SEASON AND HABITAT EFFECT ON GULF COAST TICK BIOLOGY IN CENTRAL OKLAHOMA

BY

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CHAPTER I

INTRODUCTION

The Gulf Coast tick, Amblyomma maculatum Koch, is an important pest of cattle in regions where it becomes abundant. This pest has generally been confined to a geographical area within 100 miles of the Gulf Coast (Bishopp and Hixson 1936; Bishopp and Trembley 1945; Cooley and Kohls 1944). However, in recent years it has become an established pest of cattle in Oklahoma and the distribution has increased over much of the state since it was reported in 18 counties (Semtner and Hair 1973).

The Gulf Coast tick is a three-host tick found principally on birds and small mammals in the immature stages and the adults attack a variety of large wild and domestic animals. Hosts species have an effect on engorgement time and molting success (Koch and Hair 1975).

The adult stage attaches primarily to the inner and outer surface of the external ear of their host. They feed in this location frequently creating a condition in cattle known as "gotch ear". In addition, they cause reduced weight gains in infested cattle (Williams et al., 1977). It has also been reported that the wounds caused by Gulf Coast ticks are ideal oviposition sites for screwworm flies, Cochliomyia homnivorax (Coquerel), and the resulting infestations, if not treated, may lead to the death of animals (Bishopp and Hixson 1936; Bishopp and Trembley 1945; Gladney 1976; Hixson 1940; Spicer and Dove 1938).

Limited information is available on the biology of the Gulf Coast tick outside its normal range and from a pest management standpoint it is very important to know the effect of habitat type and season on the life cycle of a noxious pest which is frequently found in open, exposed meadows and which has extended its' range with accompanying modifications in its' biology.

Studies pertaining to the biology of the Gulf Coast tick in Georgia were reported by Bishopp and Hixson (1936) and Hixson (1940). The life cycle has also been studied by Hooker (1912). Nymphs were found on meadowlarks in southern Georgia throughout the year, but they were most abundant in the late winter and early spring. Larvae were most abundant between mid-July and mid-November and adult ticks were reported to be most abundant along the Gulf Coast from mid-July to mid-October. In a study more closely related to the present one, Smetner and Hair (1973) reported that adult Gulf Coast ticks were most active in Oklahoma between late May and early July. They found larvae on hosts from mid-June to early September and nymphs were collected from early July to early October.

Habitat distribution of Gulf Coast ticks appears to be uncertain. Hixson (1940) noted that birds and small mammals frequenting meadows supported high infestations, whereas Samuel and Trainer (1970) found more Gulf Coast ticks on deer from dense habitats than on those deer frequenting moderate to sparsely vegetated habitats. In Oklahoma, adult ticks were most abundant in persimmon habitat types during late spring and summer with intermediate numbers being found in buckbrush, blackberry, lowland prairie, and sumac (Semtner and Hair 1973).

Other Oklahoma studies indicate that longevity of the lone star tick, Amblyomma americanum (L.), was influenced by habitat type (Semtner et al., 1971), and molting was affected by season (Semtner et al., 1973). In addition, adult lone star tick activity varied with different habitat types (Semtner and Hair, 1973). Robertson et al., (1975) reported that molting times in two contrasting habitats differed.

The effect of relative humidity and temperature on lone star tick survival has been reported (Sauer and Hair 1971). In another Oklahoma study, it was shown that Gulf Coast ticks have a high critical equillbrium humidity (92-93% RH) and that this may be correlated to the distribution and survival (Hair et al., 1975).

Oviposition and hatching of the American dog tick, Dermacentor variabilis (Say), and the lone star tick are affected by moisture deficit. Sonenshine and Tigner (1969) found that eggs stored at lower humidities (55%) failed to hatch.

Another researcher, Wright (1971) demonstrated that photoperiod had significant effects on oviposition of the Gulf Coast tick. Peak oviposition was reached in one to three days by females held in eight and 12 hours of light and was reached at four to seven days by females exposed to other times. Sweatman (1968) has also shown that preoviposition time of Hyalomma aegyptium (L.) was inversely related to temperature.

Under laboratory conditions, Drummond and Whetstone (1970) found that the average preoviposition period was 4.2 days, the oviposition period was 18.1 days, and the incubation time was 21.9 days for the Gulf Coast tick.

This present study was designed to determine the preoviposition time, oviposition time, survival and oviposition success of engorged females, and egg viability in three different habitat types. In addition, observations were made to determine the longevity of the larval stage, molting time of engorged larvae, longevity of the nymphal stage, molting time of the engorged nymphs, and the survival of adults. These observations were patterned after those of previous researchers studying the behavioral patterns of lone star ticks in eastern Oklahoma. Studies, herein, have attempted to elucidate the life cycle of the Gulf Coast tick in Oklahoma and compare the suitability of habitat type.

CHAPTER II

METHODS AND MATERIALS

Experimental Ticks

Immature Gulf Coast ticks used in this study were laboratory reared on rabbits as described by Patrick and Hair (1975). Adults were fed by placing equal numbers of male and female ticks in cells that were made from orthopedic stocking and glued to shaven areas on the dorsolateral area of restrained sheep.

Release Schedule

To determine the effects of season and habitat type upon the biology of the Gulf Coast tick, replete females were released from early April until mid-July 1976 on a biweekly schedule. Three replete females were introduced into four arenas randomly selected within each of three habitat types on each release date. Each female was marked by attaching colored string to the dorsum with a very small amount of contact cement so that individual females could be identified.

Engorged nymphs were released on a biweekly schedule from mid-April until mid-September. On each release date 100 engorged nymphs were released in four randomly selected arenas within each habitat type.

Engorged larvae were released on a biweekly schedule from mid-April until mid-August. On each release date ca. 1000 larvae were introduced into four randomly selected arenas within each habitat type.

Tick Confinement

Ticks used in these studies were transferred to the field and released in arenas shortly after dropping from the host. Replete females were introduced into circular arenas measuring 30 cm in diameter by 15 cm high, which had been driven into the soil ca. 5 cm deep. A bead of Stickum Special [R] around the top edge was used to prevent larvae from escaping after the eggs had hatched.

Engorged nymphs were introduced into screen wire cages similar to those used by Semtner et al (1973). Replete larvae were placed in similar cages modified by fitting crinolin over the screenwire to prevent the escape of flat nymphs.

