WHITE-TAILED DEER, *ODOCOILEUS VIRGINIANUS* (ZIMMERMAN), MANIPULATION AND ITS EFFECT ON THE LONE STAR TICK, *AMBLYOMMA AMERICANUM* (LINNAEUS)

By

JOHN SCOTT ARMSTRONG

Bachelor of Science in Entomology

Texas Tech University

Lubbock, Texas

1982

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
For the Degree of
MASTER OF SCIENCE
May, 1985

WHITE-TAILED DEER, ODOCOILEUS VIRGINIANUS (ZIMMERMAN), MANIPULATION AND ITS EFFECT ON THE LONE STAR TICK, AMBLYOMMA AMERICANUM (LINNAEUS)

Thesis Approved:

J. Alexander Hair

Thesis Adviser

F. J. McCollum III

W. E. McMurphy

R. W. Barker

Norman N. Durham

Dean of the Graduate College

ACKNOWLEDGEMENTS

The author has always considered the opportunity to continue higher education a privelege and would like to express his appreciation for funding provided by the Oklahoma Agricultural Experiment Station project #1702.

Sincere gratitude is expressed to Dr. Jakie A. Hair for his supervision and support during the course of this research. Appreciation is also extended to committee members: Drs. Bob W. Barker, Wilfred E. McMurphy, and Ted McCollum for their assistance and open-door policy. These professionals were very instrumental in guidance when the need arose.

Dr. Ronald McNew of the Department of Statistics along with Andy Mauromostakos offered vital assistance with data analysis and were a pleasure to work with.

Many thanks go to Mr. Joe Fletcher and personnel at the Oklahoma State Department of Wildlife for providing machinery and manpower that was necessary for this study. The vast experience of Jerry Bowman and the technical assistance of Tom Logan were very helpful and appreciated.

Judy Edmondson is an experienced typist who has an enormous amount of patience and was responsible for typing this manuscript.

Special family members, whom I regard with highest admiration and respect, gave support when I needed it most and include: Ross and Margaret Foster and Brent and Rachel Armstrong.

Finally a special "thank you" to my parents Charles and Courtenay Armstrong who have always led me to believe that if I truly put forth an effort, I could accomplish idealistic goals.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

The lone star tick, *Amblyomma americanum* (L.), is a three-host tick found in extremely high numbers on white-tailed deer, *Odocoileus virginianus* (Zimmerman). White-tailed deer are recorded as the principal wild host of the lone star tick (Clymer et al. 1970; Cooney and Burgdorfer 1974). Patrick (1976), who initiated one of the first intensive studies of the relationship of lone star tick parasitism and white-tailed deer, indicated that the tick depends on the deer for food, mating, and for its spatial distribution. Fawning season coincides with the adult life cycle of the lone star tick. Thus, white-tailed deer suffer high parasitism. Bolte et al. (1970) reported that heavy infestations of all stages of the lone star tick cause tissue destruction around the eyes and ears, secondary infection and sometimes the loss of eyesight. Emerson (1969) compared the high numbers of *A. americanum* on white-tailed deer of Tyler county Texas with no infestations on deer from Llano county Texas and suggested the tick is responsible for low productivity and an unthrifty condition. In a white-tailed deer, *Amblyomma* species study in south Texas, Samuel and Trainer (1970) found adult lone star ticks on adult white-tailed deer and yearling fawns with the majority attached to the ears in the spring. Infestations were correlated with vegetative densities and the lone star tick was found to infest deer from a characterized "dense" vegetative locality. Adult lone star ticks were found on 10% of deer (> 30 days of age) collected.

From data reported, infestations were much lower on deer in the spring especially on neonatal fawns when compared to the previous mentioned work of Bolte (1970). Other Amblyomma species recorded on deer from the Samuel and Trainer (1970) work were A. inornatum, A. maculatum and A. cajannese. Hoch (1973) demonstrated that under laboratory conditions, infestations of 150-540 adult A. americanum per week for four continuous weeks was enough to cause mortality in young fawns. Hoch (1973) and Barker (1973) observed Theileriasis (a hematoprotozan disease of deer) in the blood of fawns taken from eastern Oklahoma. It was evident through blood studies by these two workers that mortality to fawns occurred due to blood anemia and not the disease itself.

Deer in general have been incriminated as being the reservoirs of several diseases and parasites of livestock. Such diseases usually include those which are transmitted from deer to cattle while sharing a particular range. These diseases include foot and mouth disease (vesicular stomatitis), Texas cattle fever (bovine piroplasmosis), Gallsickness (Anaplasma marginale), Bangs disease (brucellosis), gal gangrene (malignant edema), common liver fluke worms (Fasciola hepatica), and common lung worms (Dictocaulus filaria) (Lendune and Volkmar, 1934; McKean, 1949; Emerson, 1969; Sloss and Kemp, 1978; Harwood and James, 1978; and Schipper, 1980).

Since A. americanum are highly prolific in eastern Oklahoma, a number of workers have researched the ecology and biology of the lone star tick (Hair and Howell, 1970; Wilson, 1972; Semtner and Hair, 1973; Robertson et al., 1975; Patrick, 1976; Byford, 1983). From this work, bioecological establishments of tick behavior in different environmental conditions such as different habitat type, tick plant preference, the effect of temperature and seasonal activity of different life stages have been investigated. Hair and Howell (1970) summized that the lone star tick is generally found in predominately wooded areas in the presence of heavy underbrush. The Ozark region of the United States entails many acres of this favorable micro-habitat. One of the largest plant preference studies in the field and in the laboratory was conducted by Semtner and Hair (1973). They found different habitats and plant species were more desirable for ticks than others. Brushy persimmon (Diospyros virginiana), and sassafrass (Sassafrass albidum) groves along with winged elm (Ulmus alata), supported higher numbers of ticks than any of four different vegetative types in eastern Oklahoma. It is well documented that when sampling for A. americanum, higher numbers will be found in areas with brush cover and dense tree stands (Lancaster, 1957; Bishopp and Trembley, 1945; Semtner et al. 1971a, 1971b).

The abundance of the lone star tick in any given area is directly related to its hosts activity. However, Patrick (1976) noted that although deer may introduce the tick into a particular habitat, climatic factors (i.e. relative humidity, temperature and brushcover) ultimately control the ability of the ticks survival. The temperature and relative humidity are directly correlated to the survivalship of ticks. Robertson (1974) observed the temperature and relative humidity of caged ticks in eastern Oklahoma and found that a gradual decline in the number of active ticks occurred with higher temperatures and lower humidities. The effect of temperature was greater than relative humidity or photoperiod, and a noted regularity to the activity or quiesence of individual ticks occurred. In theory, the removal of upper canopy and lower brush and shrubs increases sunlight penetration and decreases the relative humidity and creates an unsuitable micro-habitat for the lone star tick. Patrick and Hair (1978) indicated that open meadow areas that contain replete females transported by wildlife show low existence of larvae due to the death of the female before oviposition, no oviposition, and a low eclosion rate.

Many Acarine species, as well as other arthropods, possess the capability of absorbing water from subsaturated atmospheres (Knulle, 1966, 1967; Lees, 1946; Sauer and Hair, 1971). These arthropods usually exist where relative humidities are high. The critical equilibrium humidity (CEH) for adult lone star ticks is ca. 80-82% (Hair et al. 1975). The CEH is the relative humidity at which the organism gives up no water. At the CEH, a balance of water loss and water gain occurs and the tick remains at a constant weight. Life longevity is prolonged at or above this relative humidity threshold. Some researchers have worked with relative humidity and temperatures associated with life longevity of different medically important ticks. Lancaster and McMillan (1955) report that _A. americanum_ larvae die within a few days at a R.H. of 69%. _B. microplus_ (Canestrini) larvae survived 240 days at 90% R.H. and 22.2°C and only 12 days at 70% R.H. (Hitchcock, 1955). The sheep tick, _I. ricinus_ (L.) survived 3 months or more at 95% R.H. and 25°C, and survived only 4 to 8 days at a R.H. of 70% (Lees, 1946).

There is consistency on data collected pertaining to the seasonal activity of the lone star tick. General seasonal activity in eastern Oklahoma shows adult activity beginning in February with a peak occurring in late May and early June. Nymphs exhibit a bimodal peak, one in early June and one in August or September. The highest larval activity ranges from late July to September depending upon the existing environmental habitat (Hair and Howell, 1970; Semtner et al. 1971b; Patrick, 1976; Byford; 1983). In northwestern Arkansas, there were no active stages removed during December and January. Nymphs were collected in February and showed a general increase in late June or early July and declined until October or November. Larvae were removed from April to October or November with peaks occurring in September (Tugwell and Lancaster, 1963). In Virginia, Sonenshine et al. (1966) found adult lone star ticks to peak in June, larvae peaked in mid April and August while nymphs reached their highest numbers in May.

Control measures for the lone star tick include the selective use of acaricides, mechanical clearing of vegetation, use of herbicides, pasture rotation and the use of resistant bovine. Clymer et al. (1970), while studying simulated recreational areas, found that a combination of mechanical clearing, use of acaricides and herbicides or a combiantion of the three offered effective control. Hoch et al. (1971a,b) also used mechanical clearing and/or chemical treatment to suffice its effect on relative humidity, temperature and soil moisture in lone star tick habitats. A herbicide applied to previously clear woodlots increased the average seasonal temperature of the soil surface by 6.6°C, relative humidity declined by 6.2% and the soil moisture alone reduced by 22%. With this treatment over 3 years, it was shown that a drastic decrease in the tick population occurred in woodlots of eastern Oklahoma.

These field studies were important when compared to the temperature relative humidity thresholds from laboratory work in that laboratory experiments do not consider the ability of the tick to seek subsaturated atmospheres that will accommodate water balance.

Habitat modification can offer a low cost and reduced tick population over an extended period of time as indicated by Meyer et al. (1982). He found that mechanical clearing with the addition of fertilizer produced a cost of 14¢/per kilogram of dry matter, while scheduled spraying with acaricides cost 74¢/per kilogram of dry matter produced.

The use of acaricides for control of the lone star tick as well as other tick species has been thoroughly investigated (Davey et al. 1980; Barnard et al. 1983; Clymer et al. 1970; Drummond and Gladney, 1978). One of the largest field comparisons of acaricides for use on pastured cattle was conducted by Drummond and Gladney (1978). These workers determined the post-treatment effectiveness of 17 different acaricides in the field.

Another control strategy perhaps overlooked by beef producers in areas where the lone star tick exists, is the use of resistant bovine. Australians were the first to realize and utilize the resistance factor obtained in different breeds of cattle. In eastern Oklahoma, Garris and Hair (1980) and Garris et al. (1979) clearly demonstrated the resistance factor obtained in Brahman crossed with hereford, or "Braford" cattle. Braford cattle were less susceptible to infestations from larvae and adults, and the weight of females and egg masses collected from Braford cattle were less than those obtained from Hereford cattle.

