AN INTEGRATED MANAGEMENT PROGRAM FOR THE LONE STAR TICK, *AMBLYOMMA AMERICANUM* (LINNAEUS), ON CATTLE

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CHAPTER I

INTRODUCTION

There are a significant number of arthropod pests that influence livestock production in the United States. However, ticks are among the most important. The lone star tick, Amblyomma americanum (L.) is one of the most economically important tick species in the Ozark Mountain region of the southeastern United States (Hair and Howell 1970). Without doubt, lone star tick parasitism of livestock has resulted in lowered and inefficient production levels, disease transmission and even death. These problems are expected to increase as this pest becomes resistant, through evolutionary adaptation, to existing chemical control techniques.

In the past three decades, the U.S. livestock industry has been increasingly dependent on chemical pesticides for controlling pests of livestock. Although there are many Environmental Protection Agency registered pesticide formulations for livestock protection, producers use only a few acaricides for lone star tick control on cattle. Current recommendations for tick control on livestock are based on the use of commercially available, and United States Department of Agriculture (USDA) suggested acaricides applied as whole body sprays or dips. Based on the existing knowledge of the lone star tick's biology, acaricide treatments serve only as temporary measures since they are required every 7-10 days to effectively disrupt the life cycle of this tick (Hooker et al. 1912).

Despite current research efforts only marginal control of lone star ticks is available to livestock producers, primarily because of a lack of integrated approaches necessary to sustain tick control. It is not practical to concentrate on any one management strategy to the exclusion of others. If livestock production losses are to be reduced, the availability and use of an array of management strategies is essential for the future of livestock protection and pest management programs.

There has been significant progress in Integrated Pest Management (IPM) for agronomic commodities, however very little has been done for livestock production. The major obstacle preventing rapid adoption of IPM concepts has been the lack of demonstrated feasible IPM systems. This is due to an inadequate knowledge of the basic biology and ecology of pests, host-parasite interactions, economic thresholds, cost-benefit analysis of IPM programs and inadequate monitoring techniques.

Due to increasing concern regarding the environmental effects of pesticides and the dynamic nature of livestock pests, a concerted effort is required to develop and implement management programs that reduce livestock production losses. In recent years, an increased interest in livestock IPM programs which offer more stable protection in an efficient and economically sound system has evolved. Therefore, development of an effective IPM program for lone star ticks on cattle would be practical and timely. This program should emphasize basic ecological principles in an economically feasible manner accomplished by the coordinated use of multidisciplinary strategies to reduce tick populations to tolerable levels while minimizing hazards to animals, plants and the environment.

Reported in this dissertation is an integrated management program for lone star ticks affecting cattle. This concept was developed from existing methodologies for practical and cost-effective use by cattle producers. The primary objective of this study was to develop and integrate a combination of management procedures for lone star ticks entailing habitat modification, pasture forage improvement, Brahman crossbreeding of cattle and selective application of acaricides. It was hoped that this program would accelerate advances in integrated management systems for livestock production.

CHAPTER II

LITERATURE REVIEW

The lone star tick, Amblyomma americanum (L.), has been reported to be an economically important ectoparasite of man, livestock and wildlife throughout the southcentral and southeastern United States (Hooker et al. 1912; Cooley and Kohls 1944; Bishopp and Trembley 1945; Calhoun 1954; Drummond 1967). In the Ozark Mountain region, lone star tick populations have reached sufficient numbers to deter the economic development of that area (Lancaster 1957; Hair and Howell 1970).

Lone star ticks are not only an annoyance to man via their bloodsucking habits, but are also reported to be vectors of several diseases such as Rocky Mountain Spotted Fever (Parker et al. 1943), Bullis Fever (Woodland et al. 1943), Tularemia (Hopla and Downs 1953), Q - Fever (Parker and Kohls 1943) and Tick Paralysis (Swartzwelder and Seabury 1947). In addition to the annoyance and transmission of diseases to man, lone star ticks contribute to wildlife deaths and weight losses in livestock (Bolte et al. 1970; Williams 1976).

Evidence shows that the livestock industry suffers enormous losses due to tick parasitism (Francis 1960; Hewetson 1968; Johnston and Haydock 1969; Riek 1962; Seifert 1971; Francis 1966). A USDA publication (1965) estimated tick associated losses to cost cattlemen $60 million and sheep producers $4.7 million annually. Losses attributable to severe tick infestations include mechanical injury, feeding lesions susceptible to secondary bacterial infections, "tick worry", hide damage, decreased milk production, severe weight loss, anemia, disease transmission and occasionally death.

The majority of the studies concerning the effects of ticks upon cattle have been on Boophilus spp. In an early study, Hunter and Hooker (1907) reported that an animal heavily infested with B. annulatus (Say) could lose as much as 90.6 kg of blood in a single season. The ensuing effects of such an extreme infestation could result in anemia and severe weight loss regardless of how good the nutritional level of the host. Woodward and Turner (1915) demonstrated that cattle infested with this tick had a reduced milk production of ca 30% compared to tick-free cattle. Several authors have reported that Boophilus spp. cause reduced weight gains in various breeds of cattle (Little 1963; Gee et al. 1971; O'Kelley et al. 1971; Seebeck et al. 1971; Turner and Short 1972; Woodward and Turner 1915). Futhermore, Gladney et al. (1973) noted that cattle on poor nutritional diets produced higher numbers of engorged female ticks than cattle on adequate nutritional diets.

A few studies have been conducted on the economic importance of Amblyomma sp. to the livestock industry. Williams et al. (1977) reported that adult A. maculatum Koch infestations reduced weight gains of Hereford steers by as much as 24 kg during a seven week study. Likewise, Stacey et al. (1978) found that uninfested Hereford steers gained ca 27 kg more than tick-infested Hereford steers during an eight week period. Concerning lone star ticks on cattle, Lancaster et al.

(1955) reported that steers treated for tick control averaged 4.09 kg more gain than untreated steers. In a similar study, Williams (1976) demonstrated that treated Hereford steers gained an average of 5.66 kg more than untreated animals in a wooded pasture supporting natural lone star tick populations.

Most of the significant studies concerning the economic importance of lone star ticks on wildlife have been conducted on Odocoileus virginianus (Boddaert), the white-tailed deer. The white-tailed deer is considered the primary host of A. americanum (Brennan 1945; Clymer et al. 1970a; Cooney and Burgdorfer 1974) and since fawning in Oklahoma coincides with the peak activity of the adult stage of this tick, young fawns are often exposed to high populations. Emerson (1969) reported that white-tailed deer mortality could occur if young fawns were heavily infested with A. americanum. In eastern Oklahoma, Bolte et al. (1970) noted that natural lone star tick parasitism of newborn fawns resulted in a 57% mortality. Similarly, Hoch (1973) demonstrated that laboratory infestations of 150-540 adult A. americanum per week for four weeks was sufficient to cause death in young fawns. Furthermore, Theileriasis (a hematoprotozoan disease of deer) was found to be vectored by lone star ticks (Kuttler et al. 1967) with the highest incidence of anemia and mortality occurring in areas where lone star ticks were most abundant and deer nutritional levels were poor (Barker et al. 1973; Hoch 1973).

The literature contains an extensive amount of information on the biology and ecology of lone star ticks (Lancaster and McMillan 1955; Tugwell and Lancaster 1963; Hair and Howell 1970; Semtner et al. 1971a, 1971b; Hoch et al. 1971; Hair et al. 1972; Wilson et al. 1972; Semtner and Hair 1973a, 1973b; Robertson et al. 1975). These early studies in the Ozark Mountain region demonstrate that the distribution and abundance of lone star ticks is correlated to various environmental and physical factors.

Bishopp and Trembley (1945) found lone star tick populations to be higher in wooded areas with heavy, dense underbrush than in areas with less vegetation. Lancaster (1957) noted that ca 70% of all A. americanum collected were from brushy, wooded areas, suggesting a relationship between vegetation type and tick abundance. Semtner et al. (1971a, 1971b) reported the highest number of adult and nymphal ticks in association with persimmon-sassafrass type habitats. However, these same authors found greater longevity in adult ticks associated with the bottomland oak-hickory type habitats due to lower day temperatures and higher humidites.

Temperature and relative humidity are two primary factors influencing tick distribution, abundance and survival (Feldman-Muhsam 1947; Knulle 1966; Lees 1946; McLead 1935; Lancaster and McMillan 1955; Semtner et al. 1971a; Semtner and Hair 1973a). Hitchcock (1955) demonstrated that the oviposition of B. microplus (Canestrini) diminished when temperatures were above or below 24-25.6°C. He also noted that exposure to a temperature of 52°C for two hours resulted in 92% mortality. Robertson (1974) reported that the activity and behavior of lone star ticks was directly related to temperature and relative humidity. He found that a gradual reduction in the number of active ticks occurred with higher temperatures and lower humidites. A high mortality was also observed for all life stages of this tick in meadow habitats where soil temperatures reached 45^{o}C.

Another important factor is the effect of relative humidity on longevity and fecundity of lone star ticks. Lancaster and McMillan (1955) found that females exposed to relative humidities below 47% either failed to oviposit, or produced eggs which did not hatch. Normal oviposition and hatching occurred at 73 and 91% relative humidity. A direct relationship between relative humidity and percent hatch of lone star tick eggs was demonstrated by Sonenshine and Tigner (1969). They found that 0.0, 6.4, 15.4, 77.5, and 95.4% egg hatch occurred at 55, 60, 65, 85, and 95% R.H., respectively.