Habitats

Ticks observed in these studies were released in three habitat types: persimmon, sumac, and meadow. Each habitat type was ca. 0.2-ha. The vegetation within the persimmon habitat was predominantly persimmon trees, *Diospyros virginiana* (L.), which were ca. 5 m in height. Sparse undergrowth occurred in this habitat, and it provided shelter from the wind and sun.

The sumac habitat consisted primarily of winged sumac, *Rhus copallina* (L.), which averaged ca. 2 m in height with an understory of little bluestem, *Andropogon scoparius* Michx, and big bluestem, *A. gerardi* Vitman.

The vegetation within the meadow habitat consisted of little bluestem, *Andropogon scoparius* Michx; big bluestem, *A. gerardi* Vitman; switchgrass, *Panicum virgatum* L.; and Indian grass, *Sorghastrum nutans* (L.) Nash.

Observations

After an oviposition site had been selected by the replete female, wooden applicator sticks were placed near the ovipositing female. Observations were made daily until oviposition began, and twice a week thereafter. Egg masses were collected from each arena four weeks after egg hatch and eggs were observed beneath a microscope to determine egg viability. Flat larvae were observed until all activity had ceased.

Engorged nymphs were observed daily until molting and the preactivity period was complete. Active adults were observed twice a week thereafter. Activity of the flat adults was monitored after exhaling ten times into the cage and counting the number of ticks responding to the stimulus.

Engorged larvae were observed daily until molting was complete and twice weekly thereafter. Observations were continued until all activity had ceased.

Physical Parameters

Throughout the study, temperature and relative humidity measurements were recorded by the use of Belfort[R] hygrothermographs within each habitat type. On each observation date temperature was also recorded at different heights with the aid of a YSI Telethermometer[R] (Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio 45387, U.S.A.). In addition, Tempscribe[R] temperature recorders were used to monitor soil temperature within each habitat type.

Soil moisture was determined by collecting soil samples at random locations in each habitat on each observation date. Each sample was weighed, placed in a drying oven for 48 hrs. and reweighed to determine the moisture content.

Statistical Analyses

The design for this study was a completely randomized design. An analysis of variance was performed on the variables observed in the three habitats. Since the effect of habitat and date were found to be significant, Duncans multiple range test was used to compare means.

CHAPTER III

RESULTS

Oviposition and Larvae Longevity

The oviposition sites selected by replete females are illustrated in Table I. Fewer replete females were completely hidden in the persimmon habitat as compared to those in the sumac and meadow habitats. Most of the females that were exposed in the persimmon habitat were observed during April and May.

Mortality of the replete females is presented in Table II. The mean mortality during preoviposition time was 21.9% in the persimmon habitat, 29.2% in the sumac habitat, and 35.4% in the meadow habitat. Mortality during oviposition was 13.5% in the persimmon habitat, 36.5% in the sumac habitat, and 26.1% in the meadow habitat. The highest mortality of replete females in the persimmon habitat occurred in April and May. In contrast, mortality of replete females in the meadow and sumac habitats was highest in June and July. Those replete females that remained exposed suffered a high mortality rate.

The mean preoviposition time for replete Gulf Coast ticks in three habitat types is presented in Table III. Those females in the persimmon habitat had the longest overall mean preoviposition time ($\bar{x}$ = 8.97 days). The overall mean preoviposition time observed in the meadow and sumac habitats were 8.72 days and 8.68 days respectively. Mean preoviposition times were significantly different between habitats for those replete females released on 21 April and 6 May. No significant differences occurred between habitats for the other release dates. The mean preoviposition time within the persimmon habitat ($\bar{x}$ = 18.8 days) was significantly different from the mean preoviposition time that occurred within the meadow habitat ($\bar{x}$ = 13.8 days) for those replete females released on 21 April.

TABLE I

OVIPOSITION SITES OF THE GULF COAST TICK IN THREE HABITAT TYPES IN CENTRAL OKLAHOMA, 1976

Repletion Date	# Females Released/Habitat	Habitat Types								
		Persimmon			Sumac			Meadow		
		E[1]	P[1]	H[1]	E[1]	P[1]	H[1]	E[1]	P[1]	H[1]
APRIL 7	12	5	5	2	0	1	11	0	0	12
APRIL 21	12	2	0	10	0	0	12	0	0	12
MAY 6	12	4	1	7	2	1	9	3	2	7
MAY 23	12	6	1	5	0	1	11	1	0	11
JUNE 3	12	0	0	12	3	0	9	8	0	4
JUNE 17	12	2	4	6	3	2	7	0	0	12
JULY 1	12	0	1	11	2	3	7	2	0	10
JULY 16	12	1	3	8	3	0	9	12	0	0
TOTAL	96	20	16	60	13	8	75	26	2	68

[1] Categories of oviposition sites are: E = Exposed, P = Partially Exposed, and H = Hidden From View.

TABLE II

MORTALITY OF REPLETE FEMALE GULF COAST TICKS IN THREE HABITAT TYPES IN CENTRAL OKLAHOMA, 1976

Repletion Date	Habitat Types								
	Persimmon			Sumac			Meadow		
	Preoviposition Mortality(%)	Oviposition Mortality(%)	Total Mortality(%)	Preoviposition Mortality(%)	Oviposition Mortality(%)	Total Mortality(%)	Preoviposition Mortality(%)	Oviposition Mortality(%)	Total Mortality(%)
April 7	33.3	8.3	41.6	8.3	33.3	41.7	16.7	0.0	16.7
April 21	25.0	8.3	33.3	50.0	33.3	83.3	16.7	16.7	33.4
May 6	25.0	25.0	50.0	16.7	33.3	50.0	8.3	41.7	50.0
May 23	58.3	41.7	100.0	8.3	41.7	50.0	8.3	58.3	66.7
June 3	0.0	16.7	16.7	33.3	25.0	58.3	66.7	16.7	83.4
June 17	8.3	8.3	16.6	41.7	33.3	75.0	41.7	25.0	66.7
July 1	0.0	0.0	0.0	25.0	75.0	100.0	25.0	50.0	75.0
July 16	25.0	0.0	25.0	50.0	16.7	66.7	100.0	0.0	100.0
Overall Means ($\bar{x}$)	21.9	13.5	35.4	29.2	36.5	65.7	35.4	26.1	61.5

