s) has not been established. It is felt that research endeavors in this area would be very beneficial in further explaining the acute blood reductions observed in young deer.

Nevertheless, it has been firmly established that ticks are capable of concentrating their blood meal by eliminating excess water, therefore allowing for a significant increase in the quantity of red blood cells that may be withdrawn from a host by tick parasitism (Gregson, 1967; Tatchell, 1967; Seifert, 1968; Snow, 1970; Lee, 1946; and Sauer and Hair, 1972). It would, therefore, seem probable that the anemic condition existing in animals heavily infested with ticks is primarily the result

of blood removal from the host. Supporting evidence of this premise is established when comparing the severity of animal blood loss and the number of feeding ticks. Those animals supporting the largest number of ticks demonstrated the greatest reduction of PCV, Hb and RBC (Bolte, et al., 1970 and Barker, et al., 1973).

Based on the RBC, Hb and PCV data presented in Table II, it would appear that the blood parasite was not a significant factor in the rate of erythrocyte reduction. This postulation was founded on the lack of discernible differences in these blood factors when comparing Theileria-infected fawn treatments of similar tick infestation levels. Furthermore, a detectable decline in PCV, Hb and RBC due to theilerasis was not observed in the group of fawns inoculated intravenously with Theileria sp. infected blood. Thus, it would appear that the primary cause of fawn mortality was due to major hematological reductions attributed to blood loss and tick-host interaction.

The morphological classification of the blood anemia exhibited by the tick infested fawns was difficult to ascertain due to the limited number of animals contained in the different treatment groups and the sickling of red blood cells exhibited by fawns in the different treatment groups. It was felt that the sickling of red blood cells would influence the PCV readings which are used in calculating the MCV and MCHC values (Schalm, 1970).

Nevertheless, the morphological classification of the blood anemia shown by fawns in the tick infested treatments was considered to be a normocytic norochromic anemia. This assumption was formulated by comparing the MCV and MCHC measurements of the tick infested fawns with the same values obtained for the control fawns.

Blood slides of the animals under study were examined in hopes that the erythrocytic cell forms present in the peripheral vascular circulation would provide a useful index in monitoring the fawn erythrocytic response. Based on the information presented in Table VI, the blood cellular forms of the different test groups did not show any major trends in contrast to the control fawns or within the treatment groups. The lack of an erythropoetic response to tick induced blood losses in bovine was reported by O'Kelly, et al. in 1971.

The following factors were considered to be possible explanations for the lack of a noticeable erythropoetic response to the anemic fawn conditions observed in the present study: (1) the death of the animals occurred before the erythropoetic system could respond to the blood loss, or (2) that the erythropoetic system was suppressed by undetermined tick-induced toxins.

Due to the moderate variations obtained in the total leukocyte counts (Table II) and leukocyte differentials (Table V), the results did not indicate an appreciable difference between or within treatment groups. In contrast to these findings, O'Kelly, et al. (1971) reported a significant elevation in tick-infested cattle of the lymphocytes and eosinophils, and a decline of neutrophils.

The percent of sickling erythrocytes was observed to fluctuate within and between treatments (Table VI). The sickling phenomenon of deer red blood cells was recognized many years ago by Gulliver (1840), and has been observed by numerous other investigators (O'Roke, 1936; Dougherty, 1939, Whitlock, 1939). In more recent investigations, Kitchen, et al. (1964) indicated that the sickling phenomenon is related to the presence or absence of different types of hemoglobins and that the sickling of red

blood cells in deer does not seem to impair the animal's health.

In addition to observations which were made on the percent of sickling erythrocytes, sickled red blood cells were secondarily examined to determine if sickled cells were infected by the blood parasite (Theileria sp.). Blood smear examinations revealed that many of the sickled cells contained one or more protozoan parasites. There does not seem to be a correlation between the total percent of infected RBC and the percent of sickled cells.

Fawn weight losses and the suppression of fawn weight gains (Table IV) seem to be directly correlated with the number of feeding ticks and unrelated to the presence of the infective blood parasite. These findings are somewhat in contrast with the results of other workers (Barker, et al., 1973) who have monitored weight development of young deer infested with lone star ticks. Although these workers observed suppressed weight development in fawns infested with lone star ticks, they did not note a definite correlation between fawn weights and tick infestation level.

Depressions of weight gains have also been observed in cattle following heavy infestations with the cattle tick (Boophilus microplus) (Francis, 1960; Little, 1963; and Johnston and Haydock, 1969). Other investigators (O'Kelly, et al., 1970) suggested that tick toxins may suppress an animal's metabolic functions, thus resulting in reduced weight gains. Another important factor to consider in fawn weight development is reduced food intake (Seebeck, et al., 1971). In the present study, it was thought that a combination of these factors was the cause of reduced fawn weight.

CHAPTER III

INFLUENCE OF *AMBLYOMMA AMERICANUM* (L.) (ACARINA: IXODIDAE) AND *THEILERIA* SP. (PIROPLASMORIDA: THEILERIIDAE) ON BLOOD CHEMISTRY OF NEONATAL WHITE-TAILED DEER FAWNS

Numerous investigators (Bishop and Trembley, 1945; Hair and Howell, 1970, Brennan, 1945; Calhoun, *et al.*, 1956) have recognized white-tailed deer (*Odocoileus virginianus*) as being an important host or the lone star tick [*Amblyomma americanum* (L.)].

Recently it has been demonstrated that lone star tick parasitism is a major factor in reducing young deer survival (Bolte, *et al.*, 1970; Emerson, 1969; and Barker, *et al.*, 1973). Under field conditions, Bolte, *et al.* (1970) reported that 57% of the annual fawn crop was lost each year in eastern Oklahoma due to tick parasitism of deer fawns. Later investigators (Barker, *et al.*, 1973) reported the presence of a blood protozoan (*Theileria* sp.) infecting many of their test animals.

Until this study the influence of tick parasitism and/or theileriasis on white-tailed deer physiology has been defined mainly by host blood hematocrit and hemoglobin.

Although hematocrit and hemoglobin are very important blood factors in determining the physiological condition of an animal, it was felt that additional blood parameters should be monitored in order to gain a better insight as to how a fawn's physiology is changed by tick parasitism

and/or blood parasite.

Materials and Methods

Experimental Animals and Blood Samples

Blood chemistry analyses were conducted on 20 white-tailed deer fawns for a period of approximately 6 weeks. The methods of animal handling and blood removal are discussed in Chapter II.

Analytical Techniques

Blood serum ion assays for K, Na, and Ca were determined with a Beckman 440 atomic absorption spectrophotometer, while the chloride ion concentrations were determined with a Fiske/Marius micro-chlor-o-counter. Bilirubin measurements were made by a modification of the method of Malloy and Evelyn (presented in Clinical Chemistry Principles and Techniques, 1964) and blood urea nitrogen (BUN) was determined by the method employed by Chaney and Marback (1962). The total serum protein measurements were determined by using a Baush and Lomb protein meter. Tests for serum enzyme levels of serum glutamic oxaloacetic transaminase (SGOT) and serum glutamic pyruvic transaminase (SGPT) were determined by the use of a clorimeter (Baush and Lomb Spectronic 20^{R}) and Sigma^{R} transaminase kits.[1]

Results

A summary of measured serum electrolytes as influenced by treatment and age is presented in Table VII.