Lees (1946, 1947, 1948), Browning (1954) and Hafez et al. (1970) have reported on the ability of various tick species to survive adverse humidities by absorbing moisture from the environment. Sauer and Hair (1971) demonstrated that the critical equilibrium humidity (C.E.H.) for adult lone star ticks is ca 85% R.H. and this tick species has the ability to reabsorb moisture from the atmosphere if humidities are above the critical equilibrium humidity. These data demonstrate that low humidites contribute to the desiccation of tick eggs and that survival of all life stages is dependent upon high relative humidities.

Several authors have found that the relative humidity of wooded pastures are significantly higher that the relative humidity of meadows and prairies (Bruner 1931; Semtner et al. 1971b). Charactertistic of the Ozark Mountain region, dense underbrush provides a favorable microclimate in which the relative humidity remains high throughout the year (Semtner et al. 1971b) and therefore supports high numbers of lone star ticks.

Based on the observations previously mentioned, it appears that lone star tick populations within wooded pastures can be reduced by eliminating vegetation and tick microhabitat. Vegetative alteration of wooded areas results in the drastic reduction of lone star tick populations due to changes in various physical parameters including temperature, relative humidity, sunlight intensity and soil moisture (Clymer et al. 1970b). Observations by Hoch et al. (1971) indicated that removal of vegetation in wooded areas increases temperature, lowers relative humidity and reduces available soil moisture, thereby eliminating favorable tick habitat. Recently, Meyer et al. (1982) reported that mechanical modification of tick habitat resulted in a significant reduction of the lone star tick population when compared to a conventional spray treatment.

Since lone star ticks are major pests of cattle in wooded pastures of the Ozark region, current recommendations for their control are based on a topical application of acaricides. However, conventional spraying and dipping methods to protect cattle from lone star tick infestation are costly, laborious and provide only minimal protection. In addition, the short residual of commercially available acaricides currently in use requires repeated application at 7-10 day intervals to disrupt the life cycle of this tick. Field trials of insecticides for control of *A. maculatum* on cattle (Gladney et al. 1977) demonstrated that whole body sprays with chlorfenvinphos, toxaphene, coumaphos and dioxathion provided initial control at one day post-treatment, but residual protection was rapidly reduced by one week post-treatment. In a recent study by Barnard and Jones (1981), seven commercially available acaricides applied via high-pressure spray to cattle in southeastern Oklahoma provided no significant control of lone star ticks beyond one week post-treatment. With the frequent use of acaricides necessary for tick control, the evolution of an acaricide-resistant strain of ticks is possible.

Therefore, the utilization of tick resistant animals could and probably should be employed to supplement chemical control (Utech et al. 1978a; Stacey et al. 1978; Garris 1979). Tick resistance in various breeds of cattle has been extensively investigated in Australia (Wilkinson 1962; Hewetson 1968; Wharton et al. 1969; Utech et al. 1978b) and in the United States (Strother et al. 1974). Differences in the susceptibility to adult lone star ticks and reduced fecundity of females engorging on various breeds of cattle under laboratory conditions was reported by Strother et al. (1974). These authors found that Brahman and Brahman X Hereford cattle were more resistant to lone star tick infestations than purebred Hereford cattle and therefore reduced the biotic potential of this tick. This was further substantiated by Stacey et al. (1978), Garris et al. (1979) and Garris and Hair (1980) who reported that Brahman crossbred cattle supported significantly fewer numbers of lone star ticks and that their biotic potential was less than those collected from purebred Hereford cattle.

Today's increased emphasis on nonchemical practices for suppressing arthropod pests demonstrate the need for an integrated tick-control program adaptable throughout this region. To adequately maintain enduring control of lone star ticks, the treatment strategies must consider: (1) short and long-term effects on populations of free-living and parasitic life stages of ticks in management areas,

(2) animal health and performance in comparison to the management system and (3) influence of the management system on the productivity of rangeland as reflected by available forage and beef yield.

The utilization of a combination of management procedures for lone star ticks entailing habitat modification, pasture forage improvement, Brahman crossbreeding of cattle and selective applications of acaricides were necessary for an effective integrated tick management program.

CHAPTER III

METHODS AND MATERIALS

1980 Pre-Treatment Observations

The study site was established during the spring of 1980 and consisted of 365 ha of timbered land located in the Cherokee Wildlife Refuge, Cherokee County, Oklahoma. This area was selected because of the availability of land and the high population of lone star ticks which severely affect livestock and wildlife inhabiting this area.

During the 1980 season, a number of parameters were measured without disturbance for collection of base-line data. An assessment of lone star tick populations within the study area was made utilizing two standard evaluation methods to determine the severity and activity of the parasitic and free-living life stages of this tick during various times of the season.

Parasitic Life Stage Evaluation

Parasitic life stages were monitored by a series of procedures including the examination techniques of Garris (1979). In summary, procedures included using 14 Angus cattle, averaging 388 kg, pastured on 125 ha of the study area and examining them bi-weekly throughout the season beginning May 5. Each animal was offered 0.75 kg of a standard maintenance ration (Williams 1976) three times per week to facilitate gathering of these animals from the wooded pasture. The ration consisted of 30% cottonseed hulls, 30% alfalfa pellets, 24% cracked corn, 7% cottonseed meal, 7% molasses, 0.3% salt, 0.5% dicalcium phosphate, 0.5% calcium carbonate and 30,000 IU/G vitamin A at a rate of 200 g/906 kg mix. A working corral was constructed in an adjacent field to permit the restraining of animals for examination of lone star ticks, animal weighing and routine health monitoring.

Following a one week acclimation period to the study area, each animal was weighed and lone star tick counts conducted via visual and tactile examination for all life stages attached to the left side of each animal. Specifically, both sexes of the adult life stage attached to the left ear, brisket, axillaries, escutcheon and tailhead were counted and females categorized as to the stage of engorgement. Engorgement stages were estimated visually within the following weight range: unfed females (<100 mg), stage A (100-200 mg) a female tick exhibiting only slight distention of the body, stage B (200-400 mg) moderately distended, and stage C (>400 mg) fully distended. In addition, total nymphs and larvae attached to these sampling sites were counted and degree of engorgement was recorded. Engorgement of these life stages was estimated visually as either unfed (nymphs <4.0 mg, larvae <0.45 mg) or replete (nymphs >4.0 mg, larvae >0.45 mg).

Free-Living Life Stage Evaluation

Free-living, host-seeking life stages of the lone star tick were monitored by systematically sampling the study area with carbon dioxide (CO_2) traps (Wilson 1972; Kinzer 1975). The trap consisted of a base portion of 0.3 cm masonite 77.4 cm^2 to which masking tape (trapping device) was attached and a 567 cm^3 dry ice reservoir placed in the center. Two hundred CO_2 traps, each baited with 228 g solid dry ice, were systematically placed within the study area bi-weekly beginning May 5 and allowed to operate for three hours. Thereafter, CO_2 traps were collected in sequence, transported to the laboratory and actual counts of all life stages were recorded.

Forage Production

On alternating weeks, the existing forage biomass reflected by dry matter yield was estimated by replicated sampling of the study area with particular emphasis being placed on the amount and availability of desirable forage for beef production. Sixty forage samples were randomly taken from the study area according to methods described by Baker (1978) by hand clipping 0.5 m^2 sample areas bi-weekly. Samples were then transported to the laboratory for separation into species, oven dried at 60^{o}C for 48 hours and weighed to determine kg dry matter produced.

Wildlife Utilization

Since the lone star tick depends on a host for nourishment, reproduction and distribution, wildlife utilization of the study area has a great influence on lone star tick populations. Therefore, white-tailed deer utilization of the study area was monitored by transect and quadrat surveys. The frequency of utilization was estimated via the replicated sampling of deer pellet-groups bi-weekly according to Bennett et al. (1940), Hosely (1956) and Patrick

(1976). Twelve plots 0.04 ha in size and nine transect lines 100 m in length were identified with surveyors flags and all existing pellet-groups removed. During subsequent sampling, all pellet-groups were sprayed with florescent paint to prevent recounting.

1981-1982 Post-Treatment Observations

Habitat Modification

In the fall of 1980, the study area was divided into four contiguous tracts of timbered land, 91 ha each. The elimination of favorable lone star tick habitat was done as required to two of these study units by a combination of mechanical and chemical methods to achieve and maintain 90-95% overstory reduction. Within each of these study units, 40 ha was mechanically cleared using a D9 Caterpillar® dozer and the resulting timber pushed into windrows located near the center of the fields. Watering ponds of 1530 m^3 were constructed within each of the cleared study units for livestock and wildlife use.

Pasture Forage Improvement

Subsequently, the cleared study units were seeded to desirable forage utilizing Kentucky 31 tall fescue (*Festuca arundinacea*), perennial ryegrass (*Lolium perenne*) and arrowleaf clover (*Trifolium vesiculosum*). The fescue and ryegrass seed were broadcast over 36 ha in each study unit via a tractor mounted Cyclone® spreader at a rate of 20 kg/ha. Likewise, the arrowleaf clover was broadcast at 22 kg/ha over a 4 ha strip which was adjacent to the bordering unimproved study units. Fertilizer (N-P-K) was broadcast during the fall of 1980 at rates of 50 kg/ha (34-0-0) and 224 kg/ha

(3-20-20) according to recommendations provided by a soil sample analysis.[1]

As a result of the sprouting and regrowth of undesirable brush in each of the cleared study units, the use of herbicides was required to prevent the development of favorable tick habitat. During the spring of 1982, the herbicides 2,4-D [(2,4-Diclorophenoxy) acetic acid] and 2,4,5-T [(2,4,5-Triclorophenoxy) acetic acid] were sprayed over the study units via a Bean® Model 1229 Mist Blower at a rate of 56 l spray mix/ha to control brush and undesirable broadleaf plants.