Byford (1983) utilized an integrated approach for lone star tick control on beef cattle in the Cherokee Wildlife Refuge, Cherokee County Oklahoma. The combination of control methods used were habitat modification, forage improvement, Brahman crossbreeding of cattle and the selective use of an acaracide. Control measures were used to reduce all life stages of the lone star tick including parasitic and free-living. Two groups of both Hereford cattle and Hereford X Brahman or "Braford" cattle were pastured in improved pastures or unimproved pastures during the spring and summer months of 1981 and 1982. Results indicated that with the use of Braford cattle harbored in improved pastures, significant reductions of all life stages of the lone star tick were accomplished. Furthermore, Braford cattle inhabiting the improved pastures supported < 20 lone star ticks/animal and subsequently resulted in a reduction in the necessity for use of the acaracide.

Such knowledge of the biology and ecology, control strategies available, whether they be chemical or physical, are a prequisite to any attempt of controlling the lone star tick.

White-tailed deer, O. virginianus, migrated north when land clearing and settlement started from the Atlantic and progressed westward around 1907. Forests of the north did not contain low growing vegetation because of the shading effect of the upper canopy. Today, white-tailed deer are found throughout the northeastern and southeastern United States (Hosely, 1956).

The nutritional needs of deer vary with the region in which they reside. Nichol (1938) and Gerstell (1937) found that regardless of available food and differing temperatures, most adult deer reach their lowest annual weight curve in the last week of February. It appears that deer posses an innate ability to recognize the most nutritious food when available. Mitchell and Hosely (1936) found deer browsing tended to follow the nitrogen content of the vegetaiton they fed upon. Pearce (1937) noted that deer preferred vegetation on plots that had been previously burned as opposed to unburned areas. The best source for nutritional requirements of white-tailed deer in correlation to their regional location is given by Atwood (1941). Common deer browse includes almost everything grown in the forest including buds, woody shoots, leaves, seeds, herbs, grasses and mushrooms. All appear in their normal diet according to Bramble and English (1948). The favorite foods of deer in Missouri according to Dalke (1941) are grape (*Vitis* sp.), maple (*Acer* sp.), greenbier (*Smilax tamnoides*), oak (*Quercus* sp.), sassafrass (*Sassafrass albidum*), Sumac (*Rhus* sp.). Vegetal species showing lower use were: winged elm (*Ulmus alata*), blackberry (*Rubus trivialis*), American elm (*Ulmus americana*), slippery elm (*Ulmus rubra*), hickory (*Carya* sp.), lespedeza (*Lespedeza* sp.), persimmon (*Diospyros virginiana*), plum (*Prunus* sp.), poison ivy (*Rhus radicans*), sedges (*Carex* sp.), rushes (*Juncus* sp.) and black walnut (*Juglans nigra*). These types of vegetation are very similar to that of eastern Oklahoma.

Within the past 30 years, information pertaining to differing methods of determining herbivore diets has increased. This information of range herbivore food habits is important in wildlife and domestic animal production from the standpoint of managing animal utilization.

One of the more available and widely used methods for determining herbivore diets is the fecal analysis method by Baumgartner and Martin (1939). After processing a fecal sample in the manner described by these researchers, a slide is prepared of the feces of which twenty microscopic fields are randomly located. A trained technician examines the slide to determine the number of times a plant species fragment appears in each microscopic field. Frequency of occurrence is determined by dividing the number of microscopic fields in which a given species occurred by the total number of fields X 100.

Fecal analysis technique is used in a variety of locations and for differing animal species. In many cases it is used to determine pasture utilization of cattle such as the study conducted by Kirby and Stuth (1982). Wildlife food analysis often involves the fecal analysis technicque like a prairie dog diet study in South Dakota, Uresk (1984) and a white-tailed deer diet study in south Texas, Everitt and Drawe (1974).

As previously discussed in this review, habitat type and host distribution are the factors involved in determining if tick populations are high or low. Natural meadows and chemically or mechanically cleared areas will harbor fewer ticks due to unfavorable environmental conditions (Patrick and Hair 1979; Clymer et al., 1970; Hoch et al. 1971b).

It was the purpose of this research to attract white-tailed deer to open improved areas through their diet in early spring at a critical time when replete female ticks are at their highest numbers, and will subsequently drop off in the improved environment that is not conducive to tick survival. A number of evaluations on the physical make up of differing habitats and animal utilization were conducted.

The present study was designed to: (1) estimate the number of deer utilizing improved or unimproved food plots, (2) quantitate and compare different vegetative types from improved or undisturbed food sources, (3) monitor tick populations in improved and unimproved areas throughout the most active time of the lone star tick activity, (4) determine environmental parameters which influence the suitability of differing lone star tick habitats throughout the most active period of lone star tick and white-tailed deer activity.

CHAPTER II

METHODS AND MATERIALS

The Cookson Hills Refuge, located in southwestern Adair and southeastern Cherokee Counties, Oklahoma was the site selection for the study due to the accessibility of land and the high existing number of white-tailed deer and lone star ticks. Two replications of 0.4 ha size consisting of a climax forest, a meadow and an improved area were utilized to determine deer activity, tick population estimates and climatic data.

The climax forest consisted of an upland oak hickory habitat with an overstory of black hickory (*Carya texana*), post oak (*Quercus stellata*), black oak (*Q. velutina*) and blackjack oak (*Q. marilandica*). Undergrowth was sparse and consisted of Virginia wildrye (*Elymus virginicus*), buckbrush (*Symphoricarpos orbiculatus*) and differing species of ferns (*Woodsia sp.*)

Plant species of the meadow habitat included a dominate native grass cover of broomsedge (*Andropogon virginicus*) tall fescue (*Festuca arundinacea*), orchardgrass (*Dactylis glomerata*), cheat (*Bromus sp.*) and Virginia wildrye (*Elymus virginicus*). Small flowering plants and young trees and shrubs such as sumac (*Rhus sp.*), sassafrass (*Sassafras albidum*) and persimmon (*Diospyros virginiana*) were also abundant in the meadow habitat. It was approximated that the meadow had ca. 25% brush and small tree cover.

The improved plots were prepared during the fall of 1983. Two hectares of an old overgrown meadow of trees and shrubs were cleared, rocks removed and the top soil worked with different implements until it was possible to sow mixtures of forage plants. Soil samples[1] from these areas were taken in September of 1983 and determined a need for 55 kg/ha of N, 48 kg/ha P and 46 kg/ha of K. The fertilizer was administered in October 1983.

Subsequently the cleared area was divided into four 0.4 ha plots with two replications of arrowleaf clover (*Trifolium vesiculosum*), annual ryegrass (*Lolium multiflorum*), wheat (*Triticum aestivum*) and two more replications of the same mixture with the exception of arrowleaf clover being replaced by red clover (*Trifolium pratense*). These forages were planted simultaneously with a wheat drill that contained differing seed storage compartments. The proper nitrogen fixing bacteria (*Rhizobium trifolii* were mixed at the recommended rate for planting the red and arrowleaf clovers. The planting date was 6 October, 1983.

White-Tailed Deer Survey

Since the lone star tick is somewhat dependent upon white-tailed deer for its nourishment, reproduction and distribution, it was imperative that an estimate of this primary host visiting unimproved and improved study units be conducted. The method used was deer pellet group counts as described by Bennett et al. (1940), Hosely (1956) and Patrick (1976). Bi-weekly counts of two 0.04 ha squares and two 100 m transect lines within each habitat were conducted by counting feces pellet groups

---

[1] Soil sample analysis conducted by Agronomy soil testing labratory, Oklahoma State University, Stillwater, Oklahoma.

of white-tailed deer. Each habitat type, including the differing improved replications had two 100 m transect lines and 0.04 ha squares. After a pellet group was observed and tabulated, it was sprayed with a yellow plaste-cote® acrylic spray paint. This ensured that the pellet group would not have been counted again in upcoming observations. The first observations were made on 4 April, 1984 and continued until 20 September, 1984.

White-tailed Deer Diet Analysis

Two white-tailed deer feces pellet groups were collected from each an improved plot and the meadow habitat and sent to a wildlife food habits analytical laboratory[2]. Microhistological analysis of these pellet groups resulted in the percent relative frequency of plants consumed. Results of the deer diet study should have contained those plants that are more desirable for deer than others which also reflects the locality of deer eating/browsing. A knowledge of food plant utilization by deer should indicate habitat use and therefore correlate with time spent in specific habits. In turn, time spent should correlate with the probability of tick drop-off within each habitat type.

Forage Production

In December 1983, ten exclosures 1.2 m in height and 1.2 m in circumference were constructed from non-climb® horse fencing and systematically placed in all four improved plots. The exclosures were supported by 1.8 m tee posts® on either side of the circular fencing.

---

[2] White-tailed deer diet frequencies analyzed by Wildlife Foods Analytical lab, Texas Tech University, Lubbock Texas.

The standing dry matter (SDM) forage production in terms of kg/ha were measured inside the exclosures along with a random sample outside the exclosures. The method used follows that of Baker (1978) and Byford (1983) by hand clipping sample areas in April and May. A sample consisted of a 0.25 m^2 frame which were hand clipped at a ca. 3 cm from ground level, placed in a paper bag and returned to a drying oven for 72 hours at 60°C. Subsequently the samples were removed from the drying oven and weighed to determine the amount of dry matter yield to use in comparison of inside versus outside production/consumption.

On 18 June, 1984, all plots of the improved study units were cut with a swather and immediately baled to remove all but 12 cm in height of grasses and forages to expose the existing tick population or to rid them by mechanical binding.

Temperature and Relative Humidity Measurements

Throughout the study, temperature and relative humidity data were recorded on seven day charts by the use of Belfort® hygrothermographs within each habitat type. The mean weekly temperature and relative humidity were obtained at four different times (6AM, 10AM, 4PM, 10PM) during a 24-hour period of each day. Hygrothermographs were placed in weather boxes at 45 cm from ground level. Only one hygrothermograph was used to record climatic data for all four improved replications. Temperature and relative humidity readings were taken from June 11, 1984 until September 20, 1984.

Lone Star Tick Survey

Carbon dioxide (CO_2) traps (Kinzer 1975; Wilson 1972; Byford 1983) were used as a means of determining populations of free-living host seeking ticks within differing vegetative plots. Ten traps/habitat replication were baited with ca. 230g of solid dry ice and placed systematically within each plot. Trapping occurred on a biweekly basis from 6 April 1984 until 20 September 1984 with a total of 12 trapping dates. After allowing each trap to operate for three hours, they were subsequently taken back to the laboratory for counts of adults, nymphs and larvae.

Statistical Analysis

Student "t" tests were used to differintiate differences of inside versus outside sampling for forage consumption from the improved plots. Both replications of improved areas were combined to reduce sample error. Deer diet frequencies were analyzed using analysis of variance with both samples from the improved being combined and both samples from the unimproved being combined to form one mean for percent relative frequencies. Variables used were plot, week sampled and month sampled. Tick capture data of adults nymphs and larvae were also analyzed with analysis of variance. The high numbers from the wooded areas were not used in the contrast test since obvious differences occurred.