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[1]Sigma Chemical Company, P. O. Box 14508, St. Louis, Mo. 63178

TABLE VII

BLOOD SERUM ELECTROLYTES OF WHITE-TAILED DEER FAWNS AS INFLUENCED BY TREATMENT AND AGE

Treatment	Age of Fawns (Days)											
	10[1]	11[1]	12[1]	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
					Electrolyte (Sodium)[2]							
Control[3]	128.6	169.0	142.9	150.4	163.5	150.7	155.7	143.5	140.5	143.5	136.1	126.5
I.V.[4]	138.1	-	-	145.8	142.8	156.6	161.0	157.5	134.3	134.5	137.3	-
Clean Ticks,[5] High Infestation	133.7	146.0	140.2	144.0	146.0	148.0	159.2	152.0[6]				
Clean Ticks,[7] Low Infestation	138.7	-	125.0	147.0	149.0	138.5	159.5	190.0	170.0	163.0	142.0	135.0
Infected Ticks,[5] High Infestation	115.0	146.5	155.8	148.0	148.1	144.3	151.0	150.5	157.2	136.0	129.0[6]	
Infected Ticks,[8] Low Infestation	106.0	152.3	163.5	146.8	155.1	158.5	181.1	163.5	161.5	141.7	129.0	135.2
					Electrolyte (Potassium)[2]							
Control	9.0	9.8	9.2	9.3	9.3	9.2	9.6	9.1	9.3	9.8	9.9	9.7
I.V.	9.1	-	-	10.1	9.0	10.3	8.5	9.8	9.8	9.3	9.2	-
Clean Ticks, High Infestation	8.2	8.3	9.8	9.4	8.4	8.5	8.9	8.2[6]				
Clean Ticks, Low Infestation	8.7	-	9.1	9.3	9.9	9.3	8.9	9.0	10.5	10.8	10.6	9.6
Infected Ticks, High Infestation	-	9.8	-	8.0	8.7	8.8	8.4	6.6	8.5	8.6	6.3[6]	
Infected Ticks, Low Infestation	-	9.4	9.7	9.1	7.5	8.5	9.2	8.8	9.3	10.2	9.3	9.0
					Electrolyte (Chloride)[2]							
Control	95.2	92.2	103.9	104.7	104.5	111.2	106.7	102.8	99.5	103.6	99.7	100.6
I.V.	102.4	-	-	103.5	109.6	105.6	117.7	107.3	99.4	105.0	98.8	
Clean Ticks, High Infestation	97.8	94.2	103.4	104.2	104.1	114.6	113.1	129.9[6]				
Clean Ticks, Low Infestation	98.9	-	101.5	104.4	108.0	108.5	114.3	101.4	137.3	118.4	96.6	91.6
Infected Ticks, High Infestation	-	98.1	-	103.3	100.4	112.9	108.9	102.2	112.6	106.9	95.6[6]	
Infected Ticks, Low Infestation	94.6	96.1	98.1	103.5	101.2	109.8	117.2	115.3	112.4	102.4	99.4	95.7
					Electrolyte (Calcium)[9]							
Control			2.9		3.2		2.6		2.6	2.8	1.9	2.6
I.V.					2.2	2.7	2.8	2.8	-	2.4	2.2	
Infected Ticks High Infestation		3.8			3.1		2.9	1.8	2.0		1.9[6]	

[1]Pretreatment values.

[2]m Eq/L.

[3]Sample size - range from 5 to 6 fawns.

[4]Sample size - 3 fawns.

[5]Sample size - 1 to 3 fawns.

[6]Terminal measurement due to death of fawns.

[7]Sample size - 1 to 2 fawns.

[8]Sample size - 2 to 3 fawns.

[9]mg/100 ml.

In the control fawn group a 43.5 m Eq/L fluctuation of Na ion from 126.5 to 169.0 m Eq/L was observed, while a range from 134.5 to 161.0 m Eq/L existed in the I.V. fawn treatment. In both of these groups Na tended to increase until day 26-27 and was followed by a slight reduction until the conclusion of the experiment. A corresponding rise and fall of this electrolyte was also noted for the clean ticks- and infected ticks-low infestation animal treatments. Animals infested with high levels of clean ticks and infected ticks seemed to exhibit less variations of the Na ion than the low tick infestation animal treatments.

Only slight variation in the I.V. fawn treatment K ion concentration (8.5-10.3 m Eq/L) was detectable when compared to the control fawn treatment K ion levels (9.0-9.9 m Eq/L). The K levels for those animals supporting low infestation levels of ticks ranged from 7.5 to 10.8 m Eq/L, with the lower K ion concentration being detected in the infected ticks-low infestation treatment. In the clean ticks-high infestation animals, the K concentration was elevated approximately 1 m Eq/L (8.3-9.8 m Eq/L) for a short period of time and then declined by the same amount. The greatest deviation in the K ion level was recorded for the high infected tick treatment, which slightly exceeded a 3.0 m Eq/L drop (9.8-6.3 m Eq/L). The serum Cl concentration for the control animal treatment ranged from 92.2 to 111.2 m Eq/L, while the Cl ion range for the I.V. fawn treatment was 98.8 to 117.7 m Eq/L. The greatest range of Cl ion concentration for the different treatment groups was recorded for the clean ticks-low infestation fawn treatment (91.6-137.3 m Eq/L). The ionic assays of the infected ticks-low infestation and the high tick infestation fawn treatments closely approximated the electrolyte levels established for the I.V. fawn group. In all treatment groups there was a moderate elevation

of the Cl ion concentration succeeding the initial measurements followed by a decline to pre-treatment levels.

Only a limited number of Ca ion readings were determined for 3 fawn treatment groups. The ionic concentration of Ca for the control and I.V. fawn treatments were approximately the same (1.9-3.2 m Eq/L), with less than a 1.3 m Eq/L range of fluctuation between the highest and lowest value. For the infected ticks-high infestation the ionic range was slightly in excess of 1.5 m Eq/L.

Blood Urea Nitrogen and Total Protein Measurements

The values obtained for serum total protein and serum blood urea nitrogen are presented in Tables VIII and IX, respectively. From this information it was observed that more than 70% of the serum total protein readings for the control and I.V. fawn treatments fell within a range of 4.0 to 4.5 mg/100 ml. The initial serum total protein readings in the clean ticks-low infestation animals were similar to those in the control animals, while the concluding readings of the tick infested group declined slightly below 4.0 mg/100 ml. The early measurements of serum total protein in the infected ticks-low infestation animals were higher than the control fawn group, but fell below the latter group on days 38-40 and 40-44. A similar trend was noted in the clean ticks-high infestation fawn treatment. However, a reading below 4.0 mg/100 ml was recorded 2 weeks sooner than a similar value in the infected ticks-low infestation animals. The largest reduction of total protein (5.6 gm/100 ml to 2.95 gm/100 ml) occurred in the infected ticks-high infestation animal group.

The largest fluctuation of serum blood urea nitrogen (BUN) for the

TABLE VIII

TOTAL PROTEIN VALUES OF WHITE-TAILED DEER FAWNS AS INFLUENCED BY TREATMENT AND AGE

Treatment Group	Age of Fawns (Days)											
	10[1]	11[1]	12[1]	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
Control[2]												
Total Protein	4.8[3]	4.8	4.9	4.6	4.5	4.6	4.5	4.4	4.2	4.1	4.2	4.6
I.V.[4]												
Total Protein	4.7		4.4	4.3	4.1	4.3	4.4	4.3	4.3	4.1	4.1	
Clean Ticks,[5] High Infestation												
Total Protein	5.0	5.7	5.5	5.0	4.4	4.4	4.1	3.7[6]				
Clean Ticks,[7] Low Infestation												
Total Protein	4.5	4.5	4.3	4.2	3.8	4.2	4.0	4.2	3.8	4.1	3.8	3.8
Infected Ticks,[5] High Infestation												
Total Protein	5.6	5.6	5.3	5.3	4.3	4.0	4.1	4.2	3.4	3.9	2.9[6]	
Infected Ticks,[8] Low Infestation												
Total Protein	5.9	5.7	5.8	5.6	5.2	4.5	4.4	4.6	4.6	4.2	3.8	3.9

[1]Pretreatment values.