Theoretically, this habitat alteration would increase the temperature and lower the relative humidity to produce a microhabitat unfavorable for lone star tick development, activity and survival. Consequently, a reduction in the tick burden on livestock and wildlife as well as an increase in the productivity of the pastureland would be realized.

Techniques and procedures utilized during the 1981-82 season for monitoring lone star ticks within these vegetatively improved and unimproved study units were similar to those utilized during 1980. Fifty CO_2-baited traps were systematically placed within each study unit on a weekly schedule throughout the season and allowed to operate for three hours. Subsequently, CO_2 traps were collected, transported to the laboratory and actual counts of each life stage were recorded.

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

Crossbreed Cattle

The utilization of F_1-Brahman X Hereford cattle were employed on the study units so that an assessment of this management strategy could be determined when compared to purebred Hereford cattle. During 1981 and 1982, 32 purebred Hereford heifers, averaging 258 kg, and 32 F_1-Brahman X Hereford heifers, averaging 225 kg, were purchased and divided into four groups of 16 animals with each breed represented on both improved and unimproved study units.

Lone star tick infestations on these cattle were monitored by animal examination procedures (Garris 1979) as previously described during 1980. Lone star tick counts were made from selected sampling areas on the left side of each animal. Both sexes of adult lone star ticks were counted weekly and the females categorized as to the stage of engorgement. Also, total nymphs and larvae were counted and the stage of engorgement was recorded.

Acaricides

The application of an acaricide that is 95-98% effective with good residual properties should exert a selective pressure to eventually disrupt the life cycle of the tick on the host. One would expect that an application of a residual pesticide at the beginning of the adult and larval seasons would maintain tick populations at tolerable levels in most established areas.

In order to determine the role of acaricides in integrated management programs for lone star ticks affecting livestock, cattle inhabiting the study units were treated with the experimental acaricide Amitraz® [N'-(2,4-Dimethylphenyl)-N-{((2,4-dimethylphenyl) imino}methyl}-N-methylmethanimidamide] and the registered acaricide Delnav® [2,3-p-Dioxanedithiol S,S-bis-(0,0-diethyl phosphorodithioate)] at selected times during the tick season. The cattle in each study unit were divided into two treatment groups and a single control group consisting of four to six animals each. Amitraz was mixed at concentrations of 0.0125 and 0.0250% A.I. while Delnav was prepared at 0.1% A.I. Both acaricides were applied at a rate of ca 5.6 l of spray/head with a Bean® model 1010 portable power sprayer operated at 18 kg/cm^2. Treated and control cattle were released onto the same study unit following treatment. Cattle were retreated when the level of infestation reached ca 50% of that on the control animals.

Forage Production and Wildlife Utilization

Forage dry matter yields of the vegetatively improved and unimproved study units were determined according to procedures previously described by Baker (1978). Fifteen forage samples were randomly taken from each study unit by hand clipping 0.5m^2 sample areas bi-weekly throughout the season. These samples were then transported to the laboratory for identification to species and dry matter yield analysis.

The frequency of white-tailed deer utilization of these study units was monitored by replicated sampling of each study unit for deer pellet-groups as previously described during 1980. Three 0.04 ha plots and three 100 m transect lines were surveyed within each study unit and all existing pellet-groups were counted bi-weekly.

Statistical Analysis

This study was designed and statistically analyzed as a 3^2 factorial arrangement with habitat type, cattle breed and acaricide treatment serving as the main factors. For each criterion, treatment means at each date within and between each breed and study unit were compared using the LSD test (5% level). Standard errors associated with tick counts and measured parameters were calculated and analyzed for significance using factorial analysis of variance. Wildlife utilization and forage production data within and between study units, were compared using the Student's t-test (Steel and Torrie 1960).

CHAPTER IV

RESULTS AND DISCUSSION

Free-Living, Host-Seeking Life Stage

1980 Pre-Treatment Observations

Prior to vegetative manipulation of the study area, CO_2 survey data collected during 1980 revealed that all developmental stages of the lone star tick were attracted to CO_2 (Table I). The seasonal abundance of each life stage sampled in the unmanaged study area is shown in Figure 1. These data indicated that the surveying method was more effective for adult and nymphal life stages than the larval life stage.

Adults. The mean number of adult lone star ticks recorded within the study area reached a peak during early-May when sampling with CO_2 showed 30.1 adults/trap were collected on May 13. After this period, the abundance of adults began to rapidly decline with only occasional adults (<1.0/trap) being collected in late-July. Their abundance had practically ceased to exist on August 12 when <0.1 adults/trap were recorded.

Nymphs. Nymphal abundance within the unmanaged study area was greater than that recorded for the adult life stage. Data indicated that a nymphal peak occurred in early-May with 89.3 nymphs/trap being

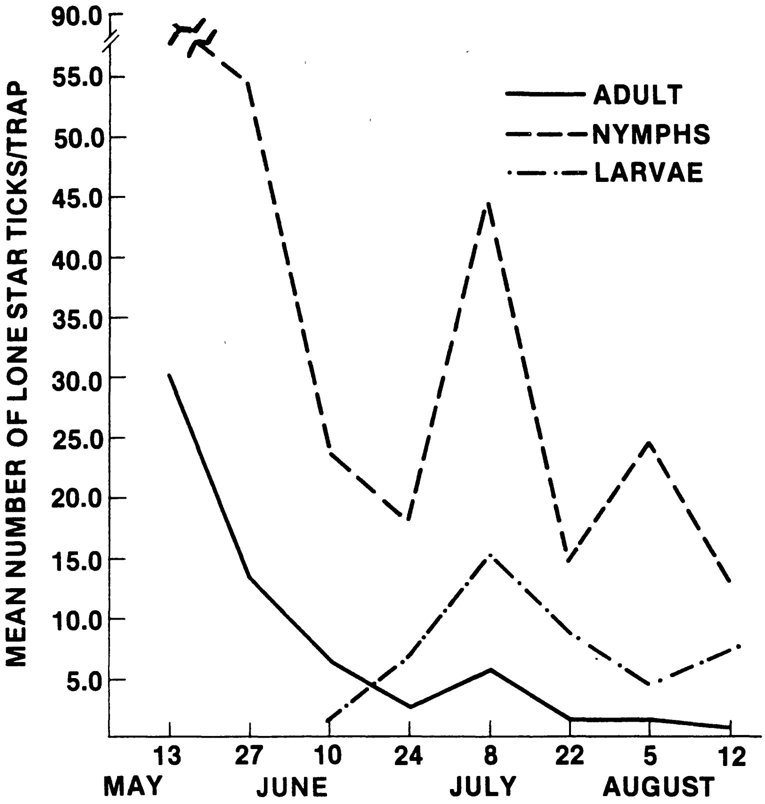
TABLE I

MEAN ($\bar{x}$) NUMBER OF ADULT, NYMPHAL AND LARVAL LONE STAR TICKS SAMPLED USING CO_2-BAITED TRAPS* IN THE VEGETATIVELY UNIMPROVED STUDY AREA OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1980

		Life Stage ($\bar{x}$ ±SE)	
Date	Adult	Nymph	Larvae
May 13	30.1±5.2	89.3±15.5	0.0
27	13.2±3.3	54.2± 9.6	0.0
June 10	6.2±2.8	23.6± 3.8	0.7±0.2
24	2.6±0.9	17.8± 4.1	6.8±1.9
July 8	5.4±1.8	44.5±10.0	15.0±4.1
22	0.1±0.1	14.2± 4.3	8.4±2.2
Aug 5	0.7±0.1	24.6± 3.7	4.0±1.5
12	0.1±0.1	13.0± 2.1	6.9±1.3

* 200 traps/sample operating for 3 hours

Figure 1. Seasonal Activity and Abundance of Adult, Nymphal and Larval Lone Star Ticks in the Vegetatively Unimproved Study Area of Cherokee Wildlife Refuge, Oklahoma During May-June, 1980


90.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
MEAN NUMBER OF LONE STAR TICKS/TRAP
ADULT
NYMPHS
LARVAE
13
27
10
24
8
22
5
12
MAY
JUNE
JULY
AUGUST

collected on May 13. Thereafter, nymphs declined in numbers with nymphal counts averaging 13.0 nymphs/trap on August 12.

Larvae. Surveying the study area with CO_2 traps revealed that lone star tick larvae were not collected in significant numbers utilizing this sampling method. As reported by Kinzer (1975), larval collection involves placement of a CO_2 trap in close proximity to a larval cluster since they migrate only a few feet to a CO_2 trap. Larvae were detected as early as June 10 which coincided with the findings reported by Lancaster (1957) in Arkansas. Larvae were not collected in appreciable numbers until early-July when 15.0 larvae/trap were collected. Observations during late-July and early-August indicated that the abundance of larvae gradually declined. This was probably due to random sampling with CO_2.

Recently, Koch and McNew (1982) demonstrated that absolute numbers of free-living, host-seeking adult lone star ticks could be determined based on estimates of sampling with dry ice. These authors indicated that one adult lone star tick/one-hour dry ice sample equaled 2285 adults/ha. Considering this, the 1980 tick survey data demonstrated that there was a high population of lone star ticks within the study area. The adult population sampled from early-May until early-July was estimated to exceed 25,000 adults/ha which represented a significant number of ticks available for host parasitism.