CHAPTER III

RESULTS AND DISCUSSION

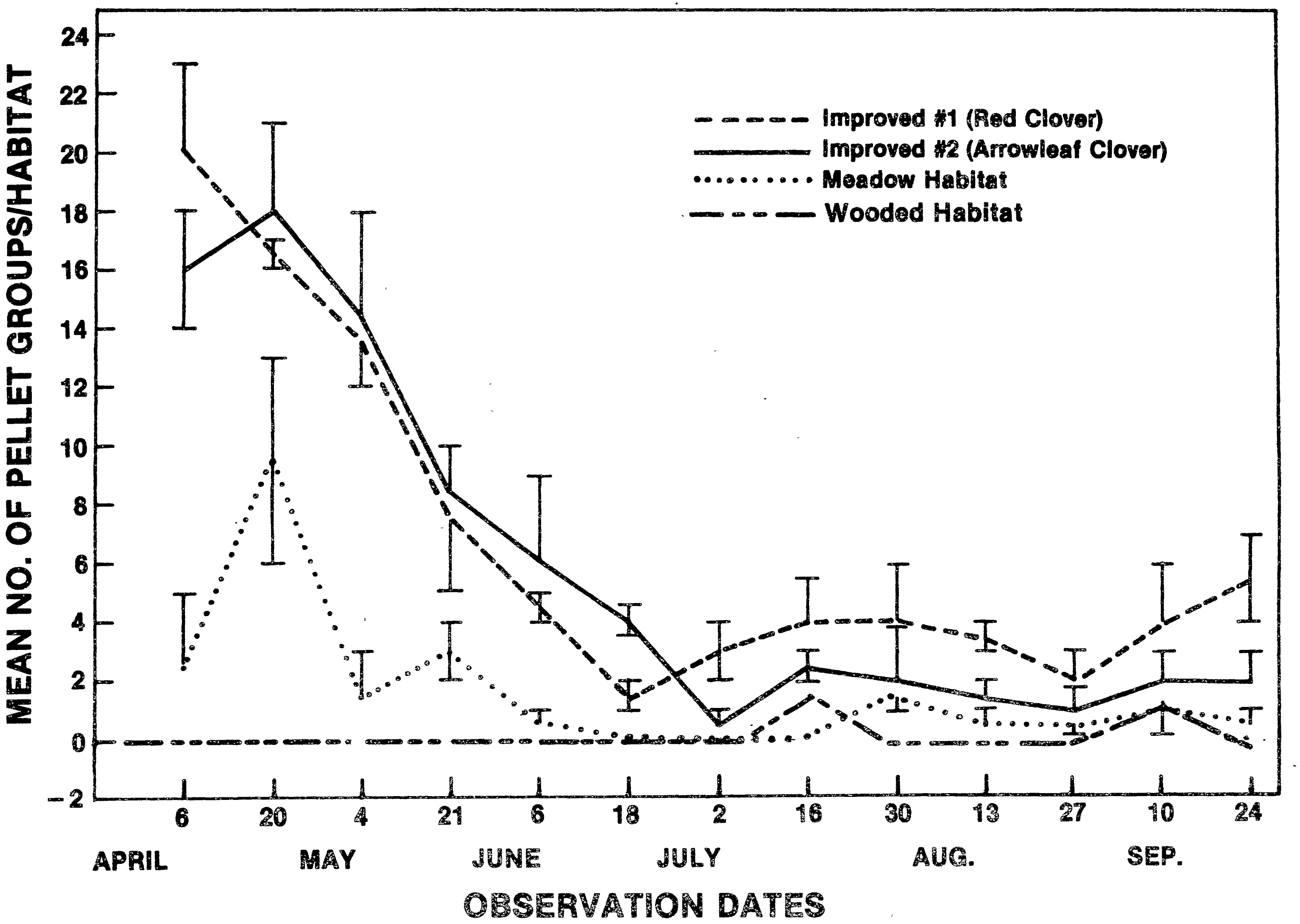
White-tailed Deer Survey

White-tailed deer utilization in improved and meadow habitats are shown in Figure 1. The red and arrowleaf clover plots were both utilized heaviest during the first two observation dates of the study. During this time, both clover species (arrowleaf, red clover) and grasses (wheat, ryegrass) were well established within the test plots. Highest deer use in the meadow habitat occurred on 20 April. Seasonal differences occurred in that white-tailed deer use from both the improved and meadow habitats was highest during the month of April, and appeared to attract deer more than wooded areas. During this early spring period, native grasses in the meadow and planted grasses and clovers from the improved areas were well established in a young succulent growth stage offering an early spring food source.

Deer utilization in the red clover replications steadily declined through April and May, reaching a low on 18 June. After this decline in deer use, it increased, and finally increased sharply from 27 August to a final observation mean of 6.5 pellet-groups on 24 September (Figure 1). This increase in deer use from 27 August to 24 September in the red clover plots can be explained by a noticeable regrowth in the red clover after the 18 June baling.

Deer usage in the arrowleaf areas declined in a similar manner as

Figure 1. Mean (±1SE) number of White-tailed Deer pellet - groups recorded from improved and natural habitats in the Cookson Hills State Game Refuge, Oklahoma during June-September, 1984


MEAN NO. OF PELLET GROUPS/HABITAT
24
22
20
18
16
14
12
10
8
6
4
2
0
−2
Improved #1 (Red Clover)
Improved #2 (Arrowleaf Clover)
Meadow Habitat
Wooded Habitat
6
20
4
21
6
18
2
16
30
13
27
10
24
APRIL
MAY
JUNE
JULY
AUG.
SEP.
OBSERVATION DATES

the red clvoer until 2 July (Figure 1). However, there was not an increase in deer utilization after this date to the same degree as the red clover. This can possibly be explained by a noticeable lack of regrowth after the 18 June cutting and subsequent baling.

White-tailed deer utilization of the meadow test areas from 18 June to the end of the study was low because the dominate native grass species were dessicating and did not provide a palatable food source (Figure 1). Patrick and Hair (1978), observed this same feeding behavior for white-tailed deer in eastern Oklahoma.

Observations for pellet groups in the upland-oak hickory habitats were conducted in the same manner as the improved and meadow habitats. Utilization in the upland-oak hickory habitat was low with one pellet group collected on 16 July and another on 10 September (Figure 1). Plant growth of forbs and grasses were limited in the wooded habitat and practically devoid of food plants within reach of the deer. Also, land mass area of the wooded habitat was many times that of the isolated meadow or improved plots. Thus utilization as measured by pellet-group counts in this study may be diluted to some degree.

Deer consumption in terms of daily air dry plant material per 45/kg deer was ca. 1.3 kg according to Cahart (1946). The estimated deffecation rate of adult white-tailed deer on winter forage was 13 pellet groups/day Dasman and Taber (1955).

White-tailed Deer Diet

Since white-tailed deer are considered browse feeders, it was assumed that a majority of plant species in deer diet would be of the browse category whether the area in which they range be within and around improved or meadow habitats. However, forb and grass species are the second and third plant class preferred respectively and used to compete with the available surrounding browse plants.

White-tailed deer diet analysis of the mean percent relative frequencies of browse, forbs and grasses resulted in no significant differences ($P > 0.05$) between the improved and meadow areas in spring (Table I). From early July until September, significant difference ($P < 0.05$) in the amount of browse and forbs occurred between the improved and meadow plots (Table II). Grass species consumption was low and no significant differences ($P > 0.05$) between the two food areas occurred during the summer months (Table II).

During the spring, individual plant species consumption of planted improved forage varieties was high. For example, the mean percent relative frequency of arrowleaf clover on 6 April from the improved area was 15.3%. This indicated that consumption of arrowleaf was high and white-tailed deer from the meadow area chose alternative native forbs (i.e. lespedeza) in place of those offered to them in an improved situation. After 4 May grass consumption declined while forb consumption increased and by the end of the spring period the percentages of forage consumed from the improved areas was 55.8% browse, 34.3% forbs and 9.9% grasses (Table I). The meadow areas resulted in 56.6% browse, 32.2% forbs and 11.3% grasses (Table I). This noted seasonal change of a decrease in grass consumption and increase in forb consumption can be explained by the dessication of most native grasses by June and the availability of forbs gradually increasing from April to June. A similar seasonal shift from grass consumption to forb consumption was noted by Davis and Winkler (1968) and by late spring forbs were the major component of deer diet.

TABLE I

MEAN PERCENT RELATIVE FREQUENCIES OF WHITE-TAILED DEER DIET FROM IMPROVED AND UNIMPROVED AREAS OF THE COOKSON HILLS STATE GAME REFUGE, OKLAHOMA, DURING APRIL-JUNE, 1984

Plant Class	Observation Dates													
	4-6		4-20		5-4		5-21		6-4		6-18		Seasonal Average ± 1SE of Mean	
	I[a]	M[b]	I	M	I	M	I	M	I	M	I	M	I	M
Browse	49.1	49.3	55.4	60.6	73.1	75.9	63.2	67.5	57.3	34.6	36.4	51.5	55.8±5.1	55.6±6.0
Forbs	22.5	20.6	25.4	18.0	26.9	21.8	28.8	31.5	42.7	57.8	59.6	43.5	34.3±5.8	32.2±6.4
Grasses	28.3	30.1	19.1	21.5	0.0	2.3	8.1	0.8	0.0	7.6	4.0	5.3	9.9±4.9	11.3±4.8

a/ Cleared improved area planted in legumes and grasses and surrounded by an upland-oak hickory forest.

b/ Meadow area surrounded by upland-oak hickory forest.

TABLE II

MEAN PERCENT RELATIVE FREQUENCIES OF WHITE-TAILED DEER DIET FROM IMPROVED AND UNIMPROVED AREAS OF THE COOKSON HILLS STATE GAME REFUGE, OKLAHOMA, DURING JULY-SEPTEMBER, 1984

Plant Class	Observation Dates												Seasonal Average ± ISE of Mean	
	7-2		7-16		7-30		8-13		8-24		9-16			
	I[a/]	M[b/]	I	M	I	M	I	M	I	M	I	M	I	M
Browse	33.7	86.6	41.9	81.0	30.1	77.8	41.2	36.2	36.0	71.1	17.8	90.9	33.5±3.6	73.9±8.1
Forbs	66.3	13.4	58.1	19.0	69.9	20.5	58.8	27.4	62.0	28.9	82.2	9.1	66.2±3.4	19.7±3.1
Grasses	0.0	0.0	0.0	0.0	0.0	1.7	0.0	36.4	1.9	0.0	0.0	0.0	.3± .3	6.4±6.0

a/ Cleared improved area planted in legumes and grasses and surrounded by an upland-oak hickory forest.

b/ Meadow area surrounded by upland-oak hickory forest.