[2]Sample size - range from 5 to 6 fawns.

[3]gm/100 ml.

[4]Sample size - 3 fawns.

[5]Sample size - range from 1 to 3 fawns.

[6]Terminal measurement due to death of fawns.

[7]Sample size - range from 1 to 2 fawns.

[8]Sample size - range from 2 to 3 fawns.

TABLE IX

VALUES OF BLOOD UREA NITROGEN (BUN) OF WHITE-TAILED DEER FAWNS AS INFLUENCED BY TREATMENT AND AGE

Treatment Group	Age of Fawns (Days)											
	10[1]	11[1]	12[1]	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
Control[2]												
BUN	9.9[3]	9.3	14.3	27.6	36.0	34.6	20.3	23.1	30.8	22.6	28.6	30.8
I.V.[4]												
BUN	9.2		12.8	17.0	39.0	31.6	28.0	34.0	33.8	25.3	35.6	
Clean Ticks,[5] High Infestation												
BUN	10.0	15.0	20.9	27.2	27.0	36.6	77.0[6]					
Clean Ticks,[7] Low Infestation												
BUN	8.6		12.5	18.2	30.2	32.0	36.5		62.4	62.0	38.0	41.0
Infected Ticks,[5] High Infestation												
BUN		8.7	7.5	10.3	20.7	46.6	40.0	45.5	77.5	52.0	42.0[6]	
Infected Ticks,[8] Low Infestation												
BUN	12.7	17.0	9.1	12.0	17.7	24.7	63.3	66.6	39.2	35.3	28.0	48.0

[1]Pretreatment Values

[2]Sample size - range from 5 to 6 fawns.

[3]mg/100 ml.

[4]Sample size - 3 fawns.

[5]Sample size - range from 1 to 3 fawns.

[6]Terminal measurement due to death of fawns.

[7]Sample size - range from 1 to 2 fawns.

[8]Sample size - range from 2 to 3 fawns.

control and I.V. fawn treatments occurred within the first week of blood sample determination, while the remaining values tended to stabilize between 20 to 35 mg/100 ml (Table IX). The serum BUN of the clean ticks- and infected ticks-low infestation treatments was increased moderately during the initial test phase with substantial BUN elevations occurring on days 26-27 (63.3 mg/100 ml, infected ticks-low infestation) and 33-34 (62.4 mg/100 ml, clean ticks-low infestation). A steady decline in the serum BUN followed these elevated readings. The highest serum BUN occurred in the 2 animal treatments infested with high levels of clean and infected ticks. For the first week, serum BUN readings for the infected ticks-high infestation animals were consistently lower than those recorded for the control fawn treatment. However, following this period of time the former fawn group was 10 to 20 mg/100 ml above the readings of the control animals.

Blood Serum Enzymes

Values for the blood enzymes serum glutamic pyruvic transaminase (SGPT) and serum glutamic oxaloacetic transaminase (SGOT) are summarized in Table X. In the control animal group the SGPT and SGOT ranged from 4.0 to 12.0 Sigma Frankel Units (SFU) and 20.0 to 64.0 SFU, respectively. The serum concentration of these enzymes of the I.V., clean ticks-low infestation fawn groups closely approximated the serum enzyme range reported for the control animal treatment. The SGOT of the infected ticks-low infestation animal group exhibited a moderate elevation in concentration (57 SFU, day 29-30) and then quickly receded, followed by elevated concentrations. A similar, irregular SGOT concentration pattern was also exhibited by the infected ticks-high infestation animal

TABLE X

VALUES OF SERUM ENZYMES GLUTAMIC PYRUVIC TRANSAMINASE (SGPT) AND GLUTAMIC OXALACETIC TRANSAMINASE (SGOT) AS INFLUENCED BY TREATMENT AND AGE

Treatment Group	Age of Fawns (Days)											
	10[1]	11[1]	12[1]	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
Control[2]												
SGPT	12.0[3]	8.0	4.8	7.3	10.5	4.3	7.0	7.6	8.2	8.0	8.0	12.0
SGOT	64.0[3]	47.0	35.5	42.6	41.6	20.1	30.8	30.2	28.6	35.0	36.3	49.0
I.V.[4]												
SGPT	9.6		9.6	3.6	5.6	4.5	9.5	4.3	12.0	6.3	9.3	
SGOT	40.0		44.0	14.0	23.3	29.0	32.7	8.0	32.3	37.0	36.0	
Clean Ticks,[5] High Infestation												
SGPT	11.0		5.5	6.9	3.7	4.0	13.5	4.0[6]				
SGOT	32.0	44.0	46.0	29.7	24.3	14.5	31.0	30.0				
Clean Ticks,[7] Low Infestation												
SGPT	9.0	12.0	3.0	7.5	3.0	5.0	8.5	13.0	6.0	16.0	10.0	10.0
SGOT	48.0	45.0	38.0	25.0	22.5	15.5	27.5	25.0	13.0	20.0	24.0	48.0
Infected Ticks,[5] High Infestation												
SGPT		11.0		13.6	5.6	6.6	6.5	16.5	12.5	14.0	17.0[6]	
SGOT		67.0		47.3	13.3	37.0	34.0	53.0	16.0	48.0	48.0	
Infected Ticks,[8] Low Infestation												
SGPT		18.3		13.0	9.3	7.3	9.0	26.3	12.5	18.5	16.0	14.5
SGOT		36.3		43.3	15.3	37.6	55.3	57.3	17.5	47.0	58.0	46.5

[1]Pretreatment Values.

[2]Sample size - range from 5 to 6 fawns.

[3]Sigma Frankel Units (SFU).

[4]Sample size - 3 fawns.

[5]Sample Size - range from 1 to 3 fawns.

[6]Terminal measurement due to death of fawns.

[7]Sample size - range from 1 to 2 fawns.

[8]Sample size - range from 2 to 3 fawns.

treatment. A 50% reduction of the SGPT concentrations for the infected ticks-low and high infestation fawn treatments was observed following the first week of measurements. Following a week of reduced serum enzyme levels, the SGPT values were elevated to the pre-treatment concentration.

Blood Serum Bilirubin

A composite of serum bilirubin concentrations is presented in Table XI. At 10 days of age, the control fawn group's total bilirubin was 0.3 mg% and rose to exceed unity during the last 10 days of the experiment (Table XI). The bilirubin determinations for the control animal treatment also show that the major component of the total bilirubin value was that in the indirect bilirubin fraction. The same correlation of serum bilirubin components was also exhibited by the I.V. fawn treatment. In the clean ticks-low infestation fawn treatment, the total bilirubin was elevated on day 29-30 (1.8 mg/100 ml) and after day 33-34 this parameter returned to pre-elevated values (.50 mg/100 ml). A similar total serum bilirubin pattern was also reported for the clean ticks-high infestation animal treatment. In the infected ticks-low infestation fawn group the direct bilirubin was equal to or greater than the indirect bilirubin until day 14-16. This trend was reversed on day 21-24 in which the indirect bilirubin was the principal hemoglobin pigment. Following the pre-treatment readings, the total bilirubin of the infected ticks-high infestation animal treatment exceeded unity at the same time (day 26-27) as that reported for the infected ticks-low infestation fawn treatment and maintained the elevated level until the conclusion of the experiment. With the exception of days 29-30 and 33-34, the different bilirubin concentrations of these treatment groups were approximately the

TABLE XI

VALUES OF SERUM TOTAL BILIRUBIN, DIRECT BILIRUBIN, AND INDIRECT BILIRUBIN OF WHITE-TAILED DEER FAWNS AS INFLUENCED BY TREATMENT AND AGE