1981 Post-Treatment Observations

The habitat modification techniques employed within the unmanaged study area had a significant influence on the free-living, host-seeking life stages of the lone star tick. This is most evident when one compares the seasonal abundance of each life stage sampled within the vegetatively improved and unimproved study units (Table II; Figures 2-4). Although sampling with CO_2 was not initiated soon enough to accurately determine early peaks in the number of adult and nymphal ticks, an abundance of ticks were observed in early-June when sampling first began.

Data indicated that the vegetatively improved study units yielded significantly ($P<.05$) fewer lone star ticks of all life stages than the unimproved study units. Although not statistically significant ($P>.05$) for each observation date, study units pasturing Brahman x Hereford cattle generally yielded fewer ticks than study units pasturing Hereford cattle.

Adults. The abundance of adults (Figure 2) within the vegetatively improved and unimproved study units appeared to have peaked on or prior to the first observation date of June 10. The unimproved study units pasturing Hereford and Brahman x Hereford cattle during this period yielded 17.9 and 15.6 adults/trap, respectively. The number of adults steadily declined as the season progressed until their abundance subsided in late-July with adult counts of 0.5 adults/trap for the unimproved study unit pasturing Hereford cattle and 0.3/trap for the study unit pasturing Brahman x Hereford cattle.

Sampling the improved study units indicated that the seasonal abundance of adults was substantially reduced to densities below normal. Adult activity within these study units, as indicated by CO_2

TABLE II

MEAN ($\bar{x}$) NUMBER OF ADULT, NYMPHAL AND LARVAL LONE STAR TICKS SAMPLED USING CO_2-BAITED TRAPS* IN VEGETATIVELY IMPROVED AND UNIMPROVED STUDY UNITS OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1981[a]

Date	Study Unit**/ Cattle Breed	Life Stage		
		Adult	Nymph	Larvae
June 10	U/H	17.9b	46.6c	-
	U/BXH	15.6b	39.2b	-
	I/H	2.0a	0.3a	-
	I/BXH	1.2a	0.3a	-
24	U/H	9.5b	28.0b	-
	U/BXH	9.2b	28.3b	-
	I/H	1.0a	0.8a	-
	I/BXH	0.6a	0.4a	-
July 2	U/H	3.8b	7.8b	-
	U/BXH	2.2ab	6.0b	-
	I/H	0.6a	0.7a	-
	I/BXH	0.7a	0.4a	-
9	U/H	6.3b	9.6b	1.4a
	U/BXH	3.1a	7.5b	1.5a
	I/H	1.0a	0.8a	0.2a
	I/BXH	0.8a	0.4a	0.7a
16	U/H	1.7a	8.3b	7.0c
	U/BXH	0.8a	8.3b	4.6b
	I/H	0.1a	0.5a	0.8a
	I/BXH	0.2a	0.5a	1.1a
23	U/H	3.1b	4.4b	15.6c
	U/BXH	1.5ab	5.0b	8.9b
	I/H	0.4a	0.4a	0.6a
	I/BXH	0.4a	0.6a	1.1a
30	U/H	0.5a	3.7b	32.0c
	U/BXH	0.3a	3.0b	19.9b
	I/H	0.0a	0.4a	0.4a
	I/BXH	0.2a	0.9a	0.2a
Aug 6	U/H	0.9a	11.5c	10.1c
	U/BXH	0.3a	7.4b	4.8b
	I/H	0.1a	1.3a	0.1a
	I/BXH	0.0a	0.8a	0.3a

TABLE II CONTINUED

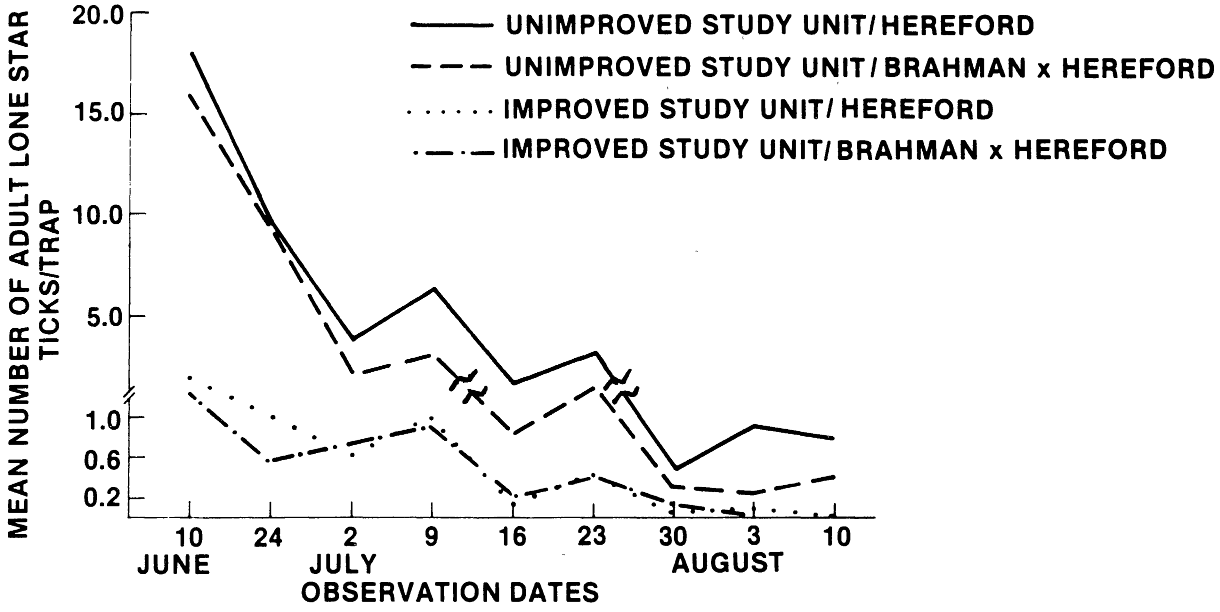
Date	Study Unit**/ Cattle Breed	Life Stage Adult	Nymph	Larvae
Aug 13	U/H	0.8a	14.6c	13.1c
	U/BXH	0.4a	9.1b	6.7b
	I/H	0.0a	1.2a	0.4a
	I/BXH	0.0a	0.9a	0.3a

* 50 traps/study unit operating for 3 hours

[a] Numbers in columns within dates followed by the same letter are not significantly (P>.05) different.

** U/H = Unimproved/Hereford
U/BXH = Unimproved/Brahman X Hereford
I/H = Improved/Hereford
I/BXH = Improved/Brahman X Hereford

Figure 2. Seasonal Activity and Abundance of Adult Lone Star Ticks Occurring in Vegetatively Improved and Unimproved Study Units of Cherokee Wildlife Refuge, Oklahoma During June-August, 1981.

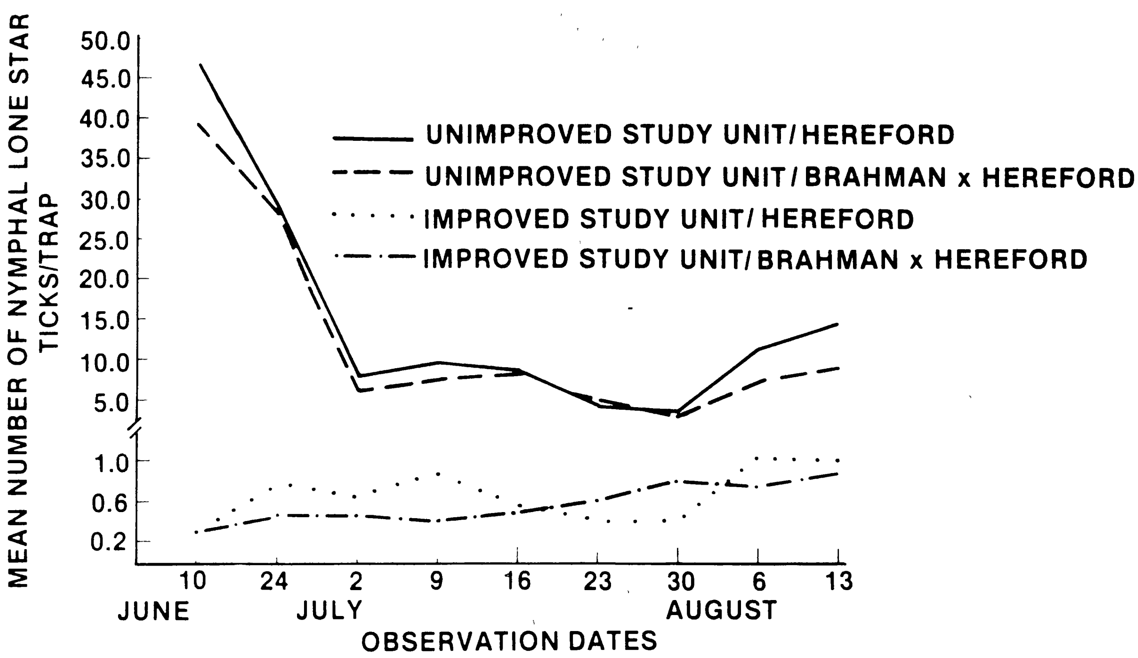

MEAN NUMBER OF ADULT LONE STAR TICKS/TRAP
20.0
15.0
10.0
5.0
1.0
0.6
0.2
UNIMPROVED STUDY UNIT/HEREFORD
UNIMPROVED STUDY UNIT/BRAHMAN x HEREFORD
IMPROVED STUDY UNIT/HEREFORD
IMPROVED STUDY UNIT/BRAHMAN x HEREFORD
10 24 2 9 16 23 30 3 10
JUNE
JULY
AUGUST
OBSERVATION DATES

survey, closely resembled each other with both improved study units failing to indicate a distinct peak in abundance. The highest number of adults was collected on June 10 with the improved study unit pasturing Hereford cattle yielding 2.0 adults/trap while 1.2 adults/trap were recorded for the study unit pasturing Brahman x Hereford cattle. Adult abundance remained $\leq$1.0/trap throughout the rest of the season and ceased to exist by early-August.

