SEASONAL DISTRIBUTION AND POPULATION DYNAMICS OF *AMBLYOMMA MACULATUM* KOCH: IXODIDAE IN OKLAHOMA

By

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CHAPTER I

INTRODUCTION

The Gulf Coast tick, Amblyomma maculatum Koch, is one of the most economically important ecto-parasites of cattle. A publication released from the XXIII World Veterinary Congress (Drummond 1987) reported that annual losses attributable to Gulf Coast tick infestations was over 58 million dollars. This tick has historically been reported within 100 miles of the Gulf Coast (Bishopp and Hixson 1936; Cooley and Kohls 1944; Bishopp and Trembley 1945). However, in the early 1970's this tick was reported to be biologically established in Oklahoma, Kansas (Semtner and Hair 1973) and as far north as Kentucky (Snoddy and Cooney 1984). There have also been reports of Gulf Coast ticks collected in New York (Wiedl 1981).

The Gulf Coast tick is a three-host tick that is found primarily on birds and occasionally on small rodents in the immature stages. The tick attaches to various large wild and domestic animals in the adult stage. The adult stage of the tick attaches mainly to the external portion of its hosts ears, especially on cattle. Tick feeding causes a condition in cattle known as "gotch-ear". Gladney et al. (1977) noted that gotch-eared calves were discriminated

against by buyers who often paid $4.00 per hundred weight less for them as compared to calves unaffected. The tick can dramatically suppress weight gains in cattle (Williams et al. 1977). Before the primary screwworm fly, Cochliomyia homnivorax Coquerel, was eradicated from the United States it had been reported that the wounds caused by Gulf Coast ticks were ideal oviposition sites for primary screwworm flies (Gladney 1976). The resulting infestations, if not treated, frequently caused death of the animal (Bishopp and Hixson 1936; Bishopp and Trembley 1945; Gladney 1976; Hixson 1940; Spicer and Dove 1938).

There is limited information on the biology of the Gulf Coast tick outside its "normal" range. It is very important from a pest management standpoint to know the seasonal distribution and effect of various environmental influences on the life cycle of this economically important tick.

The basic biology was outlined in studies in Georgia by Bishopp and Hixson (1936) and Hixson (1940). Its life cycle has also been studied by Hooker et al. (1912). Adults were most active in Georgia from mid-July to mid-October, with larvae being most abundant between mid-July and mid-November. Nymphs could be found on meadowlarks throughout the year, but were most abundant in late winter and early spring. In a recent Texas study, Fleetwood (1985) reported that adults were active from April to October with peak numbers occurring between mid-July and mid-September. While larvae were first reported in July, the greatest numbers

were found between November and January. Nymphs were recovered most abundantly and active from November to April. In a study conducted in Oklahoma, Semtner and Hair (1973) reported that adults were most active from late May to early July. Larvae were detected from mid-June through early September with largest numbers recorded in early July. Nymphs were recovered from early July to early October with peak numbers collected in early August.

The objective of this study was to determine the seasonal distribution of and habitat effect on the three developmental stages of the Gulf Coast tick in Oklahoma. I desired to determine preoviposition time and oviposition time of engorged females and the minimum egg incubation time in several ecologically different habitat types. In addition, I made observations to ascertain the longevity of the larval stage, molting time of engorged larvae, longevity of the nymphal stage, molting time of engorged nymphs and survival of adults. This study was patterned after previous research of behavioral patterns of lone star ticks in eastern Oklahoma.

CHAPTER II

MATERIALS AND METHODS

Seasonal Distribution on Hosts

Adult Seasonal Activity

Beginning on 18 February 1989 adult Gulf Coast ticks were monitored on a cow herd consisting of 13 two-year old cows from the Oklahoma State University Purebred Beef Cattle Range and 17 yearlings from the Oklahoma State University Agronomy Range. Examınations consisted of counting ticks on the front and back of both ears, as well as on the poll of animals. In order to decrease stress and weight loss of the cattle, both groups were examined on an every other week basis, as both herds had to be driven approximately one mile to cattle working facilities where observations were made. Cattle examinations were continued into the fall to determine if there was more than one significant peak in the adult activity cycle.

Immature Seasonal Activity

Weekly collections of birds to be examined for ımmature stages of the Gulf Coast tick began 1 May 1989. Since some of the birds were federally protected, a limited sample of

five birds were collected each week. Birds, which were primarily bob-white quail, meadowlarks and grasshopper sparrows, were collected under the guidelines of state and federal wildlife agencies by shotgun and then examined for the immature stages of the Gulf Coast tick. This segment of the study continued until 15 October 1989.

Gulf Coast Tick Biology

Experimental Ticks

Parents of ticks used in this portion of the study were genetically "wild" and collected from birds in the fall of 1988 at the Oklahoma State University Purebred Beef Cattle Range. Immature ticks were allowed to molt and then fed on rabbits as described by Patrick and Hair (1975). Adults were fed by placing equal numbers of male and female ticks in cells made from orthopedic stockings glued to shaven areas on the dorso-lateral area of restrained sheep.

Habitat

Ticks were released into three habitat types: 1. blackjack-oak, 2. sumac patch, and 3. meadow grass. These three habitat types were chosen because these are the areas where we have most often found the hosts of the Gulf Coast tick. Vegetation within the blackjack-oak habitat was predominantly blackjack-oak trees, Quercus marilandica (L.). The sumac habitat consisted primarily of winged sumac, Rhus copallina (L.), and contained an understory of little blue

stem, Andropogan scoparius Michx, and big blue stem, A. gerardi Vitman. Vegetation in the meadow habitat was primarily little blue stem, A. scoparius Michx; big blue stem, A. gerardi Vitman; switch grass, Panium virgatum (L.); and Indian grass, Sorghastum nutans (L.) Nash. There were three replications of each habitat type.