TABLE III

MEAN ($\bar{x}$) PREOVIPOSITION TIME OF THE GULF COAST TICK IN THREE HABITAT TYPES IN CENTRAL OKLAHOMA, 1976

Repletion Date	Habitat Types		
	Persimmon ($\bar{x}$) Preoviposition Time (Days)	Sumac ($\bar{x}$) Preoviposition Time (Days)	Meadow ($\bar{x}$) Preoviposition Time (Days)
April 7	a[1] 9.9 C[2]	a[1] 8.6 C[2]	a[1] 8.0 BC[2]
April 21	a 18.8 A	ab 16.1 A	b 13.8 A
May 6	a 14.5 B	a 13.0 B	b 9.8 B
May 23	a 8.8 C	a 8.5 C	a 7.9 BC
June 3	a 7.3 C	a 7.3 CD	a 8.5 BC
June 17	a 6.8 CD	a 7.1 CD	a 6.0 C
July 1	a 4.0 D	a 4.8 D	a 5.4 C
July 16	4.0 D	4.3 D	No Eggs Oviposited

[1] Lower case letters pertain to row means; row means preceeded by the same letter are not significantly different at the 0.05 level of probability

[2] Upper case letters pertain to column means; column means followed by the same letter are not significantly different at the 0.05 level of probability.

The mean preoviposition time for females within the sumac habitat ($\bar{x}$ = 16.1 days) was not significantly different from the other two on the same date. The mean preoviposition time for those females repleting on 6 May was 14.5 days for those located in the persimmon habitat, 13.0 days in the sumac habitat, and 9.8 days in the meadow habitat. Mean preoviposition time differed significantly between dates within all three habitat types. The longest mean preoviposition time was observed on females repleting on 21 April in the persimmon habitat ($\bar{x}$ = 18.8 days) and the shortest mean preoviposition time was recorded for those females repleting on 1 July and 16 July in the persimmon habitat ($\bar{x}$ = 4.0 days).

The mean oviposition time of Gulf Coast ticks is illustrated in Table IV. Mean oviposition time was significantly different between habitats for replete females released on 3 June. All other mean oviposition times were not significantly different over dates for all three habitats. In the persimmon habitat the longest mean oviposition time was 40.4 days for females repleting on 7 April and the shortest mean oviposition time was 17.2 days for females repleting on 16 July. The mean oviposition time observed in the sumac habitat ranged from 41.4 days for females repleting on 7 April to 8.5 days for females repleting on 16 July. In the meadow habitat, the longest mean oviposition time was observed on females repleting on 7 April ($\bar{x}$ = 37.7 days). The shortest mean oviposition time for replete females located in the meadow habitat was 12 days for those females released on 3 June. Oviposition was longer during April and continually decreased with each release throughout the study.

Table V illustrates the minimum incubation time of Gulf Coast tick eggs oviposited in three habitat types. The mean hatch time of eggs varied with habitat and date. In general, hatch time was longest in the persimmon habitat and shortest in the meadow habitat. The only significant difference between habitats occurred for those eggs oviposited by replete females released on 3 June. Mean hatch time for eggs oviposited in the persimmon ($\bar{x}$ = 39.0 days) was longer than that observed in the sumac ($\bar{x}$ = 32.5 days) and meadow habitats ($\bar{x}$ = 30.0 days). The minimum incubation time differed significantly with time in all three habitat types. The longest hatch time was for eggs oviposited by females repleting on 7 April. The mean minimum incubation time for eggs oviposited in

TABLE IV

MEAN ($\bar{x}$) OVIPOSITION TIME OF THE GULF COAST TICK IN THREE HABITAT TYPES IN CENTRAL OKLAHOMA, 1976

Repletion Date	Habitat Types		
	Persimmon	Sumac	Meadow
	($\bar{x}$) Oviposition Time (Days)	($\bar{x}$) Oviposition Time (Days)	($\bar{x}$) Oviposition Time (Days)
April 7	a[1] 40.4 A[2]	a[1] 41.4 A[2]	a[1] 37.7 A[2]
April 21	a 28.8 B	a 28.5 B	a 25.7 BC
May 6	a 26.4 B	a 25.7 BC	a 30.0 AB
May 23	None Completed Oviposition	21.0 BC	21.7 CD
June 3	a 24.3 BC	ab 17.0 CD	b 12.0 D
June 17	a 23.1 BCD	a 25.3 BC	a 19.3 CD
July 1	18.3 CD	None Completed Oviposition	18.0 CD
July 16	17.2 D	8.5 D	None Completed Oviposition

[1] Lower case letters pertain to row means; row means preceeded by the same letter are not significantly different at the 0.05 level of probability.

[2] Upper case letters pertain to column means; column means followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE V

MEAN ($\bar{x}$) HATCHING TIME OF GULF COAST TICK EGGS IN THREE HABITAT TYPES IN CENTRAL OKLAHOMA, 1976

Repletion Date	Habitat Types		
	Persimmon ($\bar{x}$)Hatch Time (Days)	Sumac ($\bar{x}$)Hatch Time (Days)	Meadow ($\bar{x}$)Hatch Time (Days)
April 7	a[1] 62.6 A[2]	a[1] 62.1 A[2]	a[1] 58.4 A[2]
April 21	a 53.9 B	a 51.0 B	a 50.5 B
May 6	a 43.9 C	a 44.3 B	a 44.3 C
May 23	a 39.0 CD	a 37.5 C	a 37.7 D
June 3	a 39.0 CD	b 32.5 C	b 30.0 DE
June 17	a 32.7 D	a 36.3 C	a 32.5 E
July 1	32.0 DE	None Hatched	29.3 E
July 16	27.8 E	32.4 C	None Hatched

[1] Lower case letters pertain to row means; row means preceeded by the same letter are not significantly different at the 0.05 level of probability.

[2] Upper case letters pertain to column means; column means preceeded by the same letter are not significantly different at the 0.05 level of probability.

the persimmon by females repleting on 7 April was 62.6 days. Those eggs oviposited by females released on 7 April in the sumac ($\bar{x}$ = 62.1 days) and meadow ($\bar{x}$ = 58.4 days) habitats had a shorter incubation time. Hatch time was shorter for later releases. The shortest mean incubation time was observed in the meadow habitat on eggs oviposited on 1 July ($\bar{x}$ = 29.3 days). No eggs were oviposited by female ticks released in the meadow habitat after 1 July.