During the summer months (July-September) browse consumption was consistently higher from the meadow area than the improved areas while the improved areas were higher in forb consumption (Table II). As stated earlier there were significant differences in browse and forb consumption between the improved and meadow habitats. From the improved area, browse consumption was 33.5%, forbs 66.2% and grasses 0.3% (Table II). Meadow consumption resulted in 73.9% browse, 19.7% forbs and 6.4% grasses (Table II).

Arrowleaf clover was the major forb consumed from the improved areas during the spring and on the last collection date of spring contained 52.9% mean relative frequency. Red clover intake was high during the summer period and reached 44.9% mean relative frequency on 24 August. Wheat appeared to be consumed until April 20 with 9.3% but does not appear in deer diet after this date. Annual ryegrass was detected only in trace amounts (i.e. 1% on 6 April) and does not appear to be a preferable grass species. Table IV and VII of the appendix lists improved and native plant species and their sum frequencies from spring and summer periods respectfully.

Forage Production

As stated previously, both replications of arrowleaf and red clover also contained ryegrass and wheat. Following referrals will only state arrowleaf or red clover because they were the major dominate plant species throughout the study.

Forage production in terms of standing dry matter indicated arrowleaf plots on the 13 April sampling had 680 kg/ha SDM inside the exclosures and 288 kg/ha SDM outside the exclosures with a significant difference ($P < 0.05$) of 392 kg/ha consumed. Red clover sampling inside exclosures on 13 April had 584 kg/ha SDM within the exclosures as opposed to 236 kg/ha SDM outside the exclosures with a significant difference ($P < 0.05$) of 248 kg/ha SDM consumed. These differences can be justified when observing the high white-tailed deer utilization during this time (Figure 1), and by deer diet analysis.

The second forage sampling on 28 May resulted in 2076 kg/ha SDM from inside arrowleaf exclosures compared to 1772 kg/ha SDM outside exclosures. The average sampling difference of 304 kg/ha was not significant of the 0.05 level of probability. Simularly, the red clover sampling within exclosures had 1352 kg/ha SDM and 1304 kg/ha SDM outside exclosures with no significant difference ($P < 0.05$) of 48 kg/ha SDM. White-tailed deer utilization had decreased by late May (Figure 1), and plant compensatory growth was at such a high rate that deer consumption did not result in significant differences in dry weights.

Arrowleaf clover with the addition of fertilizer is well adapted to the eastern half of Oklahoma. The red clover only produced 65% as much standing dry matter within exclosures when compared to the arrowleaf clover plots. This can perhaps be explained by the fact that red clover is better adapted to the northeastern part of the state in sandy loams which are high in available phosphorus (Bates 1974). Also, the arrowleaf clover on 28 May sampling was at the preflowering stage of growth while the red clover was not as advanced in maturity. After the cutting and baling on 8 June, the arrowleaf clover did not exhibit regrowth as did the red clover.

Relative Humidity and Temperature

The weekly mean temperatures and realtive humidities at selected times of a 24-hour period (6AM, 10AM, 4PM and 10PM) showed that during daylight hours of the warmer parts of the day (10AM and 4PM), a seperation in the temperatures and relative humidities occurred in the meadow and the improved plots from the upland-oak hickory habitats (Figures 2 and 3).

Generally, in early morning, the relative humidity is slightly higher (85-100%) in the open meadow and improved plots when compared to the meadow (65-95%) (Figure 2). By mid morning the relative humidity decreased in the meadows and improved plots (53-81%) while the wooded habitat remained in much the same range (70-92%). These differences were magnified to a greater extent by mid afternoon with the open plot areas ranging from 42-67% and the upland-oak hickory habitat ranging from 57-85%. The late evening relative humidities at the 10PM reading indicate that all curves from each habitat type were generally in the same range (63-91%).

These data are typical of the temperature: relative humidity inverse noted by previous researchers working in the same area (Robertson et al. 1975). The upland-oak hickory habitat wascloser to the critical equilibrium humidity (C.E.H.) of 80-82% Hair et al. (1975). When relative humidities occur below the C.E.H. the tick looses body water to the atmosphere and at relative humidities above the CEH the tick absorbs H_2O from the atmosphere.

Since both temperature and relative humidities were measured at 45 cm from ground level with hygrothermographs, no significant differences could be detected between the improved and meadow habitats. However, Hoch et al. (1971a) observed that humidities of the soil surface were lower than humidities at 45.7 cm from ground level, and soil surface

Figure 2. Mean percent relative humidity recorded at 45 cm from ground level in different habitats of the Cookson Hills State Game Refuge, Oklahoma during June-September, 1984

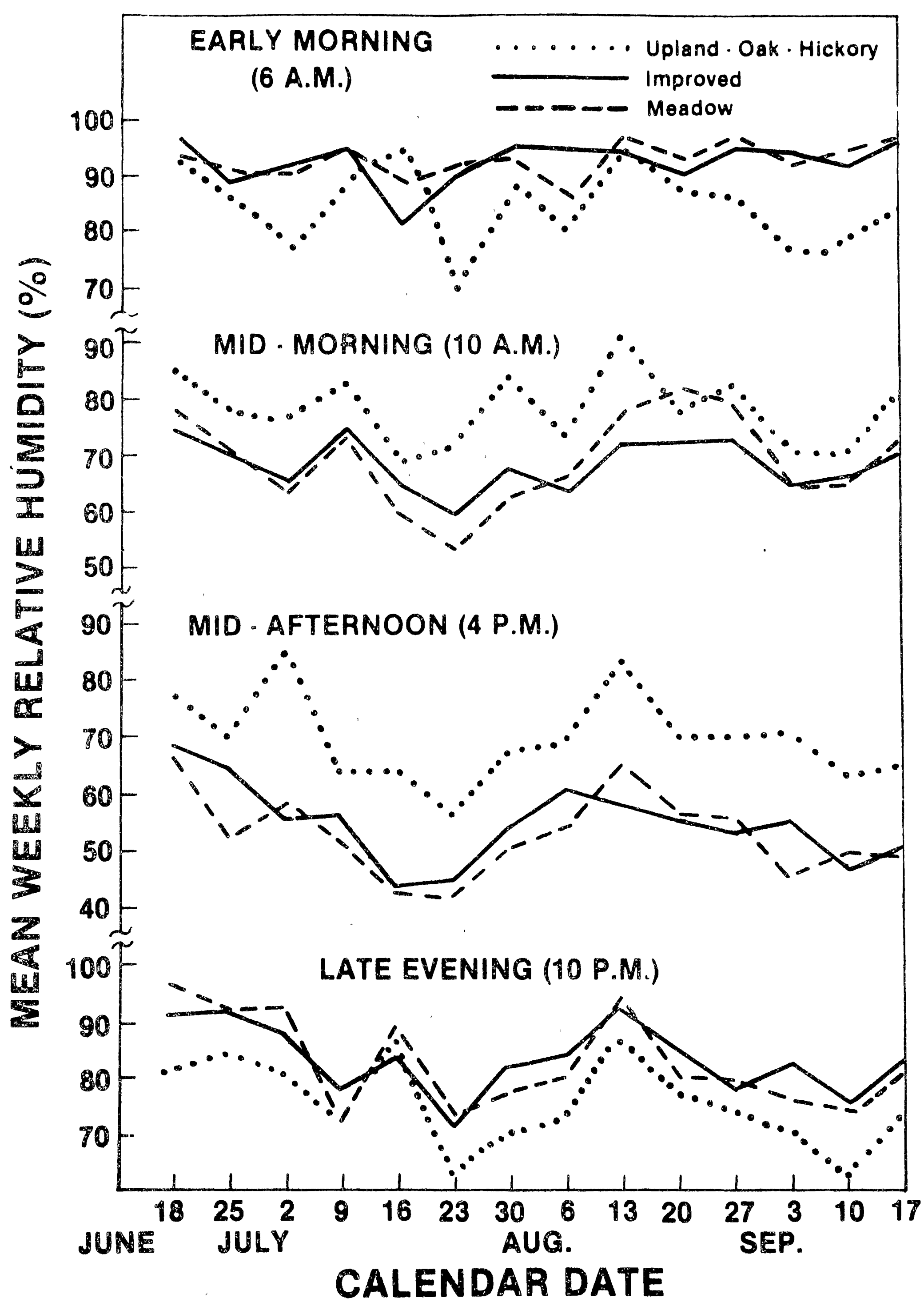
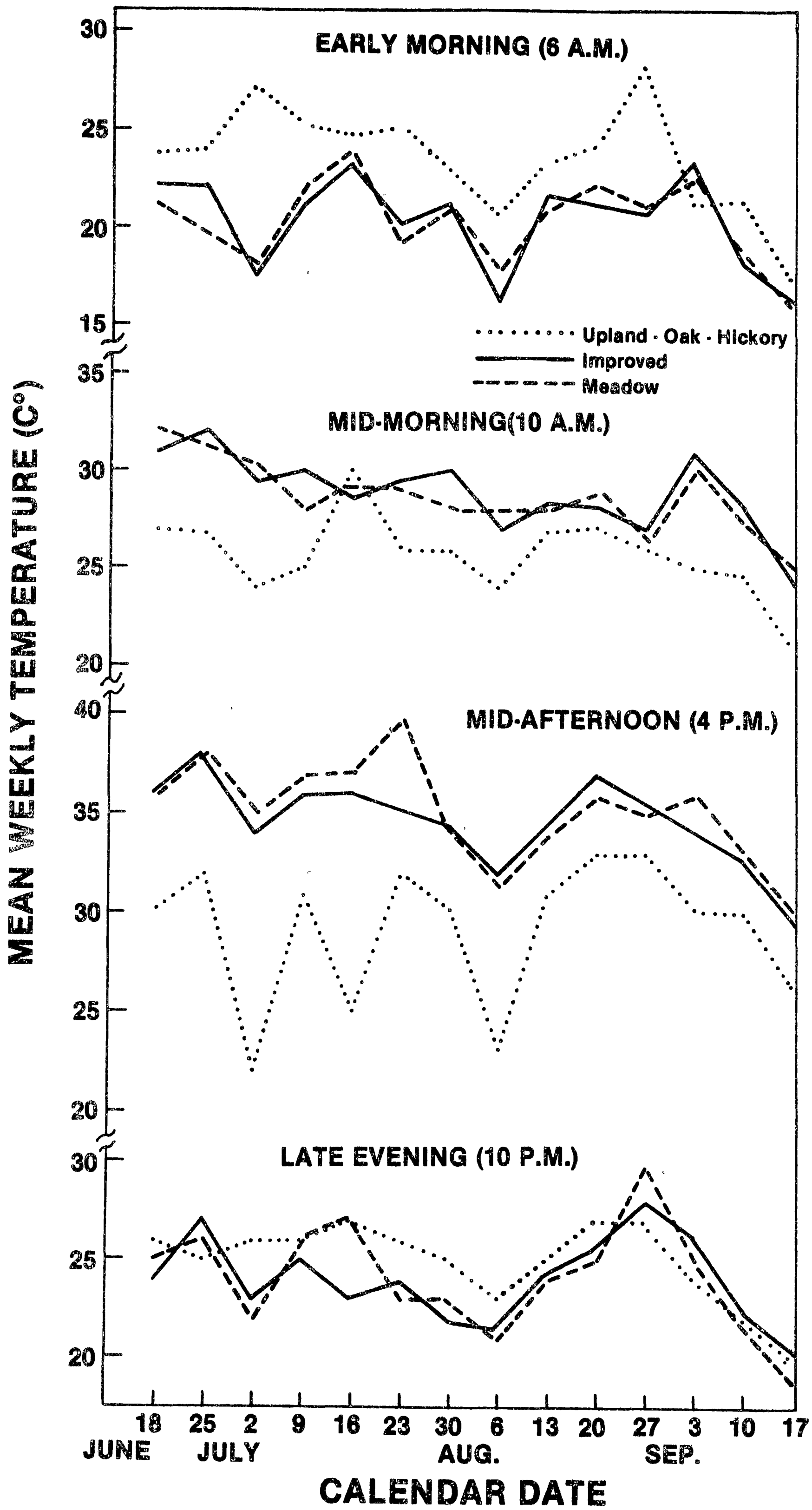