Nymphs. Nymphal activity within the vegetatively improved and unimproved study units exhibited similar patterns (Figure 3) to those of the adult life stage. However, their abundance appeared to be bimodal. Nymphal numbers within the unimproved study units was greater in early-June with peaks of 46.6 and 39.2 nymphs/trap recorded for these study units pasturing Hereford and Brahman x Hereford cattle, respectively. Nymphal abundance gradually declined after this period until a second nymphal peak was observed in early-August. The highest number of nymphs was sampled on August 13 with the unimproved study unit pasturing Hereford cattle yielding 14.6 nymphs/trap while the study unit pasturing Brahman x Hereford cattle yielded 9.1/trap.

Nymphal activity within each improved study unit was similar with no distinct peak in abundance being observed. Initial observations indicated that their abundance was repressed to very low levels and remained so throughout the season. Both improved study units yielded <1.0 nymphs/trap until early-August when the study unit pasturing Hereford cattle yielded 1.3 nymphs/trap. The number of nymphs sampled in the study unit pasturing Brahman x Hereford cattle was 0.8/trap during this same period.

Figure 3. Seasonal Activity and Abundance of Nymphal Lone Star Ticks Occurring in Vegetatively Improved and Unimproved Study Units of Cherokee Wildlife Refuge, Oklahoma During June-August, 1981


MEAN NUMBER OF NYMPHAL LONE STAR TICKS/TRAP
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
1.0
0.6
0.2
UNIMPROVED STUDY UNIT/HEREFORD
UNIMPROVED STUDY UNIT/BRAHMAN x HEREFORD
IMPROVED STUDY UNIT/HEREFORD
IMPROVED STUDY UNIT/BRAHMAN x HEREFORD
10 24 2 9 16 23 30 6 13
JUNE
JULY
AUGUST
OBSERVATION DATES

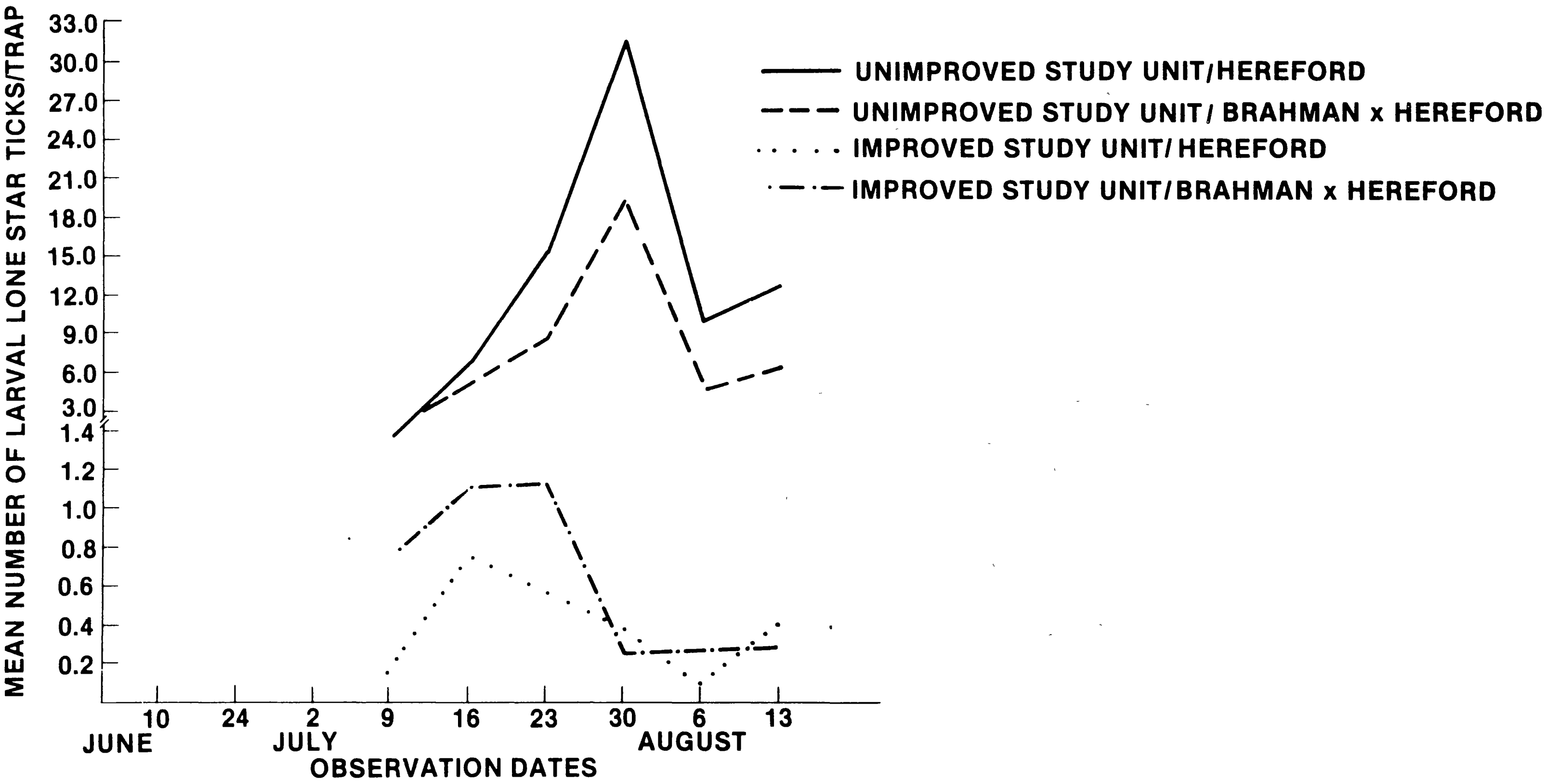
Larvae. Lone star larvae within both the improved and unimproved study units were first detected in early-July (Figure 4) with a greater abundance being observed in the unimproved study units. The unimproved study units pasturing Hereford and Brahman x Hereford cattle yielded 1.4 and 1.5 larvae/trap respectively, on July 9. Further observations indicated that larval numbers rapidly rose to a peak on July 30 when 32.0 larvae/trap were sampled from the unimproved study unit pasturing Hereford cattle and 19.9/trap from the study unit pasturing Brahman x Hereford cattle. Their abundance declined after this period to 13.1 and 6.7 larvae/trap for the unimproved study units pasturing Hereford and Brahman x Hereford cattle, respectively.

Sampling with CO_2 in the improved study units indicated that the study unit pasturing Brahman x Herford cattle had a greater abundance of larvae than the study unit pasturing Hereford cattle. This was probably due to sample variation within these study units since larval numbers were extremely low. Initial observations indicated that the improved study unit pasturing Hereford cattle yielded 0.2 larvae/trap while the study unit pasturing Brahman x Hereford cattle yielded 0.7/trap. Larval abundance increased during mid-July with 1.1 and 0.8 larvae/trap sampled from these study units pasturing Brahman x Hereford and Hereford cattle, respectively. A decline in larval numbers was observed beyond this period with larval counts ranging from 0.1-0.5 larvae/trap.

1982 Post-Treatment Observations

Surveying the vegetatively improved and unimproved study units with CO_2 during 1982 was initiated one month earlier in order to accurately determine the peaks in abundance of all life stages of the lone star

Figure 4. Seasonal Activity and Abundance of Larval Lone Star Ticks Occurring in Vegetatively Improved and Unimproved Study Units of Cherokee Wildlife Refuge, Oklahoma During June-August, 1981


MEAN NUMBER OF LARVAL LONE STAR TICKS/TRAP
33.0
30.0
27.0
24.0
21.0
18.0
15.0
12.0
9.0
6.0
3.0
1.4
1.2
1.0
0.8
0.6
0.4
0.2
10
24
2
9
16
23
30
6
13
JUNE
JULY
AUGUST
OBSERVATION DATES
UNIMPROVED STUDY UNIT/HEREFORD
UNIMPROVED STUDY UNIT/ BRAHMAN x HEREFORD
IMPROVED STUDY UNIT/ HEREFORD
IMPROVED STUDY UNIT/BRAHMAN x HEREFORD

tick. These data (Table III; Figures 5-7) were similar to those recorded during 1981 and indicated that the vegetatively improved study units yielded significantly ($P<.05$) fewer lone star ticks than the unimproved study units. Data also indicated that study units pasturing Brahman x Hereford Cattle yielded significantly ($P<.05$) fewer ticks than study units pasturing Hereford cattle.

Adults. Adult abundance (Figure 5) within the unimproved study units peaked in early-May. The unimproved study unit pasturing Hereford cattle yielded 12.4 adults/trap while the study unit pasturing Brahman x Hereford Cattle yielded 10.7/trap. The number of adults gradually declined after this period and subsided by late-July when <1.0 adults/trap were collected.