Egg viability of Gulf Coast tick eggs oviposited in three habitat types is shown in Table VI. The overall mean percent hatch was 83.8% in the persimmon habitat, 58.2% in the sumac habitat, and 48.6% in the meadow habitat. Significant differences occurred between habitats on most release dates. The mean percent hatch differed significantly with time only in the meadow habitat. The smallest mean percent hatch (16.2%) occurred in the meadow habitat on those eggs oviposited by females repleting on 23 May. Eggs with the highest percent hatch in the meadow ($\bar{x}$ = 72.4%) were those eggs oviposited by females released on 7 April. Eggs oviposited in the sumac habitat on 7 April and 21 April had higher percent hatch than did those oviposited at other times but did not differ significantly. Those eggs oviposited in the persimmon habitat had a mean percent hatch ranging from 74.8% to 90.9% without any noticeable trend.

Larvae longevity of Gulf Coast ticks is shown in Table VII. The overall mean longevity was 56.0 days in the persimmon habitat, 44.0 days in the sumac habitat, and 41.1 days in the meadow habitat. Significant differences between habitats occurred for larvae that developed from eggs oviposited by females repleting on 23 May, 3 June, and 17 June. Differences between habitats were not significant for the other release dates. Larvae longevity was generally highest for those larvae that developed from eggs oviposited earlier in the season. Larvae longevity differed significantly between dates in each habitat type.

Engorged Larvae and Molted Nymphs

The mean molting time of engorged Gulf Coast tick larvae in three habitat types is shown in Table VIII. Those larvae repleting on 20 April had the longest molting time, and those larvae repleting in July and early August had the shortest

TABLE VI

EGG VIABILITY OF GULF COAST TICK EGGS IN THREE HABITAT TYPES IN CENTRAL OKLAHOMA, 1976

Repletion Date	Habitat Types		
	Persimmon	Sumac	Meadow
	($\bar{x}$) Percent Hatch	($\bar{x}$) Percent Hatch	($\bar{x}$) Percent Hatch
April 7	a[1] 74.8 A[2]	a[1] 73.7 A[2]	a[1] 72.4 A[2]
April 21	a 80.4 A	a 83.7 A	a 60.9 AB
May 6	a 88.9 A	b 52.0 A	b 27.6 C
May 23	a 88.5 A	a 53.8 A	b 16.2 C
June 3	a 90.6 A	b 51.3 A	b 40.8 ABC
June 17	a 77.6 A	ab 57.2 A	b 34.2 BC
July 1	a 80.3 A	None Hatched	b 22.7 C
July 16	90.9 A	68.0 A	None Hatched

[1] Lower case letters pertain to row means; row means preceeded by the same letter are not significantly different at the 0.05 level of probability.

[2] Upper case letters pertain to column rows; column means followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE VII

LARVAE LONGEVITY OF GULF COAST TICKS IN THREE HABITAT TYPES IN CENTRAL OKLAHOMA, 1976

Repletion Date	Habitat Types		
	Persimmon ($\bar{x}$) Longevity (Days)	Sumac ($\bar{x}$) Longevity (Days)	Meadow ($\bar{x}$) Longevity (Days)
April 7	a[1] 63.5 AB[2]	a[1] 62.0 A[2]	a[1] 53.6 A[2]
April 21	a 49.3 B	a 56.0 AB	a 37.4 AB
May 6	a 47.0 B	a 43.1 AB	a 38.2 AB
May 23	ab 35.7 B	a 42.3 AB	6 20.0 B
June 3	a 66.8 A	b 41.5 AB	b 30.0 AB
June 17	a 51.0 AB	b 19.0 C	ab 38.5 AB
July 1	57.5 AB	None Hatched	48.0 A
July 16	58.7 AB	31.7 BC	None Hatched

[1] Lower case letters pertain to row means; row means preceeded by the same letter are not significantly different at the 0.05 level of probability.

[2] Upper case letters pertain to column means; column means followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE VIII

MEAN ($\bar{x}$) MOLTING TIME OF ENGORGED GULF COAST TICK LARVAE IN THREE HABITAT TYPES IN CENTRAL OKLAHOMA, 1976

Repletion Date	Habitat Types		
	Persimmon	Sumac	Meadow
	($\bar{x}$) Molting Time (Days)	($\bar{x}$) Molting Time (Days)	($\bar{x}$) Molting Time (Days)
April 20	a[1] 31.8 A[2]	b[1] 22.5 A[2]	b[1] 23.0 A[2]
May 13	a 24.0 B	b 20.8 B	b 20.3 B
May 22	a 22.3 C	b 19.5 B	b 18.5 C
June 3	a 14.8 D	a 15.5 C	b 11.0 EF
June 17	a 14.0 D	b 11.5 E	b 10.0 FG
July 1	a 12.0 E	a 11.5 E	b 9.0 G
July 16	a 11.0 E	a 13.0 DE	a 13.0 DE
August 3	a 11.0 E	a 11.5 E	a 11.0 EF
August 23	a 14.0 D	a 14.0 CD	a 14.0 D

[1] Lower case letters pertain to row means; row means preceeded by the same letter are not significantly different at the 0.05 level of probability.

[2] Upper case letters pertain to column means; column means followed by the same letter are not significantly different at the 0.05 level of probability.

molting time in all three habitat types. Mean molting time was significantly different between habitat type and date. The longest molt time ($\bar{x}$ = 31.8 days) was observed in the persimmon habitat for larvae repleting on 20 April. The shortest molt time ($\bar{x}$ = 9.0 days) occurred in the meadow habitat on ticks repleting on 1 July.

The mean preactive period of newly molted nymphal Gulf Coast ticks is illustrated in Table IX. Preactivity time differed significantly with date. Those larvae engorging in the latter months had shorter preactivity periods. The longest preactive time ($\bar{x}$ = 5.3 days) was observed in the sumac habitat for those larvae repleting on 20 April. The shortest mean preactivity period was 1.0 days and occurred for various releases in all three habitats. Mean molting time was also significantly different between habitat types. Only three release dates indicated significant differences between habitats and these occurred on 20 April, 13 May, and 16 July.

Table X illustrates the mean active days of nymphal Gulf Coast ticks in three habitat types. Nymphs were active longer in the persimmon habitat as compared to those in the other two habitats. Significant differences occurred between habitats for all release dates except 23 August. The number of active days differed less over time in the persimmon habitat. Only those engorged larvae released in the persimmon habitat during August had significantly different mean active days. However, the number of active days decreased significantly with date for those engorged larvae released in the sumac and meadow habitats throughout the study.