Release Schedule

Replete Females. - In an effort to determine the effect of habitat type on the biology of Gulf Coast ticks, five replete females were released, one per arena, into five randomly placed arenas within each habitat type on either 25 April, 19 May or 12 June. For observational purposes, this number was reduced to four after 5 to 7 days. This procedure was followed to allow for accidental injury or death to a portion of the test population during initial establishment.

Engorged Larvae. - Larvae were released when larvae were noted to naturally occur from wild hosts. Three releases were made and began on: 27 June and was followed by releases on 17 July and 17 August. On each release date approximately 50 engorged larvae were released into two randomly selected arenas within the three habitat types.

Engorged Nymphs. - Nymphs were first released when they were found to be occurring on wild hosts. Nymphs were released on three release dates: 15 July, 2 August and 5 September. On each release date approximately 25 engorged

nymphs were released into two randomly selected arenas within the three habitat types.

Tick Confinement

Replete females were introduced into circular arenas measuring 10 cm in diameter by 15 cm high. In order to make observations on preoviposition time, oviposition time, minimum days to egg hatch and the length of larval longevity, each arena was inserted 5 cm into the soil. A bead of Stickum^{R} Special was placed around the top edge of arenas to prevent larvae from escaping after the eggs had hatched. So that determinations could be made about molting time and activity length of the resulting nymphs and adults, engorged larvae and nymphs were placed in screen wire cages similar to those described by Semtner (1972).

Observations

After an oviposition site was selected by a female, a wooden applicator stick was placed near her in order to locate her when making observations. Observations were made every other day until oviposition began, then twice a week until oviposition was completed. Unengorged larvae were observed until their activities had ceased.

Engorged larvae were observed every other day until molting began, then once per week. Observations of unengorged nymphs, resulting from replete larval releases, were continued until their activities had ceased.

Engorged nymphs that were released were observed every other day until molting began. Unengorged adults were then monitored once a week until their activities had ceased.

Physical Parameters

A knowledge of temperature and humidity and their relationships to vegetative cover and ground surface are essential to understanding Gulf Coast tick biology. It has been shown that Gulf Coast ticks have a high critical equilibrium humidity (92 - 93%) and that this may be correlated to their distribution and survival (Hair et al. 1975). Macleod (1935) showed a significant correlation between tick activity and temperature. Therefore, during my study the ambient temperature, relative humidity, soil surface temperature and soil moisture were monitored. This data was used when comparing differences in habitat types in relation to the biology of the tick.

Beginning 1 April 1989, ambient temperatures and relative humidities occurring 30 cm above the soil surface were monitored continuously using Cole-Parmer^{R} seven day hygrothermographs that were housed in standard weather stations.

In order to monitor soil surface temperatures and correlate them with gross ambient temperatures, Temp-Scribe^{R} seven day continuous recording thermographs were used. The thermographs had a remote probe attached. Probes were positioned one meter northeast of the weather stations which

housed the thermographs.

Soil moisture was determined gravimetrically. Volume-equivalent soil samples were collected, placed into soil tins, and transported to the laboratory. Soil samples were weighed, oven dried for a minimum of 48 hrs at 105 °C, and reweighed. Soil moisture was the difference in weight between the wet and dry samples. Two soil samples were taken each week from each of the three habitat types.

Statistical Analysis

Data were compared for statistically significant differences and Least Significant Means were computed by proc GLM and differences of the Least Significant Means were compared (SAS Institute 1985).

CHAPTER III

RESULTS

Seasonal Abundance of Ticks on Hosts

Adult Seasonal Activity

Adult ticks became active on cattle in early March when males emerged and actively sought a host about three weeks before the first female tick was recorded. Tick numbers steadily increased from early March until 20 April when peak numbers of 25.38 and 3.82 adult ticks per head were recorded on the Animal Science and Agronomy herds, respectively. Numbers of adults remained constant on the Animal Science herd for a two week period until 5 May when 25.15 ticks per head were recorded (Fig. 1). Ticks on the Agronomy herd fluctuated between 2 and 3 per head during the next several weeks (Fig. 2). Numbers dropped below an average of one tick per head in July and remained low throughout the study.

Immature Seasonal Activity

Observations on immature Gulf Coast tick activities began on 1 May and larvae were first collected on 8 June. Numbers of larvae increased until 2 August when 5.40 larvae per bird were recorded (Fig. 3). On subsequent collection

Figure 1. Seasonal Activity of Adult Gulf Coast Ticks on Beef Cows in Payne Co., Oklahoma During 1989.

* Average number of ticks from 13 cows.