EARLY MORNING
(6 A.M.)
Upland · Oak · Hickory
Improved
Meadow
MID · MORNING (10 A.M.)
MID · AFTERNOON (4 P.M.)
LATE EVENING (10 P.M.)
MEAN WEEKLY RELATIVE HUMIDITY (%)
100
90
80
70
90
80
70
60
50
90
80
70
60
50
40
100
90
80
70
18
25
2
9
16
23
30
6
13
20
27
3
10
17
JUNE
JULY
AUG.
SEP.
CALENDAR DATE

Figure 3. Mean weekly temperature recorded at 45 cm from ground level in different habitats of the Cookson Hills State Game Oklahoma, during June-September, 1984


EARLY MORNING (6 A.M.)
Upland · Oak · Hickory
Improved
Meadow
MID-MORNING(10 A.M.)
MID-AFTERNOON (4 P.M.)
LATE EVENING (10 P.M.)
MEAN WEEKLY TEMPERATURE (C°)
30
25
20
15
35
30
25
20
40
35
30
25
20
30
25
20
18
25
2
9
16
23
30
6
13
20
27
3
10
17
JUNE
JULY
AUG.
SEP.
CALENDAR DATE

temperatures reach > 40°C. Considering this observation, relative humidities and temperatures of the improved and meadow habitats at ground surface perhaps had further differences but were not detected at 45 cm from ground level.

From the present data, lone star ticks are generally subjected to below the CEH for at least 6 hours or more of each clear day in spring and summer in the improved and meadow habitats while the temperature and relative humidity in the upland-oak hickory habitat are near or above the CEH threshold. This data coincides with previous workers who indicated that open areas such as meadows are not suitable habitat for the lone star tick because of lower humidities and higher ground surface temperatures when compared to wooded areas (Hoch 1971a, 1971b, Semtner 1972; and Patrick 1979).

The upland-oak hickory habitat remained at a more constant temperature especially during daylight hours of the 10AM and 4PM readings (Figure 3). The 10PM temperature reading ranged from 25-32°C in the improved and meadow replications while the upland-oak hickory habitat remained within 21-28°C. By mid afternoon (4PM), further separations of temperature within the improved and meadow habitats (30-39°C) occurred when compared to the upland-oak hickory habitat (22-23°C). Differences between temperature curves of the late evening (10PM) in all habitats showed similar trends with the improved and meadow habitat staying within 22-30°C and the upland-oak hickory habitat in the 22-27°C range.

These temperature and relative humidity readings were consistent with Semtner (1971b) in that the meadow and improved habitats were subject to higher and lower extremes on a daily basis. When considering the improved and meadow test areas as habitat for the lone star tick, the higher extremes in temperature provide a less favorable habitat, and survival rates of the lone star tick were low. Robertson et al. (1975) stated that the effect of temperature influences tick activity to a greater extent than photoperiod or relative humidity.

Free-Living Host Seeking Lone Star Tick Survey

Adults

A noted peak in the number of adult lone star ticks from the upland-oak hickory habitat occurred on the 4 June trapping date (Table III). This peak is normal and generally occurs in early June year after year in wooded areas of east-central Oklahoma. Fewer adult ticks were trapped from both the meadow and improved areas when compared with the wooded plots (Table III). The highest mean number of adult ticks trapped in the meadow was 7.5, and this occurred 3 times from the 6 April to 2 July (Table III). The peak number of adult ticks from the improved #1 occurred on June 4 and 18 with a mean of 4.5 ticks/trap (Table III). The improved #2 yielded its highest mean number of adult ticks/trap of 3.5 on the June 4 trapping date (Table III). After 4 June, adult lone star tick host seeking activity decreased and by 20 September, only the wooded and meadow habitats resulted in capture with 1.0 and 1.8 mean ticks/CO_2 trap respectively (Table III). However, on an overall seasonal basis, the lower numbers from the improved #1, #2, and meadow were a result of environmental differences which were regulated mostly by vegetative cover.

Nymphs

Further separations in nymphal lone star tick numbers with regard

TABLE III

MEAN* NUMBER OF ADULT LONE STAR TICKS/CO_2 TRAP IN NATURAL AND ECOLOGICALLY ALTERED HABITATS IN COOKSON HILLS STATE GAME REFUGE, OKLAHOMA, SUMMER 1984

Date		Habitat			
		Wooded[a]	Meadow[b]	Improved #1[c]	Improved #2[d]
April	6	16.0 ± 3.0	7.5 ± 5.5	2.0 ± 2.0	2.0 ± 0.2
	20	11.5 ± 0.5	.5 ± 0.5	0.0	0.0
May	4	17.0 ± 8.0	7.5 ± 0.6	4.0 ± 1.0	1.5 ± 1.5
	21	18.0 ± 6.0	6.5 ± 0.4	1.0 ± 0.0	2.5 ± 0.7
June	4	49.0 ±25.0	4.0 ± 3.0	4.5 ± 1.3	3.5 ± 0.4
	18	13.0 ± 7.0	5.0 ± 1.0	4.5 ± 0.6	2.5 ± 0.8
July	2	3.7 ± 0.5	7.5 ± 1.5	1.5 ± 0.5	2.0 ± 1.0
	17	4.0 ± 0.1	5.0 ± 3.0	1.5 ± 0.5	1.5 ± 0.3
Aug.	13	2.0 ± 0.1	2.5 ± 0.4	1.5 ± 0.3	1.5 ± 0.6
	24	3.5 ± 1.5	0.0	0.0	0.0
Sept.	6	0.0	0.0	0.0	1.5 ± 0.3
	20	1.0 ± 0.1	1.8 ± 0.4	0.0	0.0

[a] Consisted of an upland-oak hickory habitat with an overstory of black hickory, post oak, black oak and blackjack oak. Undergrowth was sparse with Virginia wildrye, buckbrush and differing fern species.

[b] Native grasses with approximately 25% brush cover.

[c] Cleared improved area planted in wheat, annual ryegrass and red clover.

[d] Cleared improved area planted in wheat, annual ryegrass and arrowleaf clover.

* Mean number of adult lone star ticks/20 traps (± 1SE) allowed to operate 3 hrs.

to habitat type occurred when compared with the adults (Tables III, IV), with the exception of the differences between the improved #1 and #2 areas. Significant differences ($P < 0.05$) between the meadow and improved replications occurred. The highest numbers of nymphal ticks in all habitats occurred on 18 June. In general, a positive correlation between the amount of vegetation or ground cover, and the number of nymphal lone star ticks existed.

Larvae

When considering the seasonal survey of larval lone star ticks in this study, capture from CO_2 traps did not occur in significant numbers until 17 July and this was from the wooded habitat. The upland-oak hickory habitat offered protection from environmental factors that shorten or prevent the development of lone star ticks and consistently resulted in high population numbers (Table V).

The potential for high larval populations in the two improved areas should be much higher than in the meadow or upland-oak hickory habitats since white-tailed utilization of improved areas was many times that of unimproved areas in spring. Replete females drop off white-tailed deer in greater numbers from early May until the end of July, with the highest numbers on white-tailed deer found in June (Figure 4). This provides a range in the seasonal peak of active host seeking larvae to be within August or September. Larval tick populations seem to be less tolerable than adult or nymphal lone star ticks when exposed to the harsh environmental conditions. Significant differences ($P < 0.05$) again occurred between the improved replications and the meadow area while the upland-oak hickory harbored many times the number of larval lone star ticks than the meadow (Table V).

TABLE IV

MEAN* NUMBER OF NYMPHAL LONE STAR TICKS/CO_2 TRAP IN NATURAL AND ECOLOGICALLY ALTERED HABITATS IN COOKSON HILLS STATE GAME REFUGE, OKLAHOMA, SUMMER 1984

Date		Habitat			
		Wooded[a]	Meadow[b]	Improved #1[c]	Improved #2[d]
April	6	9.5 ± 1.0	18.5 ± 15.5	1.0 ± 0.1	0.5 ± 0.5
	20	6.5 ± 4.0	0.0	0.0	0.0
May	4	32.0 ±17.0	6.5 ± 3.4	0.5 ± 0.5	1.0 ± 1.0
	21	30.0 ±10.5	7.0 ± 2.1	1.5 ± 1.5	5.0 ± 2.0
June	4	147.0 ±16.0	3.0 ± 2.4	4.5 ± 2.5	5.0 ± 2.0
	18	148.0 ±53.5	29.0 ± 8.0	17.5 ± 0.5	17.5 ± 0.5
July	2	64.0 ±32.5	25.5 ± 1.5	0.0	0.0
	17	19.0 ± 7.5	26.5 ± 2.5	0.0	1.5 ± 1.5
Aug.	13	11.0 ± 8.0	12.5 ± 7.4	1.5 ± 0.6	0.0
	24	15.0 ± 9.0	1.5 ± 1.3	0.0	0.0
Sept.	6	36.5 ± 0.5	13.0 ± 4.1	2.5 ± 0.9	0.0
	20	21.0 ± 7.0	4.7 ± 1.6	3.0 ± 3.0	0.0

[a] Consisted of an upland-oak hickory habitat with an understory of black hickory, postoak, black oak and blackjack oak. Undergrowth was sparse with Virginia wildrye, buckbrush and differing fern species.

[b] Native grasses with approximately 25% brush cover.

[c] Cleared improved area planted in wheat, annual ryegrass and red clover.

[d] Cleared improved area planted in wheat, annual ryegrass and arrowleaf clover.

* Mean number of nymphal ticks/20 traps (± 1SE) allowed to operate for 3 hrs.

The bare ground surface of the improved #2 managed area of arrowleaf clover did not result in regrowth after the 8 June cutting and baling which resulted in the lowest larval tick numbers than any of the other test area. This was probably due to the > 40°C ground surface temperature as mentioned by Robertson (1974). The improved #2 managed area exibited regrowth of red clover, therefore offered some protection that provided a mean of 33 larval lone star ticks/trap on 6 September (Table V). The ca. 25% brush cover and 0.6-0.9 m tall dessicated grasses of the meadow offered protection and consistently harbored more larval lone star ticks than the improved areas throughout the 5 trapping dates (Table V).