Engorged Nymphs and Molted Adults

The mean molting time of engorged nymphal Gulf Coast ticks in three habitat types is illustrated in Table XI. Molting time differed significantly with date for all three habitat types. Those nymphs repleting on 21 April had the longest mean molting time in all three habitat types. The molting times were 44 days in the persimmon habitat, 38.5 days in the sumac habitat, and 38.8 days

TABLE IX

MEAN ($\bar{x}$) PREACTIVITY TIME OF NEWLY MOLTED NYMPHAL GULF COAST TICKS IN THREE HABITAT TYPES IN CENTRAL OKLAHOMA, 1976

Repletion Date	Habitat Types		
	Persimmon	Sumac	Meadow
	($\bar{x}$) Preactive Time (Days)	($\bar{x}$) Preactive Time (Days)	($\bar{x}$) Preactive Time (Days)
April 20	b[1] 3.5 A[2]	a[1] 5.3 A[2]	a[1] 5.0 A[2]
May 13	b 2.0 BC	a 3.3 C	a 3.8 B
May 22	a 1.3 CD	a 2.0 E	a 1.0 C
June 3	a 1.5 CD	a 1.5 DE	a 1.0 C
June 17	a 1.0 D	a 1.0 E	a 1.8 C
July 1	a 2.5 B	a 2.0 D	a 1.8 C
July 16	b 2.0 BC	a 4.3 B	a 4.5 AB
August 3	a 2.0 BC	a 1.5 DE	a 2.0 C
August 23	a 1.0 D	a 1.0 E	a 1.0 C

[1] Lower case letters pertain to row means; row means preceeded by the same letter are not significantly different at the 0.05 level of probability.

[2] Upper case letters pertain to column means; column means followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE X

MEAN ($\bar{x}$) ACTIVE DAYS OF NYMPHAL GULF COAST TICKS IN THREE HABITAT TYPES IN CENTRAL OKLAHOMA, 1976

Repletion Date	Habitat Types		
	Persimmon ($\bar{x}$) Active Time (Days)	Sumac ($\bar{x}$) Active Time (Days)	Meadow ($\bar{x}$) Active Time (Days)
April 20	a[1] 83.0 A[2]	b[1] 51.0 A[2]	ab[1] 69.3 A[2]
May 13	a 81.0 A	b 44.5 AB	b 39.5 BC
May 22	a 77.8 A	b 41.5 AB	b 43.8 B
June 3	a 98.0 A	b 51.8 A	b 38.3 BC
June 17	a 76.5 A	b 41.3 AB	b 32.3 BC
July 1	a 75.0 A	b 24.3 BC	b 40.3 BC
July 16	a 81.0 A	b 34.3 ABC	b 24.5 BC
August 3	a 51.0 B	b 7.5 C	a 47.0 AB
August 23	a 21.0 C	a 19.7 BC	a 13.5 C

[1] Lower case letters pertain to row means; row means preceeded by the same letter are not significantly different at the 0.05 level of probability.

[2] Upper case letters pertain to column means; column means followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE XI

MEAN ($\bar{x}$) MOLTING TIME OF THE ENGORGED NYMPHAL GULF COAST TICK IN THREE HABITAT TYPES IN CENTRAL OKLAHOMA, 1976

Repletion Date	Habitat Types		
	Persimmon	Sumac	Meadow
	($\bar{x}$) Molting Time (Days)	($\bar{x}$)Molting Time (Days)	($\bar{x}$)Molting Time (Days)
April 17	a[1] 36.0 C[2]	a[1] 36.0 B[2]	a[1] 35.0 B[2]
April 21	a 44.0 A	b 38.5 A	b 38.8 A
May 6	a 42.0 B	b 35.3 B	b 35.8 B
May 21	a 29.0 D	a 29.0 C	a 27.8 C
June 3	a 29.3 D	b 25.0 D	b 24.0 DE
June 17	a 25.0 E	b 22.0 E	b 22.0 FG
July 1	a 26.0 E	a 26.3 D	a 25.0 D
July 19	a 18.0 G	a 18.0 F	a 18.0 H
August 2	a 21.3 F	a 22.3 E	a 21.0 G
August 16	a 22.0 F	a 22.0 E	a 22.0 EFG
August 29	a 26.0 E	a 25.3 D	b 23.0 EF
September 13	No Molt	No Molt	No Molt

[1] Lower case letters pertain to row means; row means preceeded by the same letter are not significantly different at the 0.05 level of probability.

[2] Upper case letters pertain to column means; column means followed by the same letter are not significantly different at the 0.05 level of probability.

in the meadow habitat. Those nymphs repleting on 19 July had the shortest mean molting time in all three habitats. Molting time was generally longer for engorged nymphs in the persimmon habitat and shorter molting time occurred in the meadow habitat. Molting time differed significantly between habitats for those engorged nymphs released on 21 April, 6 May, 21 May, 3 June, and 17 June. For the above dates molting time of engorged nymphs released in the persimmon habitat was significantly longer than molting times observed in the other two habitats. Those engorged nymphs released on 29 August had significantly shorter molting times in the meadow habitat. None of the engorged nymphs released after 29 August molted in any of the habitat types.

The mean preactivity time of newly molted adult Gulf Coast ticks is shown in Table XII. Preactivity time differed significantly with date for all habitat types. Some significant differences between habitat types occurred. Those newly molted adults with the shortest preactivity time were released as replete nymphs on 1 July. The preactivity time was 2.0 days for those released in the sumac and meadow habitats and 3.0 days for those released in the persimmon habitat. The longest preactivity time occurred for those engorged nymphs released on 17 April. The preactive time was 28.0 days in the meadow, 22 days in the sumac habitat, and 23.5 days in the persimmon habitat. Engorged nymphs repleting on 16 August and 29 August molted but failed to become active in the persimmon habitat. Engorged nymphs repleting on 2, 16, and 29 August molted but failed to become active in the sumac habitat. Engorged nymphs repleting on 29 August molted but failed to become active in the meadow habitat.

Table XIII illustrates the mean active days of adult Gulf Coast ticks in three habitats. The number of active days differed significantly with date for adult ticks in all three habitat types. The only significant difference occurring between habitats was for those ticks repleting on 21 May. The longest active period was 129 days in the meadow habitat for adults that developed from engorged nymphs released on 21 April. The shortest active period was 12.5 days for adults in the meadow habitat that developed from engorged nymphs released on 16 August.