The vegetatively improved study units showed a substantial reduction in abundance of adult ticks. This was most obvious with regard to densities which were below normal and without a distinct peak. The mean number of adult ticks sampled during May from the improved study units pasturing Hereford and Brahman x Hereford cattle was 1.5 and 1.2 adults/trap, respectively. Thereafter, the number of adults declined to a mean of 0.4 adults/trap and ceased to exist on August 10.

Nymphs. Nymphal activity (Figure 6) within the vegetatively improved and unimproved study units was similar to that recorded during 1981. Their abundance in the unimproved study units peaked in early-May when 36.5 nymphs/trap were recorded for the study unit pasturing Hereford cattle and 29.5 nymphs/trap for the study unit pasturing Brahman x Hereford cattle. These peaks were followed by a gradual decline in numbers until early-August when nymphal numbers began to

TABLE III

MEAN ($\bar{x}$) NUMBER OF ADULT, NYMPHAL AND LARVAL LONE STAR TICKS SAMPLED USING CO_2-BAITED TRAPS* IN VEGETATIVELY IMPROVED AND UNIMPROVED STUDY UNITS OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1982[a]

Date	Study Unit**/ Cattle Breed	Life Stage Adult	Nymph	Larvae
May 4	U/H	12.4b	36.5c	-
	U/BXH	10.7b	29.5b	-
	I/H	1.8a	1.9a	-
	I/BXH	1.1a	0.7a	-
11	U/H	13.8c	38.7c	-
	U/BXH	8.6b	21.4b	-
	I/H	1.6a	1.9a	-
	I/BXH	1.3a	0.4a	-
18	U/H	12.3c	20.3c	-
	U/BXH	9.8b	16.7b	-
	I/H	1.5a	1.3a	-
	I/BXH	1.7a	1.2a	-
26	U/H	4.7b	13.9b	-
	U/BXH	3.5ab	11.3b	-
	I/H	1.1a	0.9a	-
	I/BXH	0.9a	1.0a	-
June 1	U/H	3.3b	11.4c	-
	U/BXH	2.0ab	7.5b	-
	I/H	0.2a	0.6a	-
	I/BXH	0.2a	0.1a	-
8	U/H	3.8b	32.2b	-
	U/BXH	8.8c	0.9a	-
	I/H	1.1a	1.1a	-
	I/BXH	0.9a	1.0a	-
15	U/H	1.5a	9.8c	-
	U/BXH	2.3a	4.8b	-
	I/H	0.3a	0.1a	-
	I/BXH	0.3a	0.4a	-
22	U/H	2.9a	17.1c	1.8a
	U/BXH	0.7a	6.6b	0.8a
	I/H	0.2a	0.3a	0.0a
	I/BXH	0.1a	0.1a	0.0a

TABLE III CONTINUED

Date	Study Unit**/ Cattle Breed	Life Stage Adult	Nymph	Larvae
June 29	U/H	1.4a	12.8b	2.2a
	U/BXH	0.6a	10.5b	1.8a
	I/H	0.2a	0.5a	0.0a
	I/BXH	0.4a	0.7a	0.0a
July 6	U/H	0.6a	8.9b	5.7b
	U/BXH	0.9a	10.8b	3.7b
	I/H	0.7a	0.9a	0.2a
	I/BXH	0.6a	0.7a	0.3a
13	U/H	0.8a	8.3b	13.7c
	U/BXH	0.7a	13.3c	8.2b
	I/H	0.6a	0.7a	0.2a
	I/BXH	0.5a	0.4a	0.1a
20	U/H	1.2a	4.6b	10.7b
	U/BXH	2.9a	5.3b	8.7b
	I/H	0.7a	1.0a	0.3a
	I/BXH	0.3a	0.3a	0.1a
27	U/H	0.4a	3.7b	22.2c
	U/BXH	0.9a	3.6b	6.6b
	I/H	0.2a	0.4a	0.2a
	I/BXH	0.1a	0.2a	0.3a
Aug 3	U/H	0.2a	4.9b	13.5b
	U/BXH	0.1a	4.1b	19.8c
	I/H	0.2a	0.5a	1.5a
	I/BXH	0.1a	0.5a	0.3a
10	U/H	0.1a	14.2c	9.6c
	U/BXH	0.0a	8.4b	3.8b
	I/H	0.0a	0.8a	0.4a
	I/BXH	0.0a	0.7a	0.1a

* 50 traps/study unit operating for 3 hours

[a] Numbers in columns within dates followed by the same letter are not significantly (P>.05) different.

** U/H = Unimproved/Hereford
U/BXH = Unimproved/Brahman X Hereford
I/H = Improved/Hereford
I/BXH = Improved/Brahman X Hereford

Figure 5. Seasonal Activity and Abundance of Adult Lone Star Ticks in Vegetatively Improved and Unimproved Study Units of Cherokee Wildlife Refuge, Oklahoma During May-August, 1982

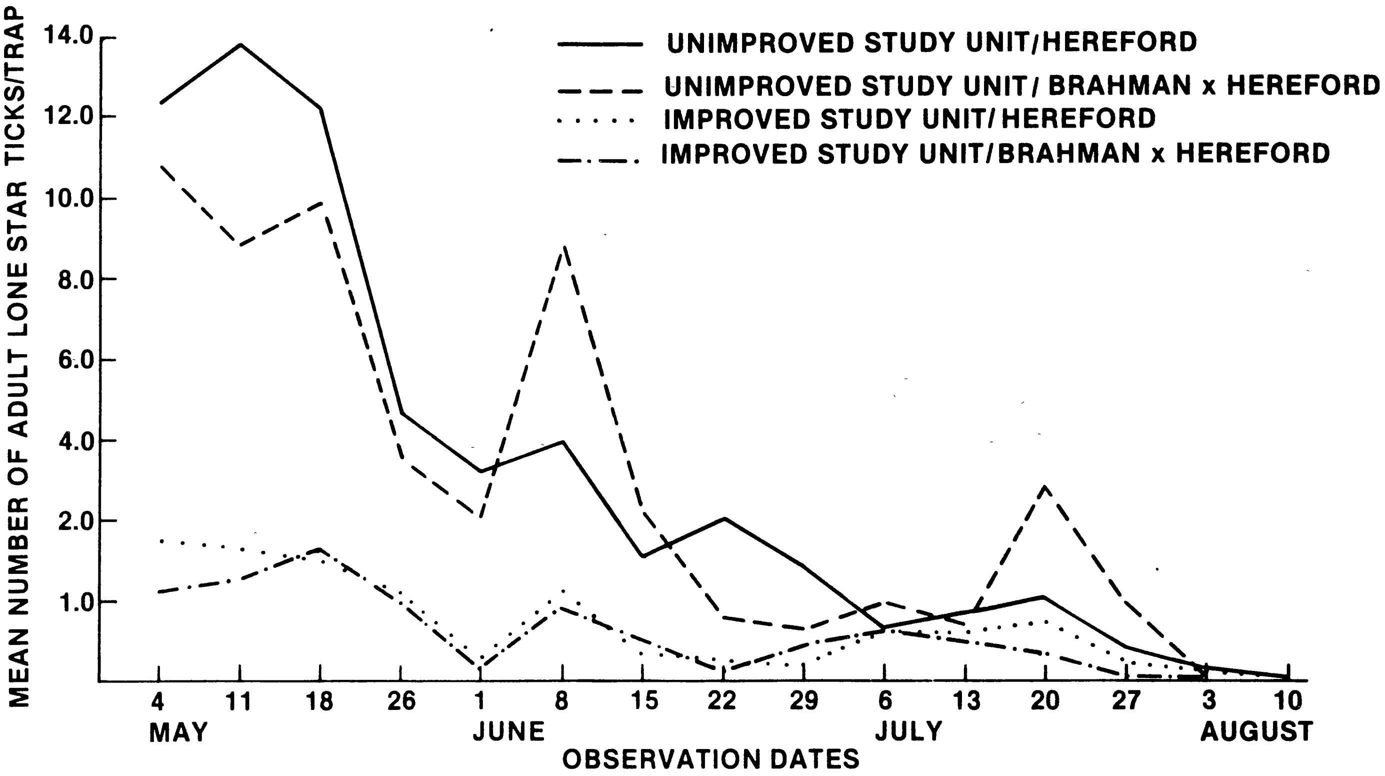
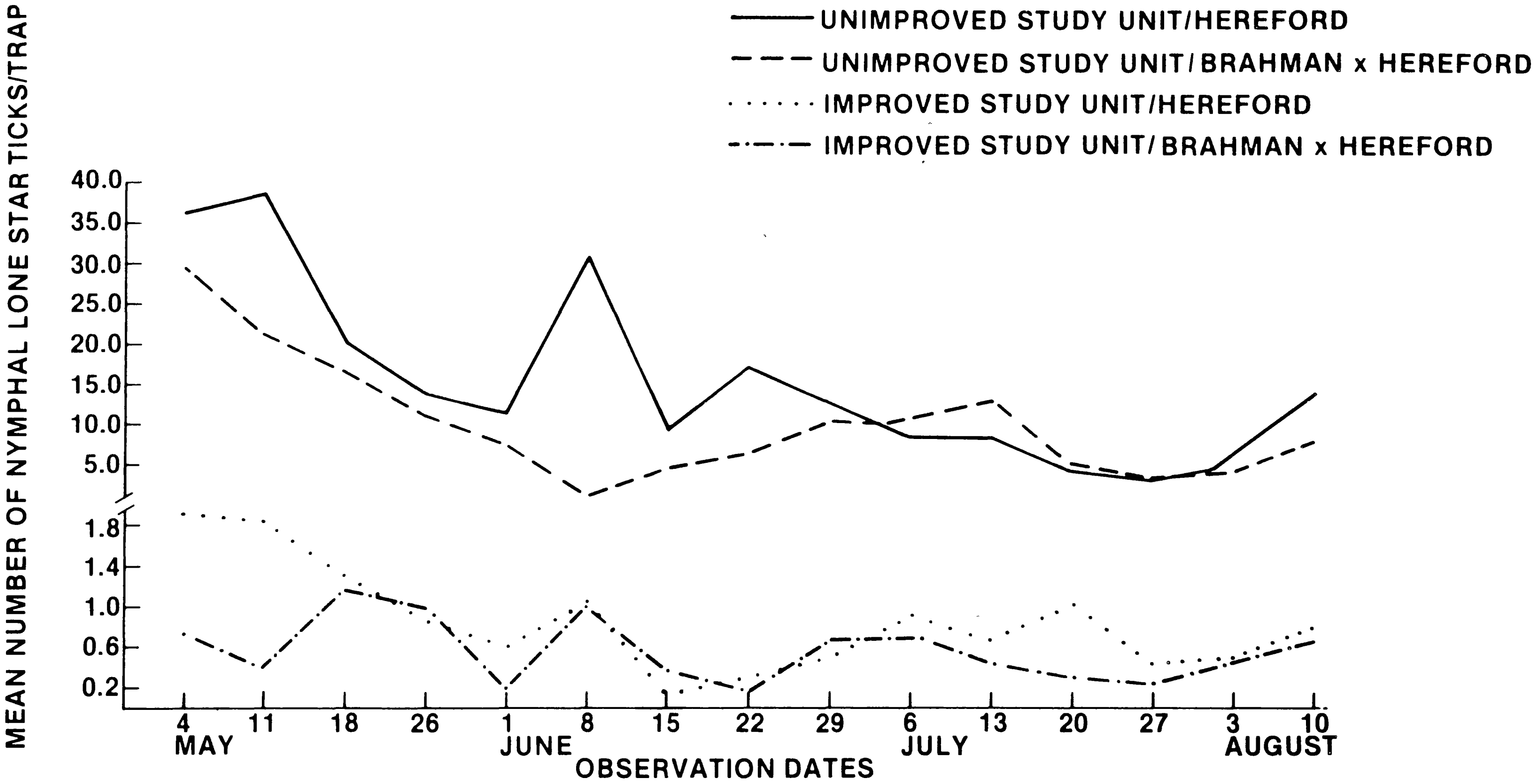