TABLE V

MEAN* NUMBER OF LARVAL LONE STAR TICKS/CO_2 TRAP IN NATURAL AND ECOLOGICALLY ALTERED HABITATS IN COOKSON HILLS STATE GAME REFUGE, OKLAHOMA, SUMMER 1984

	Habitat			
Date	Wooded[a]	Meadow[b]	Improved #1[c]	Improved #2[d]
July 17	5.0 ± 0.5	0.0	0.0	0.0
Aug. 13	42.5 ± 0.3	11.3 ± 1.2	0.0	0.0
24	66.5 ± 0.2	62.5 ± 6.5	0.0	0.0
Sept. 6	224.1 ±12.7	42.0 ±11.0	33.0 ± 3.0	1.0 ± 1.0
20	300.0 ± 9.8	66.0 ± 3.1	1.5 ± 0.5	2.0 ± 1.0

[a] Consisted of an upland-oak hickory habitat with an overstory of black hickory, postoak, black oak and blackjack oak. Undergrowth was sparse with Virginia wildrye, buckbrush and differing fern species.

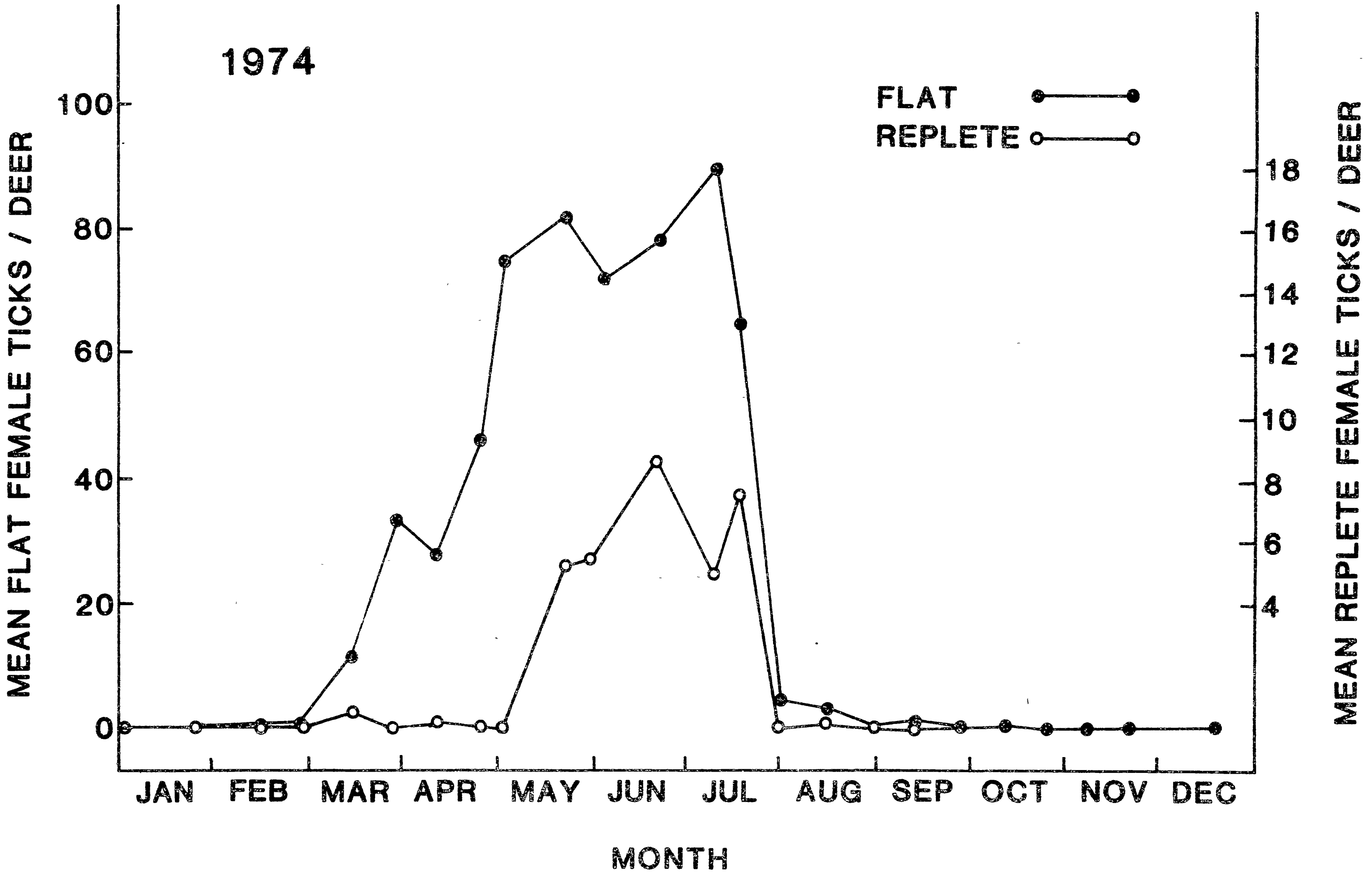
[b] Native grasses with approximately 25% brush cover.

[c] Cleared improved area planted in wheat, annual ryegrass and red clover.

[d] Clear improved area planted in wheat, annual ryegrass and arrowleaf clover.

* Mean number of nymphal ticks/20 traps (± 1SE) allowed to operate 3 hrs.

Figure 4. Mean number of flat and replete female lone star ticks from the ears of deer collected from Cookson Hills State Game Refuge, Oklahoma, taken from Patrick 1977


1974
FLAT
REPLETE
100
80
60
40
20
0
18
16
14
12
10
8
6
4
MEAN FLAT FEMALE TICKS / DEER
MEAN REPLETE FEMALE TICKS / DEER
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH

CHAPTER IV

SUMMARY AND CONCLUSIONS

White-tailed deer (*Odocoileus virginianus*) Zimmerman were attracted to open cleared areas in early spring during the time when replete female lone star ticks (*Amblyomma americanum*) (L.) normally complete their blood meal and drop off. This "drop off" environment of which female ticks are exposed has been found not conducive to the survivalship of (1) the gravid female (2) her eggs, if she oviposits and (3) the larvae if the eggs hatch (Patrick and Hair 1978). Other nymphs and adults that are a result of host distribution are subject to the same environmental stress. White-tailed deer were influenced to improved areas as a result of providing forages such as clover (arrowleaf and red clover) and grasses (annual ryegrass and wheat) at a time when other food sources were scarce. This overlap in the replete female tick drop off, and white-tailed deer actively seeking a food source in early spring were the basis of this research and used as a cultural management effort to suppress lone star tick numbers in the Cookson Hills State Game Refuge, Cherokee county, Oklahoma.

These research efforts involved (1) surveying white-tailed deer and all life stages of free living host seeking lone star ticks in natural and improved-managed areas (2) a quantitative forage study and deer diet analysis and (3) a measurement of the temperature and humidity in natural and improved areas as factors regulating tick existence.

The free-living host seeking lone star tick survey substantiated previous work that even though primary host activity is high in meadows or cleared improved areas in the spring, lone star tick numbers on a seasonal basis are directly related to the amount of vegetation (i.e. trees, brush and tall grasses) which in effect influenced environmental conditions (Patrick, 1979; Hoch, 1971; Clymer, 1970; Meyer, 1982; Byford 1983). All life stages of the lone star tick were found on a seasonal basis to be significantly lower in improved areas as compared to the meadow habitat or an upland oak hickory habitat. Larval lone star ticks seemed to be a more susceptible life stage to the environmental stress offered by improvement.

Differences in temperature and relative humidity at 45 cm from ground level were not detected between improved and meadow habitats however, they differ significantly from the upland-oak hickory habitat during the warmer parts of the day when the temperature increased and the relative humidity decreased in open areas. This difference provides for less favorable water regulation by the tick and thus lowers survival.

From improved forage species in the managed area, white-tailed deer diet analysis revealed that arrowleaf clover consumption was high and considered the major attractant throughout the spring. Red clover consumption increased during the summer months and considered the major forage attractant during the summer. Wheat was consumed early in the spring as it was the first available vegetation in early April. Annual ryegrass was not a prefferred grass species in the diet of white-tailed deer.

Significant differences were detected in terms of standing dry matter (SDM) yield inside exclosures versus outside exclosures. Arrowlear clover, annual ryegrass and wheat produced 680 kg/ha SDM inside the exclosures and 288 kg/ha SDM outside on April 13. The red clover, annual ryegrass and wheat produced 584 kg/ha SDM inside, and 236 kg/ha SDM outside exclosures on April 13. By 28 May, no significant differences in standing dry matter yields occurred indicating that deer utilization decreased and plant regrowth had compensated or adjusted to plant growth inside the exclosures. The red clover forage mixture only produced 65% the SDM yield of the arrowleaf clover within exclosures on 28 May.

REFERENCES CITED

Atwood, E.L. 1941. White-tailed deer foods of the United States. J. Wildl. Manage. 5:314-332.

Barker, R.L. 1978. Response of Oklahoma rangeland to atrazine, 2,4-D and fertilizer. Ph.D. Thesis, Department of Agronomy, Okla. St. Univ. 68p.

Barker, R.W. 1973. Characterization of oral secretion and salivary gland homogenate extracts of Amblyomma americanum (L.) (Acari: Ixodidae). Ph.D. Thesis, Department of Entomology, Okla. St. Univ. 51 p.

Baumgartner, L.L. and A.L. Martin. 1939. Plant histology as an aid in squirrel food habits studies. J. Wildl. Manage. 3:266-268.

Barnard, D.R., G.D. Rogers and B.G. Jones. 1983. Strategic treatment of pastured beef cattle with acaricides: Effect on populations of the lone star tick (Acari: Ixodidae). J. Econ. Entomol. 76:99-102.

Bates, R.C. 1974. Legumes. The Samuel Roberts Noble Foundation, Incorporated. Ardmore, Okla. 15 p.

Bennett, L.J., P.F. English and R. McCain. 1940. A study of deer populations by use of pellet-group counts. J. Wildl. Manage. 4:398-403.

Bishopp, F.C. and H.L. Trembley. 1945. Distribution and hosts of certain North American ticks. J. Parasitol. 31:1-4.

Bolte, J.R., J.A. Hair and J. Fletcher. 1970. White-tailed deer mortality following tissue destruction induced by lone star ticks. J. Wildl. Manage. 34:546-552.

Bramble, W.C. and P.F. English. 1948. The forest grazing problem created by deer in eastern forests. Proc. Soc. American Foresters. 257-263.

Byford, R.L. 1983. An integrated management program for the lone star tick, Amblyomma americanum (L.), on cattle. Ph.D. Thesis, Department of Entomology, Okla. St. Univ. 130 p.

Cahart, A.H. 1946. Hunting North American Deer. New York, The MacMillan Company. 232 pp.