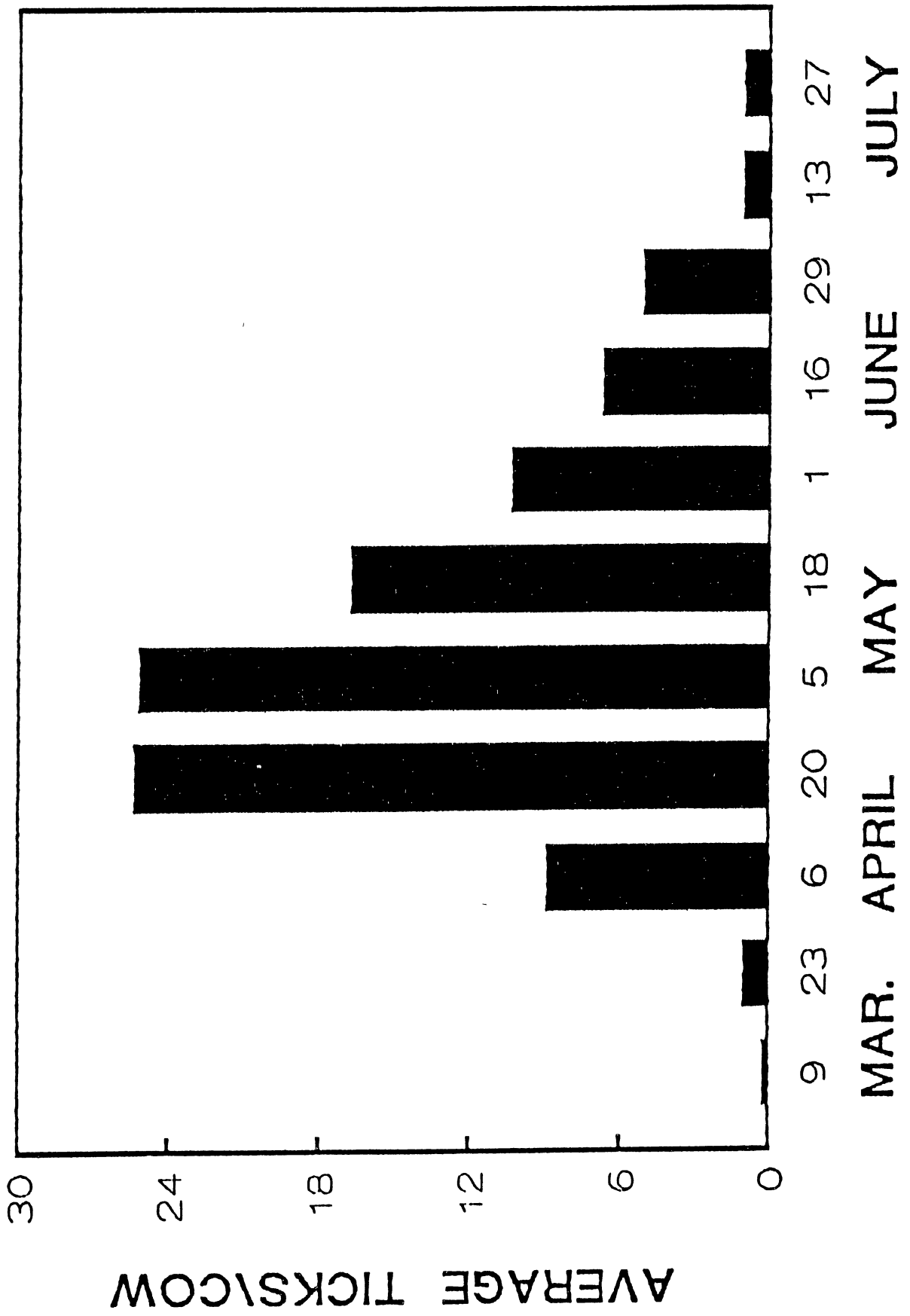

AVERAGE TICKS\COW
30
24
18
12
6
0
9
23
6
20
5
18
1
16
29
13
27
MAR.
APRIL
MAY
JUNE
JULY

Figure 2. Seasonal Activity of Adult Gulf Coast Ticks on Beef Calves in Payne Co., Oklahoma During 1989.

* Average number of ticks from 17 calves.