TABLE XII

MEAN ($\bar{x}$) PREACTIVE TIME OF NEWLY MOLTED ADULT GULF COAST TICKS IN THREE HABITAT TYPES IN CENTRAL OKLAHOMA, 1976

Repletion Date	Habitat Types		
	Persimmon	Sumac	Meadow
	($\bar{x}$) Preactive Time (Days)	($\bar{x}$) Preactive Time (Days)	($\bar{x}$) Preactive Time (Days)
April 17	b[1] 23.5 A[2]	b[1] 22.0 A[2]	a[1] 28.0 A[2]
April 21	b 13.5 B	a 17.0 B	b 12.3 B
May 6	b 6.5 C	a 11.0 C	a 12.0 BC
May 21	a 7.0 C	a 7.0 D	a 7.3 DE
June 3	b 3.8 D	a 9.0 CD	a 8.0 DE
June 17	a 8.0 C	a 8.0 D	a 7.0 E
July 1	a 3.0 D	a 2.0 E	a 2.0 F
July 19	a 7.0 C	a 7.0 D	a 9.7 CD
August 2	8.0 C	No Activity	4.0 F
August 16	No Activity	No Activity	3.0 F
August 29	No Activity	No Activity	No Activity
September 13	No Activity	No Activity	No Activity

[1] Lower case letters pertain to row means; row means preceeded by the same letter are not significantly different at the 0.05 level of probability.

[2] Upper case letters pertain to column means; column means followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE XIII

MEAN ($\bar{x}$) ACTIVE DAYS OF ADULT GULF COAST TICKS IN THREE HABITAT TYPES IN CENTRAL OKLAHOMA, 1976

Repletion Date	Habitat Types		
	Persimmon	Sumac	Meadow
	($\bar{x}$) Active Time (Days)	($\bar{x}$) Active Time (Days)	($\bar{x}$) Active Time (Days)
April 17	a[1] 120.5 A[2]	a[1] 112.0 ABC[2]	a[1] 98.5 BC[2]
April 21	a 117.5 A	a 124.5 A	a 129.0 A
May 6	a 116.5 A	a 118.8 AB	a 117.3 AB
May 21	a 114.0 A	a 114.0 AB	b 72.8 D
June 3	a 104.0 AB	a 102.0 BC	a 105.0 BC
June 17	a 90.0 B	a 93.0 C	a 94.0 C
July 1	a 64.5 C	a 52.5 D	a 59.8 D
July 19	a 40.8 D	a 42.0 D	a 39.3 E
August 2	19.8 E	No Activity	37.5 E
August 16	No Activity	No Activity	12.5 F
August 29	No Activity	No Activity	No Activity
September 13	No Activity	No Activity	No Activity

[1] Lower case letters pertain to row means; row means preceeded by the same letter are not significantly different at the 0.05 level of probability.

[2] Upper case letters pertain to column means; column means followed by the same letter are not significantly different at the 0.05 level of probability.

CHAPTER IV

DISCUSSION

Oviposition and Egg Viability

The majority of replete females selected protected oviposition sites in all three habitat types after a short period of crawling about in the vegetation. Bishopp and Hixson (1936) and Hixson (1940) observed similar behavior of gravid females. More females were exposed in the persimmon habitat during April and May and mortality of replete females was highest during this period. The only physical parameter that was significantly different between habitats during April and May was soil moisture. Soil moisture was highest in the persimmon habitat and lowest in the meadow during this time (Table XIV, Appendix). The persimmon habitat provided shade from the sun and replete females did not seek heavy cover for oviposition sites. However, replete females in the sumac and meadow habitats were exposed to more direct sunlight and usually selected oviposition sites down in the duff. Predators, especially birds, were believed to be the primary cause of mortality in the persimmon habitat during April and May when the replete females were often exposed. In contrast, mortality of replete females was highest during June and July in the sumac and meadow habitats when mean soil temperatures were significantly higher (Table XV, Appendix) and this possibly contributed to mortality of replete females in the meadow and sumac habitats.

Preoviposition time varied greatly during the study. The shortest mean preoviposition time was 4.0 days for females repleting on 1 and 16 July. This is in agreement with the findings of Drummond and Whetstone (1970). They reported that the average preoviposition time of Gulf Coast ticks was 4.15 days in a lab study. The longest mean preoviposition time was 18.8 days for replete females released in the persimmon habitat on 21 April. Preoviposition time has been shown to be influenced by temperature. Sweatman (1967) reported that temperatures below 20°C markedly extended the preoviposition time of Rhipicephalus sanguineus (Latreille). During April, ambient temperatures were less than 20°C for the most part while this study was in progress and preoviposition time was noticeably longer. In another study, Sweatman (1968) reported that preoviposition time of H. aegyptium was inversely related to temperature. Results from this study agree with those mentioned above since preoviposition time differed significantly over dates in all habitats during the study. The shortest preoviposition time occurred during July when ambient temperature was highest and soil moisture was low in all habitats (Tables XVI and XIV, Appendix). Preoviposition time was significantly different between habitats for replete females released on 21 April and 6 May. The only significant difference occurring between physical parameters during this time was for soil moisture which was highest in the persimmon.

Drummond and Whetstone (1970) reported that 18.1 days was the average oviposition period for Gulf Coast ticks in a laboratory study. Habitat and season had an effect on oviposition time during these studies. Oviposition time was longest during the early months and shortest during late summer. The longest oviposition time was for females repleting on 7 April. They had a mean oviposition time of 41.4 days. These females were ovipositing during late April and May when soil moisture was high, ambient temperatures were low, and relative humidity never dropped below 50%. The shortest oviposition time was 8.5 days and occurred in the sumac habitat for those replete females released on 16 July. These females were ovipositing during late July when several differences in physical parameters were observed. Soil temperatures were highest at this time in the sumac habitat as shown in Table XV (Appendix). During this same period soil moisture was lowest in the sumac habitat as illustrated in Table XIV. Tables XVI and XVII (Appendix) show that ambient temperatures were high and mid-afternoon relative humidites were low during July. Wright (1971) suggests that photoperiod influences the ovipositional pattern of the Gulf Coast tick. A releated study by Sweatman and Kousa (1968) showed that optimal temperature for peak egg output of R. sanguineus was 30°C.