Clymer, B.D., D.E. Howell and J.A. Hair. 1970. Animal hosts of economically important ticks in east central Oklahoma. Ann. Entomol. Soc. Amer. 63:612-614.

Cooney, J.C. and W. Burgdorfer. 1974. Zoonotic potential (Rocky Mountain Spotted Fever and Taleremia) in the Tennessee Valley Region. I. Ecological studies of ticks infesting mammals in Land Between the Lakes. Amer. J. Trop. Med. Hyg. 23:99-108.

Dalke, P. 1941. The use and availability of the more common winter browse plants in the Missouri Ozarks. Trans. Sixth N. Amer. Wildl. Conf. 155-160. pp.

Davey, R.B., E.H. Ahrens and J. Garcia, Jr. 1980. Control of the southern cattle tick with insecticide impregnated ear tags. J. Econ. Entomol. 73:651-653.

Dasman, R.F. and R.D. Taber. 1955. A comparison of four deer census methods. Calif. Fish and Game. 41:225-228.

Davis, R.R. and C.K. Winkler. 1968. Brush versus cleared range as deer habitat in southern Texas. J. Wildl. Manage. 32:321-329.

Drummond, R.D. and W.S. Gladney. 1978. Acaricides applied to cattle for control of the lone star tick. Southw. Entomol. 3:96-106.

Emerson, H.R. 1969. A comparison of parasite infestations of white tail deer (Odocoileus virginianus) from central and east Texas. Bull. Wildl. Dis. Assoc. 5:137-139.

Everitt, J.H. and D.L. Drawe. 1974. Spring food habits of white-tail deer in south Texas plains. J. Range Manage. 27:15-20.

Garris, G.I., B.R. Stacey, J.A. Hair and R.W. McNew. 1979. A comparison of lone star ticks on Brahman and Hereford cattle. J. Econ. Entomol. 72:869-872.

Garris, G.I. and J.A. Hair. 1980. Fecundity and development of the lone star tick on woodlot pastured Braford and Hereford heifers. J. Econ. Entomol. 73:407-410.

Gerstell, R. 1937. Winter deer losses. Penn. Game New 8(7):18-21, 29 illus. In W.P. Taylor (ed.) The Deer of North America. 3rd ed. 1965. The Stackpole Co., Harrisburg, PA. 66 p.

Hair, J.A. and D.E. Howell. 1970. Lone star ticks: their biology and control in the Ozark recreational areas. Okla. Agric. Exp. Sta. Bull. B-679. 47 p.

Hair, J.A., J.R. Sauer and K.A. Durham. 1975. Water balance and humidity preference in three species of ticks. J. Med. Entomol. 12:37-47.

Harwood, R.F. and M.T. James. 1978. Entomology in Human and Animal Health. 7th ed. MacMillan Publishing Co., Inc. 548 p.

Hitchcock, L.F. 1955. Studies on the non-parasitic stages of the cattle tick, Boophilus microplus (Canestrini) (Acarina: Ixodidae). Aust. J. Zool. 3:295-311.

Hoch, A.L., R.W. Barker and J.A. Hair. 1971a. Measurement of physical parameters to determine the suitability of modified woodlots as lone star tick habitat. J. Med. Entomol. 8:725-30.

Hoch, A.L., R.W. Barker and J.A. Hair. 1971b. Further observations on the control of lone star ticks (Acarina: Ixodidae) through integrated control procedures. J. Med. Entomol. 8:731-39.

Hoch, A.L. 1973. Effects of lone star tick (Acarina: Ixodidae) parasitism and theileriasis on white-tailed deer fawn survival and hematology. Ph.D. Thesis, Department of Entomology, Okla. St. Univ. 64 p.

Holechek, J.L., M. Vavra and R.D. Pieper. 1982. Botonical composition determination of range herbivore diets: A review. J. Range Manage. 35:309-15.

Hosely, N.W. 1956. Management of the white-tailed deer in its environment. p. 230. In W.P. Taylor (ed.) The Deer of North America. 3rd ed. 1965. The Stackpole Co., Harrisburg, PA. 66 p.

Kinzer, D.R. 1975. A comparison of sampling methods for the lone star tick [Amblyomma americanum (Linnaeus)]. Ph.D. Thesis, Department of Entomology, Okla. St. Univ. 79 p.

Kirby, D.R. and J.W. Stuth. 1982. Botanical composition of cattle diets grazing brush managed pastures in east-central Texas. J. Range Manage. 35:434-36.

Knulle, W. 1967. Physiological properties and biological implications of water vapour sorption mechanism in larvae of the oriental rat flea, Xenopsylla cheopis (Roths). J. Insect Physiol. 13:333-57.

Knulle, W. 1966. Equilibrium humidities and survival of some tick larvae. J. Med. Entomol. 3:335-38.

Lancaster, J.L., Jr. and H.L. McMillan. 1955. The effect of relative humidity on the lone star tick. J. Econ. Entomol. 48:338-39.

Lancaster, J.L. 1957. Control of the lone star tick. Ark. Agric. Exp. Sta. Rep. Ser. 67. 15 p.

Ledune, E.K. and Fritz Volkmar. 1934. Malignant edema in deer. Vet. Med. 29:276-79.

Lees, A.D. 1946. The water balance in Ixodes ricinus (L.) and certain other species of ticks. Parasitol. 37:1-20.

McKean, William T. 1949. A search for Bang's disease in North Dakota deer. North Dakota Outdoors. 11(8):10. In W.P. Taylor (ed.) The Deer of North America. 3rd ed. 1965. The Stackpole Co., Harrisburg, PA. 66 p.

Meyer, J.A., J.L. Lancaster and J.S. Simco. 1982. Comparison of habitat modification, animal control and standard spraying for control of the lone star tick. J. Econ. Entomol. 75:524-529.

Mitchell, H.L. and H.W. Hosley. 1936. Differential browsing by deer on plots variously fertilized. Cornwall-on-the Hudson, New York, Black Rock Forest Papers. 5:24-27.

Nichol, A.A. 1938. Experimental feeding of deer. Univ. Ariz. Coll. Agric., Agric. Exp. Sta. Tech. Bull. 75:1-39.

Patrick, C.D. 1976. Relationship of lone star ticks, Amblyomma americanum (L.) and white-tailed deer, Odocoileus virginianus (Boddaert) in Cherokee County, Oklahoma. Ph.D. Thesis, Department of Entomology, Okla. St. Univ. 62 p.

Patrick, C.D. and J.A. Hair. 1977. Seasonal abundance of lone star ticks on white-tail deer. Environ. Entomol. 70:263-69.

Patrick, C.D. and J.A. Hair. 1978. White-tail deer utilization of three different habitats and its influence on lone star tick populations. J. Parisitol. 64:1100-1106.

Patrick C.D. and Jakie A. Hair. 1979. Oviposition behavior and larval longevity of the lone star tick Amblyomma americanum (Acarina: Ixodidae), in different habitats. Ann. Entomol. Soc. of Amer. 72:308-312.

Pearce, J. 1937. The effect of deer browsing on certain western Adirondack forest types. Roosevelt Wildl. Bull. 7:1-61.

Robertson, A.S. 1974. Observations on the behavior of fed and unfed lone star ticks, Amblyomma americanum (Linnaeus) in response to various environmental parameters. M.S. Thesis, Department of Entomology, Okla. St. Univ. 90 p.

Robertson, A.S., C.D. Patrick and J.A. Hair. 1975. The ecology and behavior of the lone star tick. VI. Responses of unfed adults to certain environmental parameters. J. Med. Entomol. 12:515-19.

Samuel, W.M. and D.O. Trainer. 1970. Amblyomma (Acarina: Ixodidae), on white-tailed deer, Odocoileus virginianus (Zimmerman), from South Texas with implications for Theileriasis, J. Med. Entomol. 7:567-574.

Sauer, J.R. and J.A. Hair. 1971. Water balance in the lone star tick (Acarina: Ixodidae): the effects of relative humidity and temperature on weight changes and total water content. J. Med. Entomol. 8:479-485.

Schipper, A. 1980. Preventive Veterinary Medicine. Burgess Publishing Company. 353 p.

Semtner, P.J., D.E. Howell and J.A. Hair. 1971a. The ecology and behavior of the lone star tick (Acarina: Ixodidae). The relationship between vegetative habitat type and tick abundance and distribution in Cherokee County, Oklahoma. J. Med. Entomol. 8:327-25.

Semtner, P.J., R.W. Barker and J.A. Hair. 1971b. Ecology and behavior of the lone star tick (Acarina: Ixodidae). II. Activity and survival in different ecological habitats. J. Med. Entomol. 8:719-25.

Semtner, P.J. 1972. Ecology and behavior of the lone star tick. Ph.D. Thesis, Department of Entomology, Okla. St. Univ. 91 p.

Semtner, P.J. and J.A. Hair. 1973. The ecology and behavior of the lone star tick (Acarina: Ixodidae). V. Abundance and seasonal distribution in different habitat types. J. Med. Entomol. 10:618-28.

Sloss, M.W. and R.L. Kemp. 1978. Veterinary Clinical Parasitology. Iowa State University Press, Ames, IA. 274 p.

Sonenshine, D.E., E.L. Atwood and J.T. Lamb, Jr. 1966. The ecology of ticks transmitting Rocky Mountain Spotted Fever in a study area in Virginia. Ann. Entomol. Soc. of Amer. 59:1234-1262.

Taylor, W.P. 1965. The Deer of North America. 3rd ed. The Stackpole Co., Harrisburg, PA. 66 p.

Tugwell, P. and J.L. Lancaster, Jr. 1963. Notes on the seasonal occurrence of six tick species in northwest Arkansas. J. Kan. Entomol. Soc. 35:203-211.

Uresk, D.W. 1984. Black-tailed prairie food habits and forage relationships in western South Dakota. J. Range Manage. 37:325-29.

Wilson, J.G. 1972. Responses of the lone star tick, Amblyomma americanum (L.) to carbon dioxide stimulation. M.S. Thesis, Department of Entomology, Okla. St. Univ. 89 p.