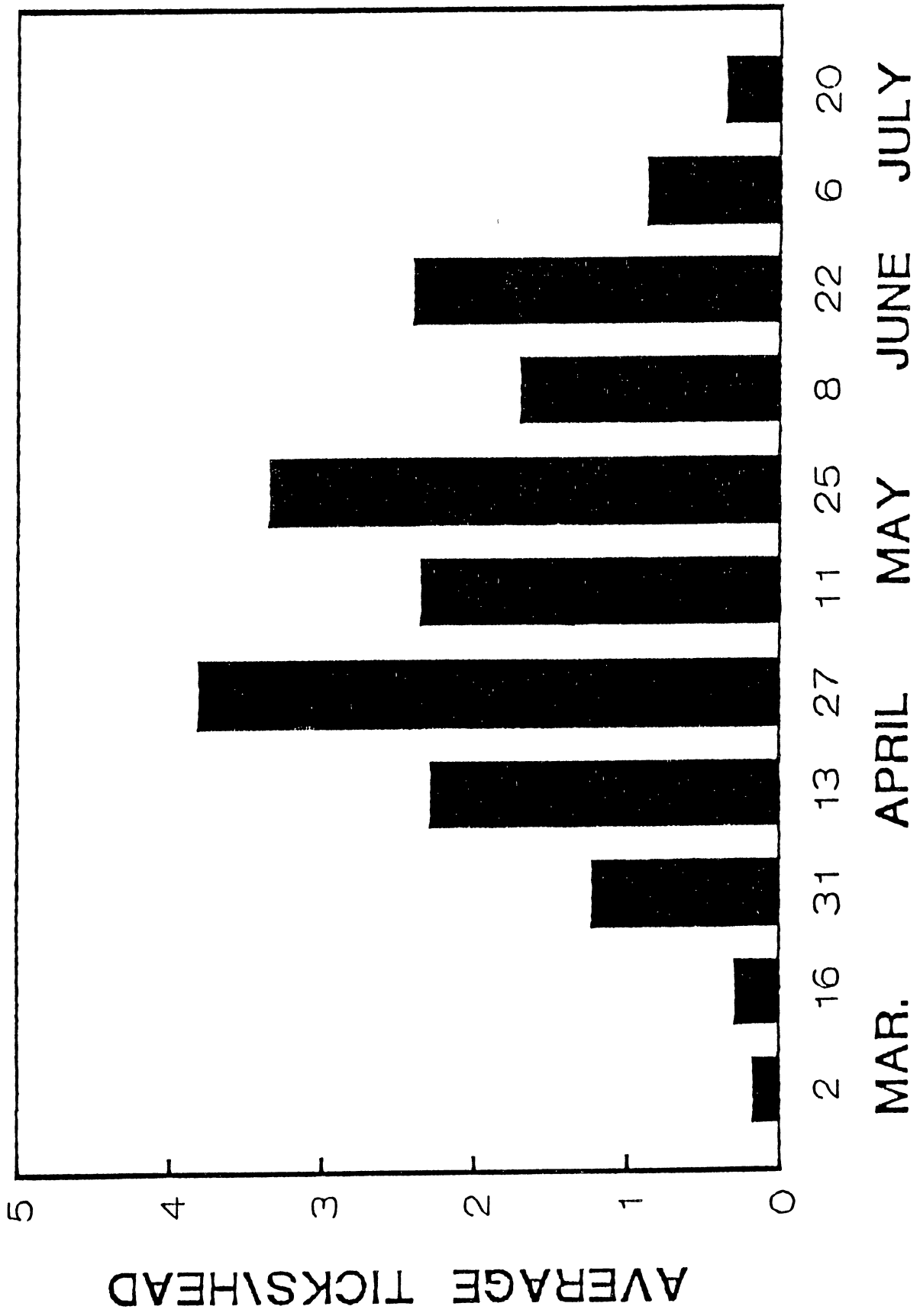

AVERAGE TICKS\HEAD
0
1
2
3
4
5
MAR.
2
16
31
APRIL
13
27
MAY
11
25
JUNE
8
22
JULY
6
20

Figure 3. Seasonal Abundance of Larval Gulf Coast Ticks on Ground-Inhabitating Birds in Payne Co., Oklahoma During 1989.

* Average number of ticks from 5 birds.

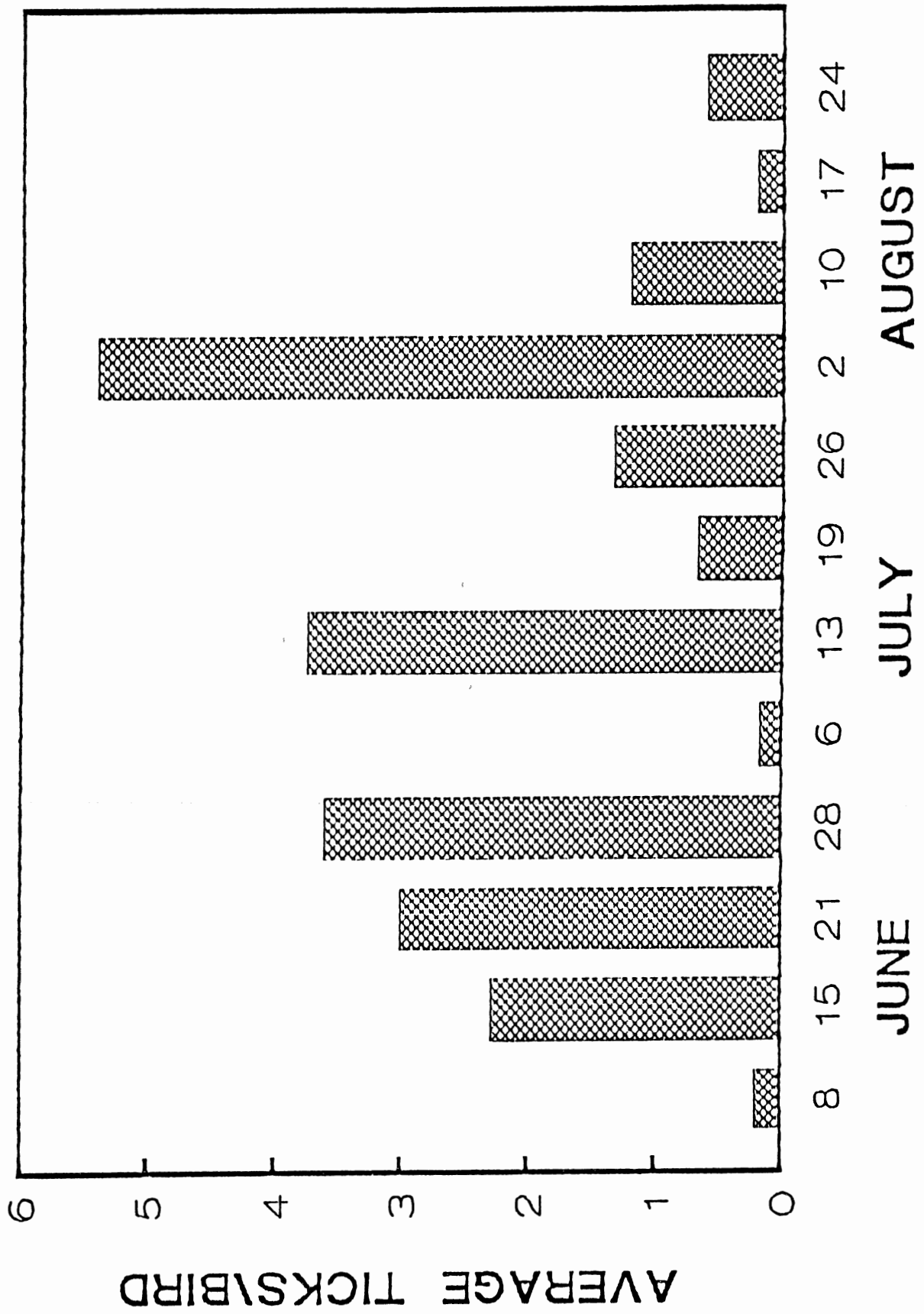
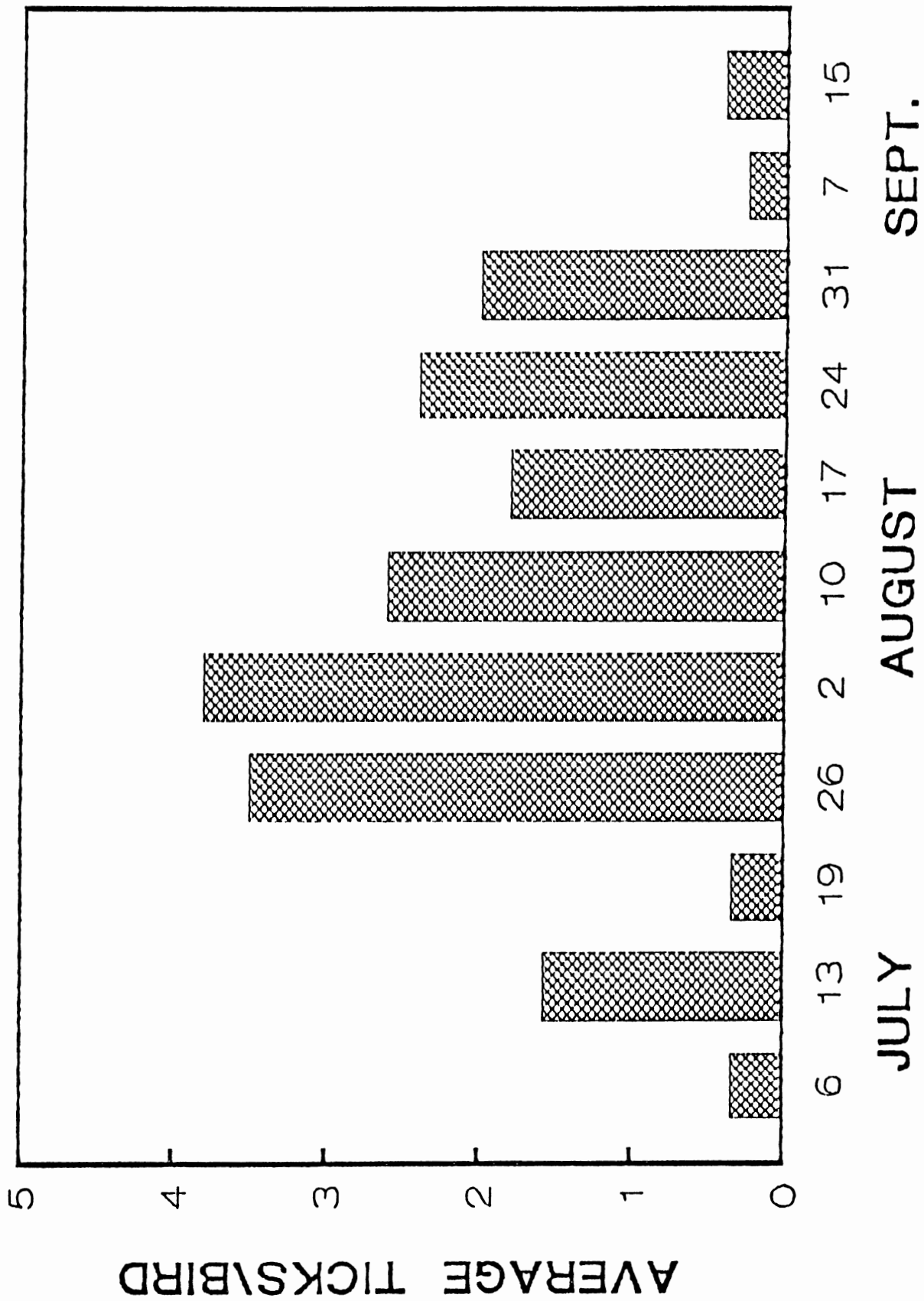