Treatment Group	Age of Fawns (Days)											
	10[1]	11[1]	12[1]	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
Control[2]												
Total Bilirubin	.30[3]	.45	.66	.70	.55	.57	.96	.84	1.30	1.30	1.70	1.40
Direct Bilirubin	.30[3]	.25	.26	.17	.20	.23	.22	.16	.30	.27	.20	.20
Indirect Bilirubin	0.00[3]	.20	.40	.53	.35	.33	.74	.68	1.00	1.00	1.50	1.20
I.V.[4]												
Total Bilirubin	.93	-	.53	.60	.43	.66	.87	.67	.67	1.30	1.80	
Direct Bilirubin	.66	-	.16	.24	.10	.20	.20	.20	.33	.47	.30	
Indirect Bilirubin	.26	-	.36	.36	.33	.46	.67	.47	.34	.80	1.50	
Clean Ticks,[5] High Infestation												
Total Bilirubin	.80	.40	.47	.67	1.50	.60	.20	.60[6]				
Direct Bilirubin	.30	.20	.27	.20	.20	.15	.20	.10				
Indirect Bilirubin	.50	.20	.20	.47	1.30	.45	.00	.50				
Clean Ticks,[7] Low Infestation												
Total Bilirubin	.50	.80	.70	.80	.80	.50	.20	1.80	1.00	.40	.20	.50
Direct Bilirubin	.30	.30	.30	.50	.20	.45	.20	.60	.50	.40	.20	.20
Indirect Bilirubin	.20	.50	.40	.30	.60	.05	.00	1.20	.50	.00	.00	.30
Infected Ticks,[5] High Infestation												
Total Bilirubin	.53	1.00	.53	.63	-	.62	1.30	3.30	1.40	5.80	2.00[6]	
Direct Bilirubin	.23	.40	.23	.23	-	.16	.40	.75	.40	1.00	.20	
Indirect Bilirubin	.30	.60	.30	.40	-	.46	.90	2.60	1.00	4.80	1.80	
Infected Ticks,[8] Low Infestation												
Total Bilirubin	.27	.96	.40	.43	-	.53	1.20	6.20	6.50	5.30	2.00	4.80
Direct Bilirubin	.20	.53	.20	.23	-	.10	.20	1.20	1.00	.70	.20	.60
Indirect Bilirubin	.07	.43	.20	.20	-	.43	1.00	5.00	5.50	4.60	1.80	4.20

[1]Pretreatment Values.

[2]Sample size - range from 5 to 6 fawns.

[3]mg/100 ml.

[4]Sample size - 3 fawns.

[5]Sample size - range from 1 to 3 fawns.

[6]Terminal measurement due to death of fawns.

[7]Sample size - range from 1 to 2 fawns.

[8]Sample size - range from 2 to 3 fawns.

same.

Discussion

In general, the electrolyte values of white-tailed deer fawns are within the range of those reported for other ruminant animals. Spector (1956) recorded the following values for Na, K, and Cl, respectively, in the serum of bovine: 132-152 m Eq/L; 3.9-5.8 m Eq/L; and 97-111 m Eq/L. Similar electrolyte values for sheep were presented by Pugh in 1966. The ionic assays for sheep serum of the former electrolyte was 139-152 m Eq/L and K ion 4.4-6.7 m Eq/L, while the latter ion concentration was 94-106 m Eq/L.

In an earlier study concerning the blood chemistry of white-tailed deer, Wilber and Robinson (1958) reported a mean ion concentration of 174 m Eq/L for Na, 10.4 m Eq/L for K, and 101 m Eq/L for Cl. By comparing these values with the present findings, it is apparent that the K and Cl ion concentrations are approximately the same. The most obvious difference in the comparison of measured values existed in the Na ion concentrations. While investigating the blood composition of white-tailed deer, Teeri, et al. (1958) reported a serum Ca ion concentration range of 4.3 to 5.3 m Eq/L. This is approximately 1.5 m Eq/L higher than was noted in the present findings.

Due to the variation of electrolyte values within a test fawn group and between treatment groups, the data tend to obscure any differences existing between tick infested and non-infested animals. Therefore, the electrolyte measurements are of limited value in evaluating the specific effects of tick infestations on serum electrolytes of neo-natal white-tailed deer fawns.

A possible contributing factor to the irregularity in electrolyte measurements was the degree of animal excitation during the process of taking blood samples. The ease of animal restraint and vein puncture varied with each sample taken. Studies have been conducted, however, on the influence of animal excitation on certain blood constituents in beef cattle (Gartner, et al., 1965). These authors found that plasma K was significantly elevated by vein puncture and physical exercise. However, the vein puncture and degree of excitation had little influence on the plasma Ca while the same factors showed no consistent pattern in the fluctuation of plasma Cl and Na ions. In the present study it was impossible to evaluate the influence of these factors on the electrolyte levels. However, a general trend was noted in the Na and Cl ion concentrations of all treatment groups. The initial values recorded for Na and Cl ions were shown to increase for a period of time succeeded by a reduction to pre-elevated levels, while only slight variations occurred in the Ca and K levels. The Na and Cl changes may be expalined in part by the physiological development of the young fawns. The findings of Wise, et al. (1947) tend to support this speculation. While studying the blood composition of young calves, these workers observed moderate reductions of Na, Ca, and K during the first 2-3 weeks of age.

The serum total protein values obtained tend to suggest that the rate of serum total protein reduction and serum total protein concentration of the tick infested fawns were related to the tick infestation level and the presence of the tick induced blood parasite. When comparing the 2 low tick infestation fawn treatments or the 2 high tick infestation fawn treatments, the fawn groups infected with the tick induced blood parasite exhibit the greatest reduction of serum total protein.

Presently, no explanation is available for the moderately enhanced reduction of serum total protein exhibited by the Theileria infected fawn treatments.

Slight reductions of the serum total protein concentration were also shown by the control and I.V. fawn treatments. However, the slight reductions of serum total protein in these fawn groups could possible be caused by the normal rapid physiological growth of young animals (Bandy, et al., 1957).

Thus, it was concluded that the normal physiological growth requirements of young fawns in the tick infested treatments would also be a contributing factor in the decline of serum total protein of these animals. However, the serum total protein reductions exhibited by the fawns in the tick infested treatments were in excess of the slight reductions believed to be caused by fawn growth requirements. Therefore, it would seem most likely that factors associated with tick feeding were the primary causes of reduced serum total protein. Some of the tick induced factors which may be the predisposing causes in reducing serum total protein levels of fawn are (1) metabolic disturbance of protein metabolism, (2) removal of blood serum protein by tick feeding, and (3) reduced food intake (Springell, et al., 1970).

The reduction of serum total protein following tick infestation has been reported in other ruminant animals. O'Kelly and Seifert (1969) reported the reduction of serum total protein in bovine following tick infestations. Contrary to these findings, more recent investigations by O'Kelly, et al. (1971) and Springell, et al. (1971) found that the serum total protein concentrations remained at about the same levels in tick infested cattle.

Data collected on the BUN levels of the control and I.V. treatments, show no discernible difference between these treatment groups. However, there was a direct correlation between elevated BUN levels and increasing age of the test animals. It is possible that the elevated BUN readings were caused primarily by an increase in protein catabolism which normally occurs in young animals (Wilkinson, 1969). Enhanced BUN concentration levels were also observed near the conclusion of the experiment in the animals subjected to tick parasitism. Although no explanation for increased BUN levels in the tick infested animals is known, a number of factors may cause elevated serum BUN concentrations. These include kidney impairment, increased protein catabolism, decreased renal blood flow, high protein diet, shock and dehydration (Wilkinson, 1969).