MEAN NUMBER OF ADULT LONE STAR TICKS/TRAP
14.0
12.0
10.0
8.0
6.0
4.0
2.0
1.0
UNIMPROVED STUDY UNIT/HEREFORD
UNIMPROVED STUDY UNIT/ BRAHMAN x HEREFORD
IMPROVED STUDY UNIT/ HEREFORD
IMPROVED STUDY UNIT/BRAHMAN x HEREFORD
4 11 18 26 1 8 15 22 29 6 13 20 27 3 10
MAY
JUNE
JULY
AUGUST
OBSERVATION DATES

Figure 6. Seasonal Activity and Abundance of Nymphal Lone Star Ticks Occurring in Vegetatively Improved and Unimproved Study Units of Cherokee Wildlife Refuge, Oklahoma During May-August, 1982


UNIMPROVED STUDY UNIT/HEREFORD
UNIMPROVED STUDY UNIT/ BRAHMAN x HEREFORD
IMPROVED STUDY UNIT/HEREFORD
IMPROVED STUDY UNIT/ BRAHMAN x HEREFORD
MEAN NUMBER OF NYMPHAL LONE STAR TICKS/TRAP
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
1.8
1.4
1.0
0.6
0.2
4
11
18
26
1
8
15
22
29
6
13
20
27
3
10
MAY
JUNE
JULY
AUGUST
OBSERVATION DATES

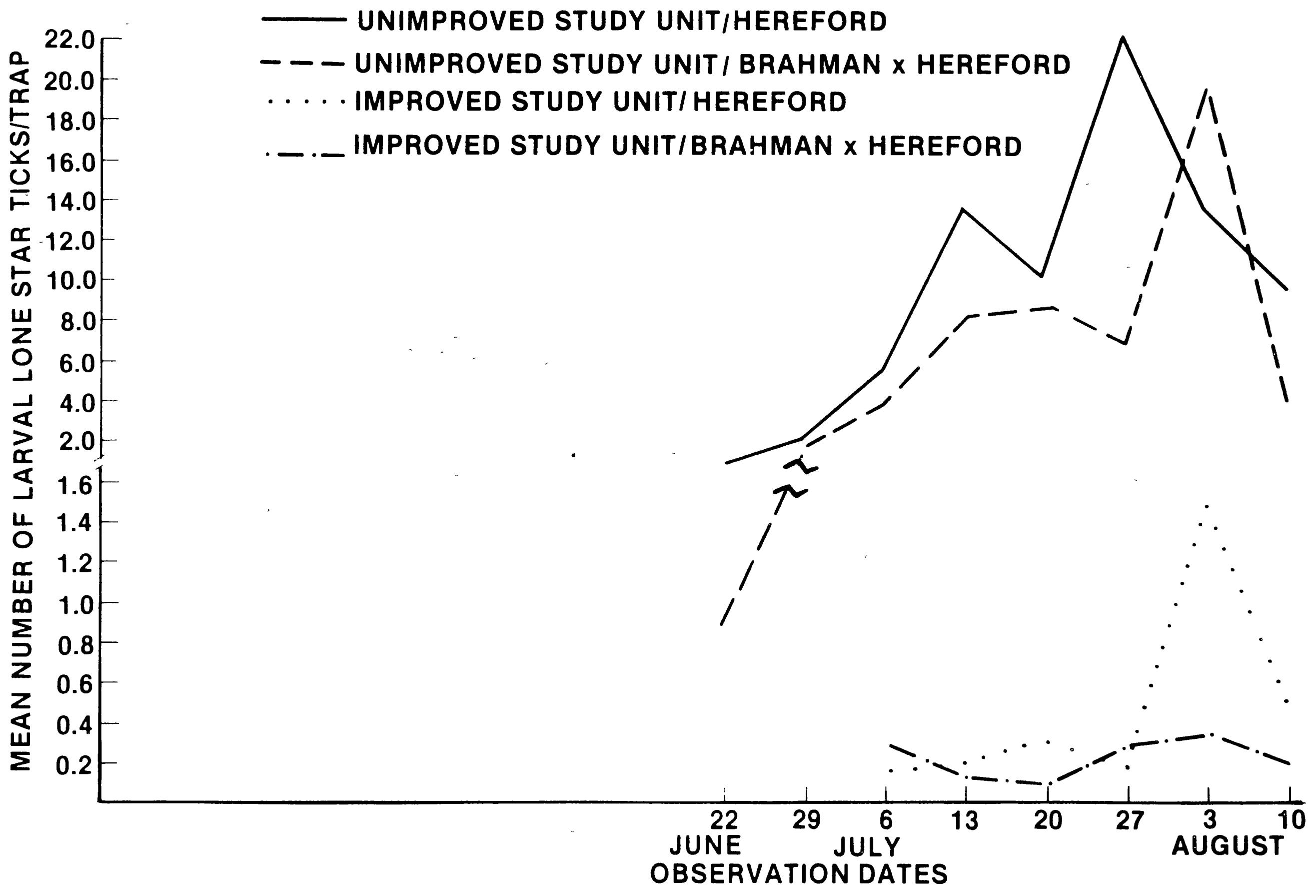
increase with 14.2 and 8.4 nymphs/trap being collected from the unimproved study units pasturing Hereford and Brahman x Hereford cattle, respectively.

Nymphal activity within the improved study units lacked a distinct peak in abundance since <2.0 nymphs/trap were collected from these study units throughout the season. The highest numbers were sampled during May with the study unit pasturing Hereford cattle yielding 1.9 nymphs/trap and the study unit pasturing Brahman x Hereford cattle yielding 1.2 nymphs/trap. Nymphal numbers remained $\leq$1.0/trap throughout the rest of the season.

Larvae. The abundance of larvae (Figure 7) within the unimproved study units was first detected on June 22 which was 12 days earlier than that reported during 1981. Carbon dioxide survey data during this period indicated that 1.8 and 0.8 larvae/trap were recorded for the unimproved study units pasturing Hereford and Brahman x Hereford cattle, respectively. Following a gradual increase in abundance to a peak of 22.2 and 19.8 larvae/trap for the study units pasturing Hereford and Brahman x Hereford cattle respectively, larval numbers declined within these study units to 9.6 and 3.8 larvae/trap, respectively.

Lone star tick larvae first appeared in the improved study units in early-July which was two weeks later than that reported in the unimproved study units. The sampling of larvae from these study units was almost non-existent with <0.3 larvae/trap collected until August 3 when the improved study unit pasturing Hereford cattle yielded 1.5 larvae/trap.