AVERAGE TICKS\BIRD
0
1
2
3
4
5
6
8
15
21
28
6
13
19
26
2
10
17
24
JUNE
JULY
AUGUST

Figure 4. Seasonal Abundance of Nymphal Gulf Coast Ticks on Ground-Inhabitating Birds in Payne Co., Oklahoma During 1989.

* Average number of ticks from 5 birds.


AVERAGE TICKS\BIRD
0
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2
3
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6
13
19
26
2
10
17
24
31
7
15
JULY
AUGUST
SEPT.

dates larval numbers remained low. No engorged larvae were found after the August 24th collection date.

No nymphal activity was recorded until 6 July (Fig. 4). Greatest numbers of nymphs were recovered on 2 August, when an average of 3.80 nymphs per bird was recorded. Tick numbers remained around 2.00 to 2.50 nymphs per bird during the month of August. Collections thereafter showed nymphal numbers to be below 0.40 nymphs per bird. No engorging nymphs were seen after the October 15th collection date.

Gulf Coast Tick Biology

Throughout the remainder of this thesis, when the words different or significantly different are used, it is to be assumed there are statistical differences inferred.

Preoviposition Time

The average preoviposition time for Gulf Coast tick females is presented in Table I. The only difference in preoviposition time occurred following the 25 April release date. Females in the blackjack-oak habitat had a average preoviposition time of 9.00 days, which was different from females in both the meadow and sumac habitats which had averages of 5.75 and 4.50 days, respectively. Preoviposition time differed between dates in only one habitat type. Preoviposition time was different between dates when the average preoviposition time for females released in the blackjack-oak habitat were all different

TABLE I

AVERAGE PREOVIPOSITION TIME (DAYS) OF GULF COAST TICKS IN THREE ECOLOGICALLY DIFFERENT HABITAT TYPES IN PAYNE CO., OKLAHOMA

Release Date	Habitat		
	Blackjack-oak	Meadow	Sumac
25 April	a 9.00 A	b 5.75 A	b 4.50 A
19 May	a 4.00 B	a 4.75 A	a 4.00 A
12 June	a 6.18 C	a 6.00 A	a 5.66 A

Lower case letters pertain to row means; row means preceded by the same letters are not significantly different at the 0.05 level of probability.

Upper case letters pertain to column means; column means preceded by the same letters are not significantly different at the 0.05 level of probability.

from one another. There were no differences for preoviposition time observed between release dates for the meadow or sumac habitats.

Oviposition Time

Table II shows the average oviposition times of female Gulf Coast ticks. Females in the blackjack-oak habitat had the most prolonged oviposition times. Females released in the meadow habitat usually had the shortest oviposition times recorded. It is evident that season had an affect on oviposition time. Oviposition times for females released 12 June were significantly different from females released 25 April.