Serum enzyme activity was measured in young white-tailed deer fawns in order to determine if there was any correlation between tick infestation levels and enzyme concentrations. It was postulated that possible serum elevation of intracellular enzymes might strongly indicate a possible tick "toxin" (O'Kelly and Seifert, 1970) which might directly or indirectly cause hepatic necrosis or other tissue damage. Depression of serum activity may suggest reduced metabolic process due to heavy tick infestations (O'Kelly, et al., 1971).

Other works have shown a definite relationship between elevated serum enzymes and tissue necrosis (Freeland and Kramer, 1970; Cornelius, et al., 1959).

However, from the present laboratory studies, there is no indication of SGPT and SGOT enzyme elevation due to detectible tissue damage.

The amount of bilirubin existing within the vascular system is a useful index in determining the rate of erythrocyte destruction and

hepatic function (Cornelius, 1970). Significant elevation of the total bilirubin is usualy indicative of a hemolytic crisis, while an increase of the serum bilirubin conjugates suggests severe hepatic involvement or extra hepatic obstruction (Cornelius, 1970).

Data in Table II do not indicate any significant elevation in total serum bilirubin levels within or between the following treatments: (1) control, (2) I.V., (3) clean ticks-low and clean ticks-high infestations. Therefore, the anemic conditions observed in the clean ticks-low and clean ticks-high infestation levels would tend to indicate that the reduced erythrocyte counts and hemoglobin measurements were a result of blood removal by ticks. The lack of bilirubin elevations in tick infested cattle was also observed by Springell, et al. (1971).

Moderate elevations in the total serum bilirubin was noted in the infected ticks-low and high infestation treatments during the terminal phase of the experiments. These elevations were noted to coincide with increased Theileria infected red blood cells of the animals in the infected tick treatment groups. This would tend to suggest that the intracellular parasite is a hemolytic agent. However, when the parasitemia was relatively low, the total serum bilirubin does not seem to exceed those reported for the control treatment animals. The causes of red blood cell destruction in these studies are not known. However, release of hemoglobin from the red blood cells may be due to the hemolytic effects of the parasite or the destruction of the infected erythrocyte in the reticuloendothelial system of the spleen (Crosby, 1959).

CHAPTER IV

SUMMARY AND CONCLUSIONS

All fawns included in the infected ticks-high infestation treatments succumbed within 30 days post tick infestations. One fawn death occurred in each of the two low tick infestation treatments. There were no signs of fawn debilitation observed in the animals inoculated with Theileria infected blood. It would seem that a major factor in fawn mortality is the number of ticks feeding on an animal. The presence of the blood parasite did not seem to be a principal factor in causing fawn mortality.

In the fawns infested with high levels of Theileria infected ticks or clean ticks, there were major reductions in the RBC, Hb, and PCV measurements recorded during the course of the experiments. Similar findings were also recorded for the low tick infestation treatments. However, blood parameter reductions were not as substantial as levels exhibited by the high tick infestation treatments. This would suggest that the reduction of these blood parameters depended on the number of ticks infesting a fawn. The total leukocyte counts did not show a major trend between or within fawn treatment groups. When comparing the MCV, MCH, and MCHC measurements of the control and tick infested fawns, it was concluded that the resulting anemia was a normocytic normochromic anemia.

The percent of Theileria infected red blood cells was highest in those fawns infected with high numbers of Theileria harboring ticks, while the lowest percent of parasitemia occurred in the fawns inoculated

intravenously with Theileria infected blood.

Weight gain suppression and weight losses in fawns were recorded in the animals infected with adult lone star ticks while the control and I.V. fawn groups showed continual weight development. Weight suppression and reductions seemed to be directly related to tick numbers.

Serum enzyme concentrations of SGOT and SGPT did not exhibit any significant differences between or within treatment groups. Therefore, the serum enzyme concentrations did not demonstrate detectible tissue necrosis. The serum ionic assays of Na and Cl in all of the different animal treatments demonstrated a general increase in concentration which was followed by a decline to pre-elevated levels, while the K and Ca ions remained fairly constant throughout the experiment. These results do not seem to indicate that tick parasitism alters serum electrolyte concentrations. The total serum protein levels of the fawns infested with ticks exhibited the most obvious reductions. This would suggest that blood removal, metabolic suppression and/or reduced food intake were possible factors in the reduction of serum total protein.

The total and indirect serum bilirubin concentrations were elevated in the fawn groups infested with Theileria infected ticks, while only slight elevations were observed in the clean ticks-low and high infestations, I.V., and control fawn treatments. Thus, it was concluded that the blood parasite directly or indirectly influenced the destruction of red blood cells.

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A P P E N D I X

TABLE XII

MEAN CORPUSCULAR VOLUME (MCV), MEAN CORPUSCULAR HEMOGLOBIN (MCH) AND MEAN CORPUSCULAR HEMOGLOBIN CONCENTRATION (MCHC) VALUES OF WHITE-TAILED DEER FAWNS AS INFLUENCED BY TREATMENT AND AGE

Treatment Group	Age of Fawns (Days)											
	10[1]	11[1]	12[1]	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
Control												
Fawn #41												
MCV[2]				23.5	23.4	27.4	21.3	21.8	20.7	21.8	17.9	17.1
MCH[3]				8.8	9.5	10.6	9.9	8.1	7.4	7.6	7.4	7.3
MCHC[4]	43.0	40.1		37.5	40.8	38.8	48.0	37.0	36.1	35.2	41.9	42.9
Fawn #43												
MCV				16.2	24.6	31.8	23.3	22.5	24.6	24.3	22.8	29.5
MCH				6.0	7.1	12.4	8.5	6.9	8.8	9.0	8.6	12.0
MCHC	38.1	40.8		36.5	29.5	38.8	35.8	30.8	36.0	36.9	37.9	40.8
Fawn #44												
MCV	30.2			37.9	40.0	37.7	34.1	31.6	34.2	29.5	30.3	
MCH	10.1			10.5	14.6	13.5	11.5	11.4	11.5	11.8	16.8	
MCHC	33.7		36.0	27.7	36.2	36.0	33.7	36.0	33.6	46.0	55.3	
Fawn #x-1												
MCV			28.3	19.5	28.8	13.3	24.2	24.7	23.8			
MCH			11.0	7.8	11.6	5.7	9.2	9.8	10.5			
MCHC			38.9	39.6	40.0	37.7	37.8	39.7	44.2			
Fawn #x-3												
MCV				23.7	23.7	23.9	24.6	27.6	27.6			
MCH				9.4	9.5	9.4	9.3	11.7	11.2			
MCHC			43.3	39.8	40.0	39.3	38.5	42.3	40.8			
Fawn #29												
MCV			36.1	27.3	32.1	20.5[5]						
MCH			13.3	10.4	10.8	7.2						
MCHC			37.2	36.0	34.0	36.0						
I.V.												
Fawn #47												
MCV	26.2			25.0	28.0	23.9	40.1	25.1	25.1	25.3		
MCH	10.1			10.2	11.1	10.0	15.9	9.7	9.2	11.1		
MCHC	38.1		40.5	40.0	39.8	42.1	39.6	38.5	36.4	43.8		
Fawn #49												
MCV	34.2				31.2	23.1	26.3	27.7	27.8	25.3	25.6	
MCH	9.5				11.9	8.9	9.9	10.6	12.6	10.0	10.3	
MCHC	27.7		37.1	36.2	38.2	38.6	37.6	38.4	45.2	39.7	40.1	

TABLE XII (Continued)