Figure 7. Seasonal Activity and Abundance of Larval Lone Star Ticks Occurring in Vegetatively Improved and Unimproved Study Units of Cherokee Wildlife Refuge, Oklahoma During May-August, 1982



UNIMPROVED STUDY UNIT/HEREFORD
UNIMPROVED STUDY UNIT/ BRAHMAN x HEREFORD
IMPROVED STUDY UNIT/ HEREFORD
IMPROVED STUDY UNIT/BRAHMAN x HEREFORD
MEAN NUMBER OF LARVAL LONE STAR TICKS/TRAP
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
22
29
6
13
20
27
3
10
JUNE
JULY
AUGUST
OBSERVATION DATES

Influence of Habitat Modification, 1981-1982

Evaluation of the data collected during 1981 and 1982 indicated that the management strategies involving habitat modification techniques had a significant effect on adult, nymphal and larval populations. Results showed that the vegetatively improved study units yielded significantly ($P<.05$) fewer lone star ticks of all life stages than the unimproved study units. This was apparently due to an alteration in the physical parameters as described by Hoch et al. (1971). Theoretically, the removal of the overstory allowed an increase in sunlight intensity which in combination with the alteration of favorable lone star tick habitat, resulted in higher temperatures, lower relative humidities and reduced soil moisture. These parameters have been shown to prevent lone star tick survival within a vegetatively altered area and thereby, reduced the number of ticks within an area.

Improved vs Unimproved/Hereford. The greatest reduction in the numbers of free-living life stages was observed between the improved and unimproved study units pasturing susceptible Hereford cattle (Tables II and III). Initial observations in early-June of 1981 indicated that the alteration of vegetation resulted in an 89% reduction in the adult lone star tick population. During the first one-half of the 1982 season, this improved study unit yielded 83% fewer adults than the unimproved study unit. Although the number of adults sampled from these study units declined in association with the apparent seasonal increase in daily temperature and reduction in relative humidity, the percent reduction between the study units remained consistent with the improved study unit yielding 88 and 50% fewer adults during 1981 and 1982, respectively.

The effects of habitat modification on the nymphal population within these study units pasturing Hereford cattle were greater than that recorded for the adult stage. The improved study unit consistently yielded >92% fewer nymphs than the unimproved study unit throughout the 1981 and 1982 season.

Differences in the larval population between these improved and unimproved study units pasturing Hereford cattle closely resembled those reported for the nymphal stage. The improved study unit yielded 94 and 97% fewer larvae than the unimproved study unit throughout the 1981 and 1982 season, respectively. A more significant finding was that initial larval activity was detected two weeks later in the improved study unit during 1982.

Improved vs Unimproved/Brahman x Hereford. Reductions in lone star tick populations recorded between the improved and unimproved study units pasturing Brahman x Hereford cattle closely resembled those reported for the same type study units pasturing Hereford cattle. Observation during the peak in adult abundance during 1981 and 1982 indicated that the improved study unit yielded 93 and 86% fewer adults respectively, than the unimproved study unit. Although the percent reduction beyond this period decreased, the improved study unit continued to yield >72% fewer adults than the unimproved study unit during both seasons.

Differences in the abundance of nymphs between these improved and unimproved study units pasturing Brahman x Hereford cattle were similar to those recorded for the same type study units pasturing Hereford cattle. Data indicated that the greatest differences occurred during the first nymphal peak when reductions of 93-99% were recorded from the improved study unit during both seasons. Significant reductions continued to be recorded throughout the remainder of the season with the improved study unit yielding 88-93% fewer nymphs than the unimproved study unit.

Comparison of the larval population between these study units pasturing Brahman x Hereford cattle indicated that the improved study unit yielded significantly fewer larvae than the unimproved study unit. Observations at the beginning of the larval season in 1981 indicated that the improved study unit yielded 49% fewer larvae than the unimproved study unit. This difference increased as the season progressed with reductions of 88-98% being recorded. Initial sampling during 1982 indicated that the detection of larvae within the improved study unit was two weeks later than that recorded in the unimproved study unit. Thereafter, the improved study unit consistently yielded >96% fewer larvae than the unimproved study unit.

Influence of Cattle Breed, 1981-1982

The efficacy of habitat modification against all life stages of the lone star tick was enhanced by the addition of cattle breed to the vegetatively improved and unimproved study units (Tables II and III). Results showed that the study units pasturing Brahman x Hereford cattle generally yielded fewer lone star ticks than the study units pasturing Hereford cattle. This could have been due to differences in the attachment rate, development and fecundity of lone star ticks feeding on these animals. Brahman x Hereford cattle have been shown to be less susceptible to tick infestations, cause a greater reduction in percent molt, reduce the weights of females and egg masses and lower the percent hatch (Garris 1979). Therefore, a lower infestation pressure due to a reduction in the lone star tick population could be attributed to the effects of cattle breed.

Brahman x Hereford vs Hereford/Unimproved. The most significant reductions in the free-living lone star tick population were observed within the unimproved study units. Comparison of the data during 1981 and 1982 indicated that the study unit pasturing Brahman x Hereford cattle yielded 14-27% fewer adults than the study unit pasturing Hereford cattle during the peak in adult abundance. Throughout the seasonal decline in the number of adults. The unimproved study unit pasturing Brahman x Hereford cattle continued to yield fewer ticks with reductions ranging from 34-71% during both seasons.

Nymphal activity within these unimproved study units as indicated by CO_2 survey data, revealed that their abundance was greater in the study unit pasturing Hereford cattle. The percent reduction in the nymphal population was similar to that reported for the adult life stage. During the peak in abundance for 1981 and 1982, the unimproved study unit pasturing Brahman x Hereford cattle yielded 16 and 25% fewer nymphs respectively, than the unimproved study unit pasturing Hereford cattle. In early-August when the second nymphal peak occurred, data indicated that the percent reduction increased to 36 and 41% during 1981 and 1982, respectively.

Larval abundance within these unimproved study units was similar although the study unit pasturing Brahman x Hereford cattle yielded fewer larvae than the study unit pasturing Hereford cattle. Observations during the first one-half of the 1981 and 1982 season indicated that there were ca 35% fewer larvae in the study unit pasturing Brahman x Hereford than in the study unit pasturing Hereford cattle. Thereafter, data showed larval reductions of 30-46%.

Brahman x Hereford vs Hereford/Improved. Surveys with CO_2 within the improved study units indicated a significant reduction in all life stages of the lone star tick during 1981 and 1982. However, differences between these study units due to the effects of cattle breed were not statistically significant, primarily because of the extremely low number of ticks within these study units and sample variation. Data collected during both seasons indicated a distinct trend existed in which fewer adults, nymphs and larvae were sampled from the improved study unit pasturing Brahman x Hereford cattle. Differences between these study units were most noticeable during the early part of the season with reductions of 26 and 39% for the adults and nymphs respectively, during 1981 and 43% for both life stages during 1982. The influence of cattle breed on the larval population was almost non-existent during both seasons since <1.5 larvae/trap were collected from these study units.

Parasitic Life Stage

1980 Pre-Treatment Observations

Surveys for lone star ticks infesting susceptible Angus cattle pastured on the unmanaged study area during 1980 provided a reliable indication of the seasonal abundance of this tick species (Table IV). Data indicated that the seasonal abundance of the parasitic life stage followed a similar pattern as the free-living life stage (Figure 8).

TABLE IV

MEAN ($\bar{x}$) NUMBER OF ADULT, NYMPHAL AND LARVAL LONE STAR TICKS IN WOODLOT-PASTURED ANGUS CATTLE IN THE VEGETATIVELY UNIMPROVED STUDY AREA OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1980

Date	Life Stage ($\bar{x}$ $\pm$SE)		
	Adult	Nymph	Larvae
May 13	285.3$\pm$20.1	223.3$\pm$18.7	0.0
27	94.5$\pm$12.3	64.0$\pm$ 9.3	0.0
June 10	33.4$\pm$ 2.6	57.3$\pm$ 3.4	0.0
24	33.6$\pm$ 4.9	20.5$\pm$ 1.3	27.6$\pm$ 5.9
July 8	16.7$\pm$ 2.9	13.8$\pm$ 1.4	97.4$\pm$17.1
22	4.3$\pm$ 1.2	33.6$\pm$ 5.2	125.0$\pm$27.9
Aug 5	0.9$\pm$ 0.4	61.0$\pm$ 8.3	162.3$\pm$33.8
12	1.6$\pm$ 0.5	69.3$\pm$ 7.5	170.1$\pm$30.3

Adults. Adult infestation levels indicated that they peaked in abundance on or prior to May 13. The mean number of adults sampled on this observation date was 285.3/animal. Number of adults rapidly declined following this peak and were observed to have subsided in early-August with numbers ranging from 0.9-1.6 adults/animal.

Nymphs. Infestation levels for the nymphal population were essentially the same as the adult stage, however their abundance within the unmanaged study area was bimodal. The first nymphal peak occurred in early-May with numbers averaging 223.3 nymphs/animal. The abundance of nymphs declined after this period until late-July and early-August when the second peak occurred. During this period, the highest number of nymphs sampled was 69.3/animal on August 12.

Larvae. Lone star tick larvae were first detected on the cattle in late-June when 27.6 larvae/animal were recorded. Larval abundance increased over time and peaked in early-August with numbers averaging 170.1 larvae/animal.

Lone Star Tick Engorgement on Angus Cattle, 1980

The infestation patterns for male and female lone star ticks were observed to be identical although females accounted for 60% of the total adult counts during May and June. The degree of female engorgement on these cattle (Table V) was similar to that reported by Williams (1976). The percentage female repletion indicated that females at stage A made up the largest percentage of the total females attached over the course of the season. These cattle averaged 25% females at the unfed stage, 49% at stage A, 18% at stage B and 8% at stage C. Engorgement for

Figure 8. Seasonal Activity and Abundance of Adult, Nymphal and Larval Lone Star Ticks on Woodlot-Pastured Angus Cattle in the Vegetatively Unimproved Study Area of Cherokee Wildlife Refuge, Oklahoma During May-August, 1980