The minimum incubation time of Gulf Coast tick eggs varied with habitat and date. Generally, incubation time was longest in the persimmon habitat and shortest in the meadow habitat. The only significant difference in incubation time between habitats was observed on eggs oviposited by replete females released on 3 June. The incubation time was longer for eggs oviposited in the persimmon habitat. These eggs began hatching in late July and were exposed to lower temperatures than those in the sumac and meadow habitats. Soil moisture was also higher in the persimmon habitat for this same period. Mean incubation time ranged from 27.8 days to 62.6 days in this study. Season had an obvious effect on the incubation time. Those eggs oviposited in July had shorter incubation times in all three habitats than those oviposited in April. Incubation time was progressively shorter for releases made after the initial one in early April. This was probably due to a combination of all the physical parameters. Drummond and Whetstone (1970) reported that the average minimum incubation time was 21.9 days in a laboratory study. Bishopp and Hixson (1936) noted that the normal incubation time was about three weeks but eggs oviposited late in the fall may require up to five months of incubation time.

Egg viability was not affected by season in the sumac and persimmon habitats. However, eggs oviposited after April in the meadow habitat had a low percentage hatch. Sonenshine and Tigner (1969) showed that hatching was related to moisture defecit in two species of ticks. They believed that a grass-herb-dominated old field provided a poor habitat for incubation of D. variabilis and A. americanum eggs. Patrick (1976) observed reduced egg viability when soil moisture was low in July and August. This is in agreement with the results obtained during this study, since the meadow habitat had lower soil moistures and lower relative humidities during mid-morning and mid-afternoon.

Longevity of Larvae

Larvae generally survived longer in the persimmon habitat and the mean maximum longevity of unfed larvae was 66.8 days. Survival of unfed larvae in the persimmon habitat was lower for those larvae developing from eggs that were oviposited by females repleting in late April and May. These larvae would have been emerging from eggs during early July when soil and ambient temperatures were high.

Larvae in the sumac habitat survived longer during the early months of the study. The shortest lived larvae were those that developed from eggs oviposited by females repleting on 17 June. These larvae began hatching near the first week in August when mid-afternoon relative humidities were lowest.

Larvae in the meadow habitat that developed from eggs oviposited by females repleting on 23 May and 3 June were the shortest lived in this habitat. These larvae began emerging from eggs during June and early July when soil moisture was the lowest and soil temperatures were highest. At the time these larvae were active, ambient temperature was high and relative humidity was low in the meadow habitat. None of the flat larvae overwintered in any of the habitat types in this study.

Molting of Engorged Larvae

Engorged larvae crawled about for a short time before selecting a protected molting site. Molting usually took place near the base of grasses or down in the protective duff.

Molting time was generally longer in the persimmon habitat. Significant differences were observed on the molting times of engorged larvae released in April, May, June, and early July. Those engorged larvae in the meadow habitat had significantly shorter molting times. A combination of factors were responsible for the shorter molting time occurring in the meadow habitat. Higher ambient temperature, higher soil temperature, lower soil moisture, and lower relative humidity was observed in the meadow habitat. Molting time was inversely related to temperature and after the initial release of engorged larvae, the molting time decreased with subsequent releases in all three habitat types.

Activity Periods of Nymphs

Very little difference was observed in the preactive time of nymphs located in the three different habitat types. The preactive time of nymphs ranged from 1.0 to 5.3 days in this study.

The mean active time of nymphal Gulf Coast ticks was significantly longer in the persimmon habitat. This habitat provided a better environment for flat nymphs than the sumac and meadow habitats because soil moisture and relative humidities were higher and ambient temperatures and soil temperatures were lower. Very little difference was observed between the mean active days of nymphal Gulf Coast ticks located in sumac and meadow habitats. Active time was shorter in all three habitats for nymphs molting later during the summer. This was probably related to increased temperatures occurring in the habitats in the latter part of the study.

Molting Time of Engorged Nymphs

Season had an effect on molting time in all three habitat types. Molting time was generally longer during the cooler months of April and May and the shortest molting time was observed on engorged nymphs released in mid-July when a combination of factors was responsible for the shorter molting times. These factors can be summarized as increased ambient temperatures, increased soil temperature, reduced relative humidity, and reduced soil moisture (Tables XIV, XV, XVI, and XVII, Appendix). None of the engorged nymphs repleting after 29 August molted in this study. These findings are somewhat similar to those reported by Semtner et al. (1973) on the lone star tick.

Activity Periods of Adults

Season had a pronounced effect on preactivity time and the number of active days of adult Gulf Coast ticks in all three habitat types. Very little difference in preactivity time occurred between habitat types. Preactivity time was shortest during mid-summer when temperatures were highest. Those adults that molted early in the study had the longest activity periods in all three habitat types. Habitat types did not affect the active time of adults.

Engorged nymphs repleting after 2 August failed to become active in the persimmon habitat. No activity was observed for adults molting from engorged nymphs released after 19 July in the sumac habitat. All adults in the meadow habitat became active except those which developed from engorged nymphs released after 16 August. These adults were emerging when late evening temperatures were beginning to decline. Flat adults overwintered in all three habitat types and became active the next spring.

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APPENDIX

TABLE XIV

MONTHLY SOIL MOISTURE MEANS ($\bar{x}$) OF THREE HABITAT TYPES IN CENTRAL OKLAHOMA, 1976

Month	Habitat Types		
	Persimmon	Sumac	Meadow
	($\bar{x}$) Percent Soil Moisture	($\bar{x}$) Percent Soil Moisture	($\bar{x}$) Percent Soil Moisture
April	a[1] 26.9 A[2]	ab[1] 23.0 AB[2]	b[1] 18.5 AB[2]
May	a 29.4 A	ab 25.0 A	b 20.6 A
June	a 19.3 B	b 12.2 C	b 10.1 C
July	a 15.6 B	ab 8.9 C	b 8.4 C
August	a 14.0 B	a 10.6 C	a 8.9 C
September	a 15.5 B	a 11.2 C	a 9.5 C
October	a 16.8 B	a 14.7 BC	a 10.9 BC

[1] Lower case letters pertain to row means; row means preceeded by the same letter are not significantly different at the 0.05 level of probability.