Treatment Group	Age of Fawns (Days)											
	10	11	12	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
Fawn #50												
MCV	28.8			26.3	27.6	26.9	21.1	25.3	25.9	27.3	27.4	
MCH	10.8			10.1	10.4	10.6	10.6	10.3	9.5	11.3	13.2	
MCHC	37.4		45.9	38.4	37.5	39.3	36.4	40.6	36.6	41.2	48.3	
Clean Ticks, High Infestation												
Fawn #42												
MCV				28.2	24.3	25.3	20.9	25.5[5]				
MCH				11.5	8.7	9.0	9.0	7.3				
MCHC	40.0	33.1	39.1	40.9	36.0	35.7	43.3	28.4				
Fawn #46												
MCV	24.3			26.9	35.3[5]							
MCH	8.1			9.7	12.7							
MCHC	33.4		37.6	36.3	36.0							
Fawn #30												
MCV				25.5	43.9	11.8	27.2[5]					
MCH				16.9	15.4	4.2	11.4					
MCHC			37.0	59.0	35.9	35.7	42.0					
Clean Ticks, Low Infestation												
Fawn #48												
MCV				21.0	25.5	29.0	24.7	27.9	17.4	31.3	30.8	36.2
MCH				10.9	9.7	11.1	10.0	10.7	6.1	15.0	12.3	14.7
MCHC	39.7	39.5	52.2	51.7	37.9	37.6	40.3	38.3	35.0	47.7	40.0	40.7
Fawn #45												
MCV	32.2			30.5	43.5	27.0	27.8[5]					
MCH	10.5			9.9	19.3	10.1	10.8					
MCHC	32.6		36.0	32.5	44.5	37.5	36.2					
Infected Ticks, High Infestation												
Fawn #31												
MCV				28.7	19.2	9.3[5]						
MCH				9.2	7.7	4.0						
MCHC	37.0	37.0	41.6	32.1	40.0	42.3						

TABLE XII (Continued)

Treatment Group	Age of Fawns (Days)											
	10	11	12	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
Fawn #33												
MCV				34.3	30.0	35.6	35.1	37.9	15.1	46.3	42.7[5]	
MCH				13.2	12.0	15.3	11.6	13.4	5.4	13.6	13.4	
MCHC	41.1	48.4	37.0	39.2	40.7	43.1	33.0	35.4	35.8	29.4	32.4	
Fawn #34												
MCV				29.3	30.7	29.9	21.3	28.1	26.3[5]			
MCH				10.8	11.8	11.7	8.6	10.3	8.7			
MCHC	36.9	39.6	37.9	36.1	38.5	38.9	40.6	36.7	32.1			
Infected Ticks, Low Infestation												
Fawn #32												
MCV				22.2	21.1	24.6	19.9					
MCH				7.9	7.8	8.9	6.1					
MCHC	35.4	34.4	40.6	45.8	36.9	37.5	36.0	35.5[5]				
Fawn #35												
MCV				29.3	27.2	28.5	24.5	37.1	24.7	34.5	27.7	27.3
MCH				11.1	10.0	13.3	10.1	12.3	8.7	12.5	11.4	12.5
MCHC	41.2	35.0	45.6	38.0	36.7	46.1	41.5	34.3	35.7	36.3	41.4	45.7
Fawn #36												
MCV				37.8	29.5	33.9	32.4	39.4	33.9	47.5	36.7	43.4
MCH				15.7	10.9	13.2	12.6	13.3	12.5	16.0	14.2	15.8
MCHC	29.6	32.2	38.0	41.6	37.1	39.1	30.9	33.8	36.8	33.6	38.7	36.5

[1]Pretreatment values.

[2]μ^3.

[3]$\mu\mu g$.

[4]%.

[5]Fawn died.

TABLE XIII

BLOOD SERUM ELECTROLYTES OF WHITE-TAILED DEER FAWNS AS INFLUENCED BY TREATMENT AND AGE

Treatment Group	Age of Fawns (Days)											
	10[1]	11[1]	12[1]	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
Control												
Fawn #x-1												
Na[2]			145.5	173.0	176.0	159.0	149.0	130.0	138.0			
Cl[2]			108.4	115.4	114.0	103.8	96.2	101.2	97.4			
K[2]			9.6	10.5	9.1	9.5	10.4	8.5	9.2			
Fawn #x-3												
Na			146.0	158.0	149.0	161.0	143.0	137.5	137.0			
Cl			114.8	103.9	101.6	116.6	101.2	97.8	97.7			
K			9.8	8.7	9.1	9.2	9.2	7.8	8.7			
Fawn #44												
Na	131.0			142.5	192.5	152.5	202.0	146.0	140.0	137.0	133.0	
Cl	101.3			99.0	100.4	112.7	117.3	95.1	104.1	104.2	103.2	
K	8.1			9.6	8.6	8.5	8.6	8.9	9.0	9.0	9.0	
Fawn.#29												
Na			134.0	156.0	150.0	147.5[3]						
Cl			105.5	103.4	102.3	99.3						
K			9.8	7.1	8.9	8.2						
Fawn #43												
Na	131.0		125.0	135.0	156.0	145.5	137.0	154.0	141.0	147.5	138.0	118.0
Cl	94.6		98.6	104.0	108.4	127.4	106.1	115.6	96.3	105.4	97.3	101.0
K	9.8		8.3	10.1	9.2	9.8	9.8	9.1	9.8	10.0	10.1	9.9
Ca[4]			2.9				2.6		2.6		2.6	2.4
Fawn #41												
Na	124.0	169.0	164.0	138.0	157.5	139.0	147.5	150.0	145.0	146.0	137.5	135.0
Cl	89.8	92.2	92.4	102.6	100.6	107.4	112.8	104.3	102.0	101.4	98.6	100.2
K	9.1	9.8	8.5	9.4	11.1	9.8	10.2	11.1	9.6	10.3	10.5	9.5
Ca			2.8		3.2		2.5			2.8	3.2	2.8
I.V.												
Fawn #47												
Na	128.0			147.5	147.5	155.0	155.0	152.5	145.0	135.0	130.0	
Cl	102.7			104.3	116.0	101.8	110.8	109.6	94.6	107.0	98.4	
K	9.4			9.7	9.1	9.8	10.4		10.8	9.5	9.3	
Fawn #49												
Na	139.0			138.0	138.0	164.0	164.0	146.0	138.0	136.0	139.0	
Cl	96.6			100.5	113.6	106.6	117.3	100.1	98.2	98.8	96.5	
K	9.2			10.5	9.1	10.8	8.2	9.7	8.6	9.2	9.0	
Ca				2.9		2.6	2.6	2.8		2.2	1.7	

TABLE XIII (Continued)

Treatment Group	Age of Fawns (Days)											
	10	11	12	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
Fawn #50												
Na	147.5			152.0	143.0	151.0	164.0	174.0	120.0	132.5	143.0	
Cl	107.9			105.9	99.4	108.5	125.0	112.2	105.5	109.4	101.6	
K	8.6				9.0	10.3	6.8	9.9	10.1	9.1	9.3	
Ca					2.2	2.8	2.9			2.6	2.7	
Clean Ticks, High Infestation												
Fawn #46												
Na	142.5			142.5	133.0[3]							
Cl	100.3			106.5	106.9							
K	8.6			9.9	7.4							
Fawn #42												
Na	125.0	146.0	137.5	145.5	162.0	138.0	171.0	152.0[3]				
Cl	95.3	94.2	93.6	101.0	104.0	122.2	118.6	129.9				
K	7.7	8.3	8.5		9.3	7.8	8.9	8.2				
Fawn #30												
Na			143.0	144.0	143.0	158.0	147.5[3]					
Cl			113.3	105.2	101.5	107.0	107.7					
K			11.1	8.8	8.6	9.7						
Clean Ticks, Low Infestation												
Fawn #45												
Na	142.5			148.0	136.0	138.0	150.0[3]					
Cl	100.5			109.9	115.1	107.4	100.6					
K	7.9			9.4	9.3	8.9	6.6					
Fawn #48												
Na	135.0		125.0	146.0	162.0	139.0	169.0	190.0	170.0	163.0	142.0	135.0
Cl	97.3		101.5	98.9	100.9	109.7	128.0	101.4	137.3	118.4	96.6	91.6
K	9.5		9.1	9.1	10.4	9.6	11.1	9.0	10.5	10.8	10.6	9.6
Infected Ticks, High Infestation												
Fawn #31												
Na		147.5	140.0	149.0	138.0	154.0[3]						
Cl		95.4		104.1	100.4	128.2						
K		11.6		7.8	8.4	9.7						