Minimum Incubation Time

Table III illustrates the average minimum incubation time for Gulf Coast tick eggs. Eggs that were oviposited by females released in the meadow habitat generally had the shortest incubation times. Longest egg incubation times were recorded for eggs oviposited in the sumac habitats. The only difference to occur for the average minimum incubation time, between habitat types and within release dates, occurred for the 19 May release. Egg incubation times were different between the blackjack-oak and meadow habitats. Season influenced incubation times of eggs oviposited by females released in the meadow and sumac habitats. Differences were found for incubation times

TABLE II

AVERAGE OVIPOSITION TIME (DAYS) OF GULF COAST TICK FEMALES IN THREE ECOLOGICALLY DIFFERENT HABITAT TYPES IN PAYNE CO., OKLAHOMA

Release Date	Habitat		
	Blackjack-oak	Meadow	Sumac
25 April	a 30.50 A	b 24.00 A	ab 28.20 A
19 May	a 28.00 A	b 22.55 A	b 22.33 B
12 June	a 17.40 B	a 14.14 B	a 17.66 B

Lower case letters pertain to row means; row means preceded by the same letters are not significantly different at the 0.05 level of probability.

Upper case letters pertain to column means; column means preceded by the same letters are not significantly different at the 0.05 level of probability.

TABLE III

AVERAGE MINIMUM INCUBATION TIME (DAYS) OF GULF COAST TICK EGGS IN THREE ECOLOGICALLY DIFFERENT HABITAT TYPES IN PAYNE CO., OKLAHOMA

Release Date	Habitat		
	Blackjack-oak	Meadow	Sumac
25 April	a 16.50 A	a 18.60 A	a 23.50 A
19 May	a 13.80 A	b 7.12 B	ab 10.50 B
12 June	a 10.80 A	a 8.42 B	a 9.37 B

Lower case letters pertain to row means; row means preceded by the same letters are not significantly different at the 0.05 level of probability.

Upper case letters pertain to column means; column means preceded by the same letters are not significantly different at the 0.05 level of probability.

between the 25 April release date and the last two release dates for these habitat types.

Larval Longevity

Table IV depicts the average longevity of the Gulf Coast tick larvae. No significant differences were found for length of larval longevity between habitat types for any release date. However, larval longevity in the meadow and sumac habitats were different among themselves between release dates. Larval longevity was significantly different for the 25 April release date, in both the meadow and sumac habitats, when compared to the length of larval longevity for the 19 May and 12 June releases.

Molting Time of Engorged Larvae

The average molting time of engorged Gulf Coast tick larvae is given in Table V. No differences for molting time occurred between habitat types for any of the release dates. Differences were not found between release dates for the blackjack-oak or meadow habitats. However, differences did occur for molting times within the sumac habitat between release dates. Engorged larvae that were released on 27 June in the sumac habitat took longer to molt than those engorged larvae released 17 July and 17 August.

Activity Periods of Newly-Molted Nymphs

Table VI shows the average number of active days of

TABLE IV

AVERAGE LONGEVITY PERIODS OF (DAYS) GULF COAST TICK LARVAE IN THREE ECOLOGICALLY DIFFERENT HABITAT TYPES IN PAYNE CO., OKLAHOMA

Release Date	Habitat		
	Blackjack-oak	Meadow	Sumac
25 April	a 47.50 A	a 35.80 A	a 34.66 A
19 May	a 55.16 A	a 60.12 B	a 70.66 B
12 June	a 63.10 A	a 67.85 B	a 67.77 B

Lower case letters pertain to row means; row means preceded by the same letters are not significantly different at the 0.05 level of probability.

Upper case letters pertain to column means; column means preceded by the same letters are not significantly different at the 0.05 level of probability.

TABLE V

AVERAGE MOLTING TIME (DAYS) OF ENGORGED GULF COAST LARVAE IN THREE ECOLOGICALLY DIFFERENT HABITAT TYPES IN PAYNE CO., OKLAHOMA

Release Date	Habitat		
	Blackjack-oak	Meadow	Sumac
27 June	a 21.83 A	a 54.66 A	a 54.50 A
17 July	a 20.83 A	a 32.00 A	a 9.66 B
17 August	a 11.50 A	a 24.83 A	a 11.66 B

Lower case letters pertain to row means; row means preceded by the same letters are not significantly different at the 0.05 level of probability.

Upper case letters pertain to column means; column means preceded by the same letters are not significantly different at the 0.05 level of probability.

TABLE VI

AVERAGE DAYS OF ACTIVITY OF NEWLY-MOLTED NYMPHAL GULF COAST TICK IN THREE ECOLOGICALLY DIFFERENT HABITAT TYPES IN PAYNE CO., OKLAHOMA

Release Date	Habitat		
	Blackjack-oak	Meadow	Sumac
27 June	a 60.82 A	b 6.16 A	c 37.50 A
17 July	a 38.50 B	b 2.75 A	a 29.50 AB
17 August	a 19.16 C	a 14.00 A	a 13.83 B

Lower case letters pertain to row means; row means preceded by the same letters are not significantly different at the 0.05 level of probability.

Upper case letters pertain to column means; column means preceded by the same letters are not significantly different at the 0.05 level of probability.

newly-molted Gulf Coast tick nymphs. Differences for activity periods occurred between habitat types for both the 27 June and 17 July release dates. No differences occurred between habitat types for the 17 August release date. Season had an affect on the length of activity in the blackjack-oak and sumac habitats. Newly-molted nymphs were active for a shorter period of time as release dates were later in the year. No differences in the length of activity were found for the meadow habitat.

Molting Time of Engorged Nymphs

The average molting time of engorged Gulf Coast tick nymphs is presented in Table VII. Differences occurred between all three habitat types for the 15 July release date. Engorged nymphs molting in the sumac habitat had the most elongated molting time of 57.66 days. This was different from ticks molting in the blackjack-oak and meadow habitats. The only engorged nymphs to molt for the 2 August release date occurred in the blackjack-oak habitat. No other engorged nymphs molted for this release. There were no engorged nymphs to molt from the 3rd release.