[2] Upper case letters pertain to column means; column means followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE XV

MONTHLY MEAN ($\bar{x}$) SOIL TEMPERATURES OF THREE HABITAT TYPES IN CENTRAL OKLAHOMA, 1976

Month	Minimum Soil Temperatures (°C)			Maximum Soil Temperatures (°C)		
	Persimmon	Sumac	Meadow	Persimmon	Sumac	Meadow
June	a[1] 15.8 AB[2]	a[1] 18.4 AB[2]	a[1] 17.6 AB[2]	b[1] 35.9 BC[2]	a[1] 45.3 AB	a[1] 48.9+[3] A[2]
July	a 18.4 A	a 19.3 A	a 20.0 A	b 39.7 AB	a 47.7 A	a 48.9+A
August	a 17.4 A	a 18.5 A	a 18.7 AB	b 40.7 A	a 47.2 A	a 48.0 A
September	b 12.8 B	ab 15.0 B	a 16.6 B	c 38.9 AB	b 43.8 B	a 47.6 A
October	b 3.7 C	a 8.5 C	a 8.6 C	a 32.8 C	a 36.3 C	a 36.7 B

[1] Lower case letters pertain to row means; row means preceeded by the same letter are not significantly different at the 0.05 level of probability.

[2] Upper case letters pertain to column means; column means followed by the same letter are not significantly different at the 0.05 level of probability.

[3] Maximum Soil Temperature was greater than the upper operating range of soil temperature recorders used in this study.

TABLE XVI

MONTHLY MEAN ($\bar{x}$) AMBIENT TEMPERATURES FOR FOUR DAILY TIME PERIODS IN THREE HABITAT TYPES IN CENTRAL OKLAHOMA, 1976

Month	Early Morning (6 am) Ambient Temperature (°C)			Mid-Morning (10 am) Ambient Temperature (°C)			Mid-Afternoon (4 pm) Ambient Temperature (°C)			Late Evening (10 pm) Ambient Temperature (°C)		
	Persimmon	Sumac	Meadow	Persimmon	Sumac	Meadow	Persimmon	Sumac	Meadow	Persimmon	Sumac	Meadow
April	a[1] 9.5DE[2]	a[1] 10.9DE[2]	a[1] 11.7CD[2]	a15.7CD	a16.6B	a17.8C	a20.2C	a20.6C	a21.3C	a13.7CD	a13.9CD	a14.9CD
May	a 12.9CD	a 13.7CD	a 13.1C	a 19.0C	a20.8B	a20.3C	a22.4C	a24.4C	a25.1C	a16.0BC	a16.8C	a16.2C
June	a 18.2AB	a 19.0AB	a 18.4AB	a23.6AB	a25.9A	a25.1AB	a28.1B	a31.1AB	a31.5AB	a22.7A	a23.8A	a23.1A
July	a 20.5A	a 21.0A	a 20.6A	a27.0A	a29.1A	a28.4A	a31.9AB	a34.3A	a35.4A	a24.9A	a25.4A	a25.7A
August	a 20.1A	a 20.5A	a 19.7A	a25.8A	a26.6A	a26.9A	a32.8A	a34.3A	a35.5A	a24.3A	a24.8A	a24.0A
September	a 15.4BC	a 16.4BC	a 15.3BC	a20.4BC	a20.6B	a21.7BC	a28.6B	a29.1B	a30.1B	a18.9B	a20.1B	a19.3B
October	a 8.1E	a 9.1E	a 7.5D	a11.8D	a10.7C	a11.6D	a21.0C	a21.8C	a23.3C	a11.4D	a12.5D	a11.3D

[1] Lower case letters pertain to row means; row means preceeded by the same letter are not significantly different at the 0.05 level of probability.

[2] Upper case letters pertain to column means; column means followed by the same letter are not significantly different at the 0.05 level of probability.

TABLE XVII

MONTHLY MEAN ($\bar{x}$) RELATIVE HUMIDITIES FOR FOUR DAILY TIME PERIODS IN THREE HABITAT TYPES IN CENTRAL OKLAHOMA, 1976

Month	Early Morning (6 am) Relative Humidity (%)			Mid-Morning (10 am) Relative Humidity (%)			Mid-Afternoon (4 pm) Relative Humidity (%)			Late Evening (10 pm) Relative Humidity (%)		
	Persimmon	Sumac	Meadow	Persimmon	Sumac	Meadow	Persimmon	Sumac	Meadow	Persimmon	Sumac	Meadow
April	a[1] 94.9A[2]	a[1] 92.2A[2]	a[1] 91.3A[2]	a[1] 71.7A[2]	a[1] 73.2A[2]	a[1] 65.4A[2]	a[1] 56.1AB[2]	a[1] 50.6AB[2]	a[1] 54.2A[2]	a[1] 81.3AB[2]	a[1] 80.9AB[2]	a[1] 79.0AB
May	a 97.5A	a 97.7A	a 97.8A	a 69.4A	a 69.0A	a 64.1A	a 60.9A	a 54.4A	a 52.0A	a 89.4A	a 85.8A	a 89.1A
June	a 93.1A	a 94.7A	a 94.6A	a 71.7A	a 71.7A	a 61.8A	a 54.6AB	a 49.4AB	a 45.8AB	a 79.4AB	a 75.6AB	a 80.3AB
July	a 96.7A	a 97.4A	a 96.4A	a 65.3A	a 64.4A	a 55.2A	a 47.8AB	a 38.2B	a 38.7AB	a 75.7AB	a 69.8B	a 73.3B
August	a 92.6A	a 92.5A	a 91.6A	ab 66.5A	a 70.5A	b 54.5A	a 44.9B	a 36.2B	a 34.9B	a 72.4B	a 68.0B	a 70.7B
September	a 95.1A	a 94.1A	a 92.1A	a 73.3A	a 80.3A	b 58.9A	a 46.0B	a 42.6AB	a 38.3AB	a 83.2AB	a 79.2AB	a 76.9AB
October	a 91.9A	a 90.7A	a 89.9A	ab 62.8A	a 74.7A	b 50.2A	a 41.7B	a 37.5B	a 34.2B	a 80.7AB	a 73.1AB	a 73.5AB

[1] Lower case letters pertain to row means; row means preceeded by the same letter are not significantly different at the 0.05 level of probability.

[2] Upper case letters pertain to column means; column means followed by the same letter are not significantly different at the 0.05 level of probability.

VITA[2]

Billy Ray Stacey

Candidate for the Degree of

Master of Science

Thesis: SEASON AND HABITAT EFFECT ON GULF COAST TICK BIOLOGY IN CENTRAL OKLAHOMA

Major Field: Entomology

Biographical:

Personal Data: Born in Stuart, Oklahoma, February 12, 1949, the son of Alvie William and Annalene Elizabeth Stacey.

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Member: Entomological Society of America and Acarological Society of America.