TABLE XIII (Continued)

Treatment Group	Age of Fawns (Days)											
	10	11	12	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
Fawn #33												
Na	115.0	151.0	177.5	145.0	157.5	139.0	150.0	146.0	167.5[3]			
Cl		97.7		104.5	102.1	110.3	109.2	102.8	124.9			
K		9.5		8.4	9.1	8.6	8.1	6.4	8.8			
Ca		3.8			3.1		2.9	1.5	2.0			
Fawn #34												
Na		141.0	150.0	152.0	149.0	140.0	151.0	155.0	147.0	136.0	129.0[3]	
Cl		101.4		101.3	98.9	100.2	168.7	101.6	100.3	106.9	95.6	
K		8.5			8.8	8.0	8.8	6.9	8.5	8.6	6.3	
Ca							2.6	2.2	2.0		2.0	
Infected Ticks, Low Infestation												
Fawn #35												
Na	106.0	148.0		147.5	160.0	138.0	167.5	153.0	161.0	141.0		132.5
Cl		97.8			105.0	115.1	108.1	101.9	114.0	108.7		91.5
K		8.7			8.8	7.9	8.3	8.5	8.9	10.8		8.5
Fawn #32												
Na		149.0	151.0	140.0	147.5	137.5	181.0	182.5				
Cl		94.5	99.9	106.2		109.5	134.5	140.2				
K		10.1	9.7	9.1		10.0	10.4	9.6	10.4[3]			
Fawn #36												
Na		160.0	176.0	153.0	158.0	200.0	195.0	155.0	162.0	142.5	129.0	138.0
Cl	94.6		96.3	100.8	97.5	104.9	109.0	104.0	110.9	96.1	99.4	100.0
K		9.5			10.3	7.8	8.9	8.3	9.7	9.6	9.3	9.5

[1]Pretreatment values.

[2]m Eq/L.

[3]Fawn died.

[4]mg/100 ml.

TABLE XIV

BLOOD CHEMISTRY OF WHITE-TAILED DEER FAWNS AS INFLUENCED BY TREATMENT AND AGE

Treatment Group	Age of Fawns (Days)									
	10-12[1]	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
Control										
Fawn #41										
Total Protein[2]	5.2	5.1	5.2	4.7	5.0	4.9	4.8	4.6	4.9	4.7
BUN[3]	7.7	11.0	13.0	38.0	9.0	26.0	23.5	27.0	32.0	30.8
SGPT[4]	8.0	10.0	6.0	2.0	4.0	8.0	4.0	7.0	8.0	12.0
SGOT[4]	50.0	48.0	9.0	32.0	26.0	34.0	5.0	32.0	36.0	53.0
Total Bilirubin[3]	.5	.8	-	.4	.5	1.2	.2	1.6	2.2	1.6
Direct Bilirubin[3]	.3	.1	-	.1	.1	.2	.2	.4	.2	.2
Indirect Bilirubin[3]	.2	.7	-	.3	.4	1.0	0	1.2	2.0	1.4
Fawn #43										
Total Protein	4.4	4.1	4.2	4.4	4.2	4.2	4.3	4.1	4.2	4.5
BUN	8.3	-	-	-	-	26.0	27.0	20.8	18.0	30.8
SGPT	-	12.0	7.0	8.0	5.0	-	6.0	8.0	9.0	12.0
SGOT	44.0	48.0	23.0	28.0	26.0	13.0	10.0	35.0	36.0	45.0
Total Bilirubin	.26	.6	-	1.0	.5	1.0	2.8	1.4	1.2	1.2
Direct Bilirubin	.23	.2	-	.1	.2	.1	.2	.2	.2	.2
Indirect Bilirubin	.03	.4	-	.9	.3	.9	2.6	1.2	1.0	1.0
Fawn #44										
Total Protein	5.1	3.8	3.7	3.7	3.8	3.7	3.6	3.6	3.5	
BUN	10.9	13.3	63.0	35.0	20.0	15.6	27.0	20.0	35.8	
SGPT	8.5	7.0	3.0	4.0	14.0	-	16.0	9.0	7.0	
SGOT	48.0	30.0	42.0	39.0	40.0	-	32.0	38.0	37.0	
Total Bilirubin	.5	.4	.2	.2	.6	.2	.4	.8	1.6	
Direct Bilirubin	.2	.1	.2	.2	.2	.1	.2	.2	.2	
Indirect Bilirubin	.3	.3	0	0	.4	.1	.2	.6	1.4	
Fawn #45										
Total Protein	5.3	5.2	5.1	4.7[5]						
BUN	24.7	26.8	40.0	29.4						
SGPT	6.0	4.0	21.0	6.0						
SGOT	48.0	67.0	112.0	9.0						
Total Bilirubin	1.0	1.0	1.2	1.0						
Direct Bilirubin	.1	.2	.2	.2						
Indirect Bilirubin	.9	.8	1.0	.8						
Fawn #x-3										
Total Protein	5.1	5.0	4.6	4.8	4.3	4.4	3.9			
BUN	11.0	36.0	24.0	29.6	20.8	20.0	38.4			
SGPT	6.0	7.0	8.0	3.0	2.0	8.0	6.0			
SGOT	42.0	46.0	38.0	6.0	38.0	40.0	62.0			
Total Bilirubin	.7	.2	.6	.2	1.6	.2	2.1			
Direct Bilirubin	.7	.2	.2	.2	.2	.2	.6			
Indirect Bilirubin	0	0	.4	0	1.4	0	1.5			

TABLE XIV (Continued)

Treatment Group	Age of Fawns (Days)									
	10-12	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
Fawn #x-1										
Total Protein	4.4	4.3	4.3	5.3	5.1	4.8	4.6			
BUN	28.0	51.0	40.0	41.0	31.2	28.0	38.0			
SGPT	2.0	4.0	18.0	3.0	10.0	7.0	9.0			
SGOT	20.0	17.0	26.0	7.0	24.0	34.0	34.0			
Total Bilirubin	.8	1.2	.2	.6	1.6	1.6	1.0			
Direct Bilirubin	.1	.2	.2	.6	.4	.2	.2			
Indirect Bilirubin	.7	1.0	0	0	1.2	1.4	.8			
I.V.										
Fawn #49										
Total Protein	4.4	4.2	4.2	4.3	4.3	4.0	-	3.9	3.0	
BUN	6.9	15.5	31.0	28.0	24.0	29.6	29.0	24.0	25.0	
SGPT	10.5	4.0	6.0	5.0	10.0	4.0	10.0	4.0	8.0	
SGOT	41.5	16.0	18.0	39.0	46.0	9.0	32.0	41.0	37.0	
Total Bilirubin	.75	.4	.4	1.0	2.2	1.6	5.4	2.2	.6	
Direct Bilirubin	.5	.4	.2	.2	.2	.2	.4	.2	.2	
Indirect Bilirubin	.25	0	.2	.8	2.0	1.4	5.0	2.0	.4	
Fawn #50										
Total Protein	4.5	4.3	5.0	4.3	4.6	4.6	4.2	4.1	4.7	
BUN	16.5	20.0	-	36.0	38.0	33.3	35.0	26.0	51.2	
SGPT	9.0	3.0	5.0	4.0	9.0	6.0	14.0	9.0	10.0	
SGOT	50.0	12.0	39.0	22.0	26.0	10.0	35.0	40.0	34.0	
Total Bilirubin	.6	.4	.5	.8	.2	.2	2.4	1.0	4.2	
Direct Bilirubin	.2	.1	.1	.2	.2	.2	.4	.6	.5	
Indirect Bilirubin	.4	.3	.4	.6	0	0	2.0	.4	3.7	
Clean Ticks, High Infestation										
Fawn #46										
Total Protein	3.9	3.8	3.1[5]							
BUN	11.2	26.0	11.0							
SGPT	9.0	9.0	4.0							
SGOT	40.0	20.0	12.0							
Total Bilirubin	.8	1.0	1.0							
Direct Bilirubin	.4	.3	.2							
Indirect Bilirubin	.5	.7	.8							
Fawn #42										
Total Protein	5.9	6.5	5.5	5.0	3.7	3.7[5]				
BUN	11.5	11.0	17.7	34.0	75.0	-				
SGPT	-	8.0	3.0	2.0	4.0	4.0				
SGOT	44.0	36.0	13.0	22.0	16.0	30.0				
Total Bilirubin	.4	.8	-	1.0	.2	.6				
Direct Bilirubin	.3	.1	-	.1	.2	.1				
Indirect Bilirubin	.1	.7	-	.9	0	.5				