Activity Periods of Newly-Molted Adults

The average number of active days for newly-molted adult Gulf Coast ticks is shown in Table VIII. Differences occurred between habitat types for the 15 July release date. Adult activity was different between the blackjack-oak and

TABLE VII

AVERAGE MOLTING TIME (DAYS) OF ENGORGED GULF COAST TICK NYMPHS IN THREE ECOLOGICALLY DIFFERENT HABITAT TYPES IN PAYNE CO., OKLAHOMA

Release Date	Habitat		
	Blackjack-oak	Meadow	Sumac
15 July	a 21.66 A	b 41.50 A	c 57.66 A
2 August	a 33.66 A	no molt	no molt
5 September	no molt	no molt	no molt

Lower case letters pertain to row means; row means preceded by the same letters are not significantly different at the 0.05 level of probability.

Upper case letters pertain to column means; column means preceded by the same letters are not significantly different at the 0.05 level of probability.

TABLE VIII

AVERAGE DAYS OF ACTIVITY OF NEWLY-MOLTED ADULT GULF COAST TICKS IN THREE ECOLOGICALLY DIFFERENT HABITAT TYPES IN PAYNE CO., OKLAHOMA

Release Date	Habitat		
	Blackjack-oak	Meadow	Sumac
15 July	a 7.75 A	b 31.50 A	ab 19.00 A
2 August	a 5.50 A	no molt	no molt
5 September	no molt	no molt	no molt

Lower case letters pertain to row means; row means preceded by the same letters are not significantly different at the 0.05 level of probability.

Upper case letters pertain to column means; column means preceded by the same letters are not significantly different at the 0.05 level of probability.

meadow habitats. However, no differences were found for adult activity between the sumac and the other two habitat types. Adults in the blackjack-oak habitat were only active for 5.50 days for the 2 August release.

Physical Parameters

The average monthly temperatures °C and the percent relative humidity is shown in Table IX. The only differences to occur between habitat types for monthly temperatures occurred during the months of May and June. However, relative humidity was significantly different between habitat types during the months of April, May, June, July and August. No differences were found for relative humidity between habitat types for the month of September.

Average monthly percent soil moisture is reported in Table X. From the data collected it is evident that the meadow had the lowest percent soil moisture throughout the study period. There were differences found in percent soil moisture between habitat types for all months recorded.

The average monthly soil surface temperature °C is depicted in Table XI. Throughout the study period the sumac habitat had the highest soil surface temperature. With the exception of September, the soil surface temperature in all three habitat types was significantly different from each other.

TABLE IX

AVERAGE MONTHLY TEMPERATURES °C AND PERCENT RELATIVE HUMIDITIES FOR THREE ECOLOGICALLY DIFFERENT HABITAT TYPES IN PAYNE CO., OKLAHOMA

Month	Habitat		
	Blackjack-oak	Meadow	Sumac
	Temp.\ RH	Temp.\ RH	Temp.\ RH
April	a 16.58	a 16.55	a 17.42
	a 63.86	a 63.17	b 66.45
May	a 18.71	ab 19.37	b 20.15
	a 74.46	b 70.72	c 77.29
June	ab 21.79	a 21.37	b 22.58
	a 76.69	b 73.25	c 79.99
July	a 24.78	a 25.20	a 24.53
	a 74.89	b 70.97	c 77.37
August	a 24.53	a 24.98	a 24.46
	a 75.74	b 72.17	a 77.58
September	a 19.24	a 19.57	a 19.02
	a 73.79	a 70.99	a 73.83

Lower case letters pertain to row means; row means preceded by the same letters are not significantly different at the 0.05 level of probability.

TABLE X

AVERAGE MONTHLY PERCENT SOIL MOISTURE FOR THREE ECOLOGICALLY DIFFERENT HABITAT TYPES IN PAYNE CO., OKLAHOMA

Month	Habitat		
	Blackjack-oak	Meadow	Sumac
April	a 11.47	b 7.08	a 12.93
May	a 16.52	b 11.02	a 14.61
June	a 14.03	b 9.72	a 13.22
July	a 16.77	b 11.21	c 14.10
August	a 11.84	b 9.24	a 11.94
September	ab 11.01	a 8.54	b 12.19

Lower case letters pertain to row means; row means preceded by the same letters are not significantly different at the 0.05 level of probability.

TABLE XI

AVERAGE MONTHLY SOIL SURFACE TEMPERATURE °C FOR THREE ECOLOGICALLY DIFFERENT HABITAT TYPES IN PAYNE CO., OKLAHOMA

	Habitat		
Month	Blackjack-oak	Meadow	Sumac
April	a 18.76	b 21.63	c 24.63
May	a 20.50	b 25.19	c 27.38
June	a 22.56	b 26.92	c 29.15
July	a 25.76	b 29.75	c 31.80
August	a 25.78	b 28.80	c 32.03
September	a 21.12	b 27.25	b 27.71

Lower case letters pertain to row means; row means preceded by the same letters are not significantly different at the 0.05 level of probability.

CHAPTER IV

DISCUSSION

Seasonal Abundance of Ticks on Hosts

Adult Seasonal Activity

Unengorged adult Gulf Coast ticks are known to overwinter in Oklahoma (Stacey and Hair 1977) and generally complete one generation per year. Semtner and Hair (1973) found adult Gulf Coast ticks to be most abundant and active between late May and early June. Adults in my study were most abundant between late April and early May, a time when 25 ticks per head were recorded on cattle. However, scientists in a more southern and coastal distribution have reported peak activity on cattle during August and September (Bishopp and Hixson 1936; Spicer and Dove 1938; Gladney 1976; Gladney et al. 1977; Fleetwood 1985). Host-seeking activity of adults in Georgia ranged from mid-April to early October. In Texas activity was from mid-April through late November, and peak numbers between mid-July and mid-September. In the present study, the host-seeking activity period ranged from late February to late July. Adult males in Georgia and Texas were reported to become active before the females. I also found males to be active before the

females.