APPENDIX

TABLE VI

SUM MEAN RELATIVE FREQUENCY OF PLANT SPECIES OCCURRENCE IN WHITE-TAILED DEER DIET THAT RANGED FROM IMPROVED AND UNIMPROVED LOCATIONS OF THE COOKSON HILLS STATE GAME REFUGE, OKLAHOMA DURING APRIL-JUNE 1984

		Feces Collection Date											
		4-6		4-20		5-4		5-21		6-4		6-18	
Scientific Name	Common Name	I[a/]	U[b/]	I	U	I	U	I	U	I	U	I	U
I. Grasses:													
Andropogon virginicus	broomsedge	1.0	0.7	1.5	0.0	0.0	0.7	0.0	0.0	0.0	0.6	0.0	0.0
Bouteloua curtipendula	sideoats grama	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.8	0.0	0.0	0.0	0.0
Bromus sp.	brome	5.6	3.3	1.0	3.3	0.0	.9	8.1	0.0	0.0	0.0	0.0	0.0
Carex sp.	sedge	5.2	12.4	4.4	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Elymus virginicus	Virginia wildrye	1.0	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Festuca arundinacea	tall fescue	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Hordeum pusillum	little barley	1.6	1.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lolium multiflorum	annual ryegrass*	1.0	0.5	0.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Panicum scribnerianum	scribner panicum	2.1	0.0	1.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sorgnastrum nutans	Indiangrass	1.6	0.7	0.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0
Triticum aestivum	wheat*	8.4	10.2	9.3	11.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unknown grass	unknown	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0
Unknown grass	unknown	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	2.5	5.3
II. Forbs:													
Achillea lanulosa	western yarrow	1.5	7.7	0.0	9.0	0.0	0.0	0.0	1.1	0.0	8.2	0.0	8.0
Actinomeris alternifolia	wingstem	1.6	2.1	1.5	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Arabis canadensis	sicklepod	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clematis virginiana	virginsbower	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Croton sp.	croton	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0
Geranium carolinianum	Carolina cranesbill	0.5	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0
Helianthus sp.	sunflower	0.0	0.0	0.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lespedeza cuneata	sericea lespedeza	0.0	0.0	1.5	0.0	16.6	8.7	0.0	4.0	11.4	7.0	2.7	16.8
Lespedeza hirta	hairy lespedeza	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.8	1.9	0.0	0.0

TABLE VI CONTINUED

		Feces Collection Date											
		4-6		4-20		5-4		5-21		6-4		6-18	
Scientific Name	Common Name	I[a/]	U[b/]	I	U	I	U	I	U	I	U	I	U
Oxalis sp.	oxalis	0.5	0.0	0.5	0.0	0.6	0.0	4.4	0.0	0.0	0.0	0.0	0.0
Psoralea psoroloides	bobsroot scurfpea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1
Solanum carolinense	horsnettle	0.0	1.2	0.0	0.0	0.0	0.0	0.0	20.1	0.0	0.6	0.0	0.0
Specularia perfoliata	clasping venus	0.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trifolium pratense*	red clover*	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	3.7	0.0	7.2
Trifolium vesiculosum*	arrowleaf clover*	15.3	3.3	17.6	2.8	9.8	3.9	18.6	5.7	28.4	13.2	52.9	5.3
Trifolium procumbens	large hop clover	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	15.7	4.0	0.0
Trifolium repens	white clover	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0
Unknown	unknown	0.0	0.0	0.0	0.0	0.0	5.9	4.1	0.8	0.0	4.4	0.0	0.8
Verbascum thapsus	flannel mullein	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	1.0
Vicia villosa	hairy vetch	1.5	6.3	1.5	0.6	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
III. Browse:													
Acer saccharum	sugar maple	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0
Amelancheir arborea	serviceberry	0.0	0.0	0.0	0.6	0.0	1.4	3.2	0.0	0.0	0.0	0.0	0.0
Bumelia lanuginosa	wollybucket bumelia	0.0	0.0	0.0	3.4	0.6	0.0	0.0	6.3	2.3	1.2	0.0	0.0
Cornus florida	flowering dogwood	11.2	0.0	3.4	2.3	0.6	5.5	0.0	0.0	3.6	0.0	4.0	0.8
Diospyros virginiana	persimmon	3.6	1.9	2.5	0.0	1.2	3.6	0.0	0.0	0.0	0.0	0.0	0.8
Gleditsia triacanthos	honeylocust	0.5	1.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nyssa sylvatica	blackgum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.8
Passiflora sp.	unknown	16.8	16.1	14.7	8.5	0.0	1.4	0.0	0.0	0.6	0.0	1.5	17.4
Parthenocissus quinquefolia	Virginia creeper	0.0	1.0	2.5	0.0	0.0	0.0	0.0	0.0	2.1	0.0	1.5	3.1
Quercus stellata	post oak	8.2	2.5	7.8	10.2	19.0	31.4	32.5	15.4	20.3	10.2	29.5	28.6
Quercus falcata	southern red oak	2.5	0.0	3.9	0.0	7.4	0.7	9.6	5.9	4.1	0.0	0.0	0.0
Quercus velutina	black oak	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.0	0.0	0.0
Rhus sp.	rhus	0.0	2.9	3.4	0.0	6.7	3.0	0.8	0.0	2.3	1.2	0.0	0.0
Sassafras albidum	sassafras	2.5	3.8	6.4	14.1	9.2	8.2	4.9	3.5	1.4	1.9	0.0	0.0

TABLE VI CONTINUED

Scientific Name	Common Name	Feces Collection Date 4-6 I[a]	U[b]	4-20 I	U	5-4 I	U	5-21 I	U	6-4 I	U	6-18 I	U
Smilax tamnoides	bristly greenbriar	2.0	4.1	1.5	2.8	4.3	2.3	1.6	2.4	1.9	0.0	0.0	0.0
Symphoricarpos orbiculatus	buckbrush	0.0	15.8	6.4	18.1	21.5	18.2	8.8	31.6	11.2	16.9	0.0	0.0
Ulmus americana	American elm	0.0	0.0	0.0	0.0	2.5	0.0	1.7	1.6	1.4	2.6	0.0	0.0
Unknown	unknown	1.6	0.0	2.0	0.6	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0

* Indicates palatable plant species planted in improved area and used to increase white-tailed deer utilization.

a/ Cleared improved area planted in legumes and grasses and surrounded by and upland-oak hickory forest.

b/ Meadow area surrounded by upland-oak hickory forest.

TABLE VII

SUM MEAN RELATIVE FREQUENCY OF PLANT SPECIES OCCURRENCE IN WHITE-TAILED DEER DIET THAT RANGED FROM IMPROVED AND UNIMPROVED LOCATIONS OF THE COOKSON HILLS STATE GAME REFUGE, OKLAHOMA DURING JULY-SEPTEMBER 1984

		Feces Collection Date													
		7-2		7-16		7-30		8-13		8-24		9-16			
Scientific Name	Common Name	I[a/]	U[b/]	I	U	I	U	I	U	I	U	I	U	I	U
I. Grasses:															
Andropogon virginicus	broomsedge	0.0	0.0	0.0	0.0	0.0	1.7	0.0	6.1	1.9	0.0	0.0	0.0	0.0	2.1
Chloris sp.	unknown	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.2	0.0	0.0	0.0	0.0	0.0	0.0
Panicum scribnerianum	scribner panicum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0
Triticum aestivum	wheat*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
II. Forbs:															
Achillea lanulosa	western yarrow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	8.6	6.3
Ambrosia sp.	ragweed	0.0	0.0	0.0	1.7	0.0	2.9	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0
Croton sp.	croton	0.0	0.0	0.0	0.0	0.0	3.3	0.0	3.4	0.0	0.0	0.0	0.0	0.0	4.5
Eupatorium serotinum	late eupatorium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Geranium carolinianum	Carolina cranesbill	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0
Lespedeza cuneata	sericea lespedeza	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lespedeza hirta	hairy lespedeza	0.0	0.0	6.3	6.9	0.0	3.3	2.0	1.7	0.0	15.3	0.0	0.0	0.0	0.0
Oxalis sp.	oxalis	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8	0.0	0.0	6.8	0.0	0.0
Solanum carolinense	horsenettle	3.4	1.9	2.1	8.7	14.1	3.3	9.7	9.9	11.3	10.1	2.1	0.0	6.7	27.1
Specularia perfoliata	clasping venus	0.0	4.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0
Trifolium pratense	red clover*	57.7	7.6	49.8	1.8	54.1	59.0	45.8	10.6	44.9	0.0	78.2	0.0	51.0	0.0
Verbascum thapsus	flannel mullein	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0
Vicia villosa	hairy vetch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0
III. Browse:		7-2		7-16		7-30		8-13		8-24		9-16		9-20	
Cornus florida	flowering dogwood	3.4	0.0	3.9	3.5	0.0	0.0	13.1	0.0	7.5	0.0	0.0	0.0	0.0	0.0
Diospyros virginiana	persimmon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0
Nyssa sylvatica	blackgum	0.0	0.0	3.9	11.8	3.6	0.0	0.0	0.0	1.9	6.8	1.9	2.3	6.8	6.8

TABLE VII CONTINUED

		Feces Collection Date													
		7-2		7-16		7-30		8-13		8-24		9-16		9-20	
Scientific Name	Common Name	I	U	I	U	I	U	I	U	I	U	I	U	I	U
Browse Continued:															
Passiflora sp.	unknown	0.0	2.0	0.0	0.0	0.0	22.3	1.3	1.7	0.0	0.0	0.0	0.0	0.0	0.0
Quercus falcata	Southern red oak	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Quercus velutina	Black oak	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0
Quercus stellata	Post oak	16.8	3.9	3.9	0.0	3.3	0.0	0.0	0.0	1.9	3.3	7.7	0.0	5.1	2.1
Rhus sp.	rhus	6.7	7.7	0.0	0.0	0.0	1.7	0.0	0.0	3.8	0.0	0.0	2.3	0.0	0.0
Sassafrass albidum	sassafrass	1.7	1.9	0.0	0.0	0.0	21.0	2.0	1.7	0.0	3.4	0.0	2.3	8.3	0.0
Symphoricarpos orbiculatus	buckbrush	5.0	69.3	24.3	65.7	23.2	32.9	23.5	32.8	15.2	57.5	8.2	84.1	3.3	51.1
Ulmus americana	American elm	0.0	0.0	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unknown	unknown	0.0	2.0	0.0	0.0	0.0	22.3	1.3	1.7	0.0	0.0	0.0	0.0	0.0	0.0

* Indicates palatable plant species planted in improved area and used to increase white-tailed deer utilization.

a/ Cleared improved area planted in legumes and grasses and surrounded by on upland-oak hickory forest.

b/ Meadow area surrounded by upland-oak hickory forest.

VITA 2

JOHN "SCOTT" ARMSTRONG

Candidate for the Degree of

Master of Science

Thesis: WHITE-TAILED DEER, ODOCOILEUS VIRGINIANUS (ZIMMERMAN), MANIPULATION AND ITS EFFECTS ON THE LONE STAR TICK, AMBLYOMMA AMERICANUM (LINNEAUS)

Major Field: Livestock Entomology

Biographical:

Personal Data: Born in Hereford, Texas, February 12, 1959, the son of Charles and Courtenay Armstrong.

Education: Graduated from Dimmitt High School, Dimmitt, Texas in May 1978; received Associate of Science degree in Agriculture from South Plains Junior College in Levelland, Texas in May 1980; received Bachelor of Science degree in Entomology from Texas Technological University, Lubbock, Texas in December, 1982; completed requirements for Master of Science degree at Oklahoma State University in May 1985.

Professional Experience: Graduate research assistant, Medical Entomology Laboratory, Oklahoma State University, 1983-1985; High Plains Beekeepers Association; Entomological Society of America; Alpha Zeta.