TABLE XIV (Continued)

Treatment Group	Age of Fawns (Days)									
	10-12	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
Fawn #30										
Total Protein	4.7	4.7	4.6	3.7	4.5[5]					
BUN	45.0	44.0	52.0	39.2	79.1					
SGPT	3.9	3.8	4.0	6.0	23.0					
SGOT	39.0	33.0	48.0	7.0	46.0					
Total Bilirubin	.3	.2	2.0	.2	1.6					
Direct Bilirubin	.2	.2	.2	.2	.4					
Indirect Bilirubin	.2	0	1.8	0	1.2					
Clean Ticks, Low Infestation										
Fawn #45										
Total Protein	3.9	3.6	3.4	3.6	3.9					
BUN	10.0	13.3	16.0	52.0	38.0	98.0[5]				
SGPT	5.5	4.0	3.0	5.0	12.0	18.0				
SGOT	43.0	22.0	39.0	23.0	38.0	18.0				
Total Bilirubin	.6	.6	.8	.2	.2	.2				
Direct Bilirubin	.2	.2	.2	.1	.2	.2				
Indirect Bilirubin	.8	.4	.6	.1	0	0				
Fawn #48										
Total Protein	5.1	4.7	4.2	4.7	4.2	4.2	3.8	4.1	3.8	3.8
BUN	9.8	23.0	44.4	12.0	35.0	58.0	62.4	62.0	38.0	41.0
SGPT	12.0	11.0	3.0	5.0	5.0	8.0	6.0	16.0	10.0	10.0
SGOT	45.0	28.0	6.0	8.0	17.0	32.0	13.0	20.0	24.0	48.0
Total Bilirubin	.7	1.0	-	.8	.2	3.4	1.0	.4	.2	.5
Direct Bilirubin	.4	.8	-	.8	.2	1.0	.5	.4	.2	.2
Indirect Bilirubin	.4	.2	-	0	0	2.4	.5	0	0	.3
Infected Ticks, High Infestation										
Fawn #34										
Total Protein	5.5	5.4	4.5	4.8	4.5	4.4	3.9	3.9	2.9[5]	
BUN	7.7	12.5	13.3	43.0	16.0	35.0	49.0	52.0	42.0	
SGPT	11.0	12.0	3.0	8.0	10.0	18.0	10.0	14.0	48.0	
SGOT	53.0	42.0	14.0	42.0	29.0	34.0	14.0	48.0	17.0	
Total Bilirubin	.66	1.0	-	1.0	1.0	5.0	1.2	5.8	2.0	
Direct Bilirubin	.40	.3	-	.3	.2	.6	.2	1.0	.2	
Indirect Bilirubin	.26	.7	-	.7	.8	4.4	1.0	4.8	1.8	
Fawn #31										
Total Protein	5.8	5.4	4.0	3.5[5]						
BUN	7.8	7.4	26.6	36.0						
SGPT	11.0	15.0	7.0	10.0						
SGOT	88.0	54.0	14.0	38.0						
Total Bilirubin	.5	.4	-	.2						
Direct Bilirubin	.2	.2	-	.1						
Indirect Bilirubin	.3	.2	-	.1						

TABLE XIV (Continued)

Treatment Group	Age of Fawns (Days)									
	10-12	14-16	17-19	21-24	26-27	29-30	33-34	35-36	38-40	41-44
Fawn #33										
Total Protein	5.3	5.1	4.5	3.8	3.7	4.1	2.9[5]			
BUN	15.7	11.0	22.2	61.0	64.0	56.0	106.0			
SGPT	11.0	14.0	7.0	2.0	3.0	15.0	15.0			
SGOT	60.0	46.0	12.0	32.0	39.0	72.0	18.0			
Total Bilirubin	.6	.5	-	.8	1.6	1.8	1.5			
Direct Bilirubin	.3	.2	-	.2	.6	.9	.6			
Indirect Bilirubin	.4	.3	-	.6	1.0	.9	.9			
Infected Ticks, Low Infestation										
Fawn #35										
Total Protein	6.3	6.2	5.4	4.6	4.7	4.9	4.7	4.1	-	3.9
BUN	10.5	12.5	17.7	43.0	60.0	50.0	39.2	29.0	-	38.2
SGPT	17.0	12.0	6.0	2.0	4.0	14.0	10.0	16.0	-	12.0
SGOT	6.0	32.0	13.0	32.0	42.0	45.0	15.0	40.0	-	40.0
Total Bilirubin	.5	.2	-	.4	1.0	1.0	1.0	1.0	-	3.8
Direct Bilirubin	.3	.2	-	.1	.2	.1	.2	.4	-	.6
Indirect Bilirubin	.2	0	-	.3	.8	.9	.8	.6	-	3.2
Fawn #32										
Total Protein	5.5	5.2	5.2	4.3	4.1	4.2[5]				
BUN	16.9	11.0	22.2	21.0	86.0	134.0				
SGPT	22.0	11.0	8.0	8.0	10.0	46.0				
SGOT	39.0	40.0	15.0	36.0	82.0	82.0				
Total Bilirubin	.5	.5	-	.8	.5	2.0				
Direct Bilirubin	.4	.2	-	.1	.2	.2				
Indirect Bilirubin	.1	.3	-	.7	.3	1.8				
Fawn #36										
Total Protein	5.5	5.5	4.9	4.5	4.3	4.6	4.4	4.2	3.8	3.9
BUN	12.9	12.5	13.3	10.0	44.0	16.0	39.2	41.6	28.0	43.4
SGPT	16.0	16.0	14.0	12.0	16.0	19.0	15.0	21.0	16.0	17.0
SGOT	64.0	58.0	18.0	45.0	42.0	45.0	20.0	54.0	58.0	53.0
Total Bilirubin	.8	.6	-	.4	2.2	6.6	2.0	9.6	2.0	5.8
Direct Bilirubin	.3	.3	-	.1	.2	.6	.9	1.0	.2	.6
Indirect Bilirubin	.5	.3	-	.3	2.0	6.0	1.1	8.6	1.8	5.2

[1]Pretreatment values.

[2]gm/100 ml.

[3]mg/100 ml.

[4]Sigma Frankel Units (SFU).

[5]Fawn died.

VITA

Alfred Lynn Hoch

Candidate for the Degree of

Doctor of Philosophy

Thesis: EFFECTS OF LONE STAR TICK (ACARINA: IXODIDAE) PARASITISM AND THEILERIASIS ON WHITE-TAILED DEER FAWN SURVIVAL AND HEMATOLOGY

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