Immature Seasonal Activity

No immature ticks were recovered until the first week of June. This agrees with the work of previous Oklahoma researchers studying immature tick activity. They noted that activity began sometime in early to mid-June (Semtner and Hair 1973). Semtner and Hair (1973) found larvae active as early as late June. Numbers peaked in early to mid-July and no larvae were collected after September 5th. I noted that larvae were active between early June and late August. Hixson (1940) reported that larvae were found on animals year-round in Georgia, but they were most abundant between mid-July and mid-November. Fleetwood (1985) reported that larvae were active in Texas in July. Highest numbers were reported between November and January.

Nymphs in my study were collected between early July and mid-October. Semtner and Hair (1973) reported that nymphs were found on hosts between early July and early October with a primary peak occurring in August. I also found peak numbers of nymphs to occur in August. Hixson (1940) collected nymphs from meadowlarks throughout the year. In Texas, Fleetwood (1985) reported nymphal activity to be between November and April, with the highest parasitism occurring in February.

Gulf Coast Tick Biology

Preoviposition Time

The preoviposition period is the interval which elapses between the detachment of engorged females and the time when eggs are deposited by the female. Preoviposition time varied slightly in this study. Sweatman (1967) reported that temperatures below 20°C markedly extended the preoviposition time of Rhipicephalus sanguineus (Latreille). Ambient temperatures during April were less than 20°C and preoviposition time for the April release was slightly longer than preoviposition time for the later dates. Thus, the findings here are similar with those of previous researchers. Furthermore, ambient temperatures for the blackjack-oak and meadow habitats were both less than 20°C, while the sumac habitat had a average ambient temperature of 20.15°C for the month of May. Replete females that were released in May had the shortest preoviposition times recorded. Ambient temperatures for the month of June were only slightly higher than 20°C. However, replete females released in June had a slightly longer preoviposition time period than those released in May.

Oviposition Time

Oviposition time varied from 14.14 days to 30.50 days during the course of this study. Oviposition time was longer for the early season releases and shorter for the

late season releases. Release date and habitat type had an effect on oviposition time during this study. Replete females that were released on 25 April were ovipositing during May when ambient temperatures were low and soil moisture was high. These females had the longest oviposition times. Sweatman and Kousa (1968) showed the optimal temperature for peak output of eggs of R. sanguineus was 30°C. Replete females released 12 June were ovipositing during late June and early July when conditions were near those described by Sweatman and Kousa. Significant differences were not observed for oviposition time between habitat types for this release date. Females ovipositing during this time had the shortest oviposition times recorded.

Minimum Incubation Time

Bishopp and Hixson (1936) reported that the normal incubation time of Gulf Coast tick eggs was about three weeks but eggs oviposited late in the fall may require up to five months of incubation time. The minimum incubation time of Gulf Coast tick eggs in this study varied from 7.12 days to 23.50 days. Season had a significant effect on the minimum incubation time in the meadow and sumac habitats, but not on the blackjack-oak habitat. Generally, ambient temperatures and soil surface temperatures were higher for the meadow and sumac habitats. Also the percent soil moisture was lower for both meadow and sumac habitats when

compared to the blackjack-oak habitat. Eggs oviposited by females released 25 April had longer incubation times than did those eggs from females released 12 June.

Larval Longevity

Season had an effect on larval longevity in the meadow and sumac habitats but not in the blackjack-oak habitat. Throughout the study and especially when the larvae were active, the soil surface temperatures were higher in the meadow and sumac habitats. Stacey and Hair (1977) reported that no unengorged Gulf Coast tick larvae overwintered in a similar type of study.

Molting Time of Engorged Larvae

Once engorged larvae were released they usually crawled around for a short time before selecting a protective place to molt. Molting usually occurred around the edge of the arena within the duff.

Engorged larvae molted quicker in the blackjack-oak habitats, than they did in the meadow and sumac habitats. However, unengorged Gulf Coast nymphs are very small and hard to see in their natural environment. Making observations on engorged larvae and unengorged nymphs was made difficult because during the summer of 1989 we had above normal rainfall and for the most part below average ambient temperatures. Therefore, grasses that grew in the meadow and sumac habitats completely engulfed the arenas in

which engorged larvae were released. The blackjack-oak habitat provided a greater canopy cover and did not allow grasses to grow to the extent that they did in the meadow and sumac habitats; thus making it easier to observe larval molting and detect nymphal activity.

Activity Periods of Newly-Molted Nymphs

Season had an effect on both the blackjack-oak and sumac habitats. Newly-molted nymphs were active longer in the blackjack-oak habitat. This habitat had a higher % soil moisture content and a lower soil surface temperature than the meadow or sumac habitats. As the later releases were made the length of activity of unengorged nymphs began to decrease.

Molting Time of Engorged Nymphs

There were differences for molting times of engorged nymphs between habitat types for the 15 July release date. The only engorged nymphs that molted for the 2 August release were nymphs released in the blackjack-oak habitats. Due to decreasing day length and a reduction in the average daily temperature, engorged nymphs released in the meadow and sumac habitats on 2 August did not molt, nor did any engorged nymphs released in any of the 3 habitats for the 5 September release date. These findings agree with previous researchers studying the lone star tick (Semtner 1973) and Stacey (1977) studying the Gulf Coast tick. Engorged nymphs

that did not show any signs of molting may have molted and not shown any activity and if they did molt could overwinter as flat adults. Past data (Stacey 1977) found flat adults to overwinter in an earlier Oklahoma study.

Activity Periods of Newly-Molted Adults

Habitat did have an effect on the activity times of newly-molted adult Gulf Coast ticks. Unengorged adult ticks were active longer in the meadow habitat and for a shorter time period for the blackjack-oak and sumac habitats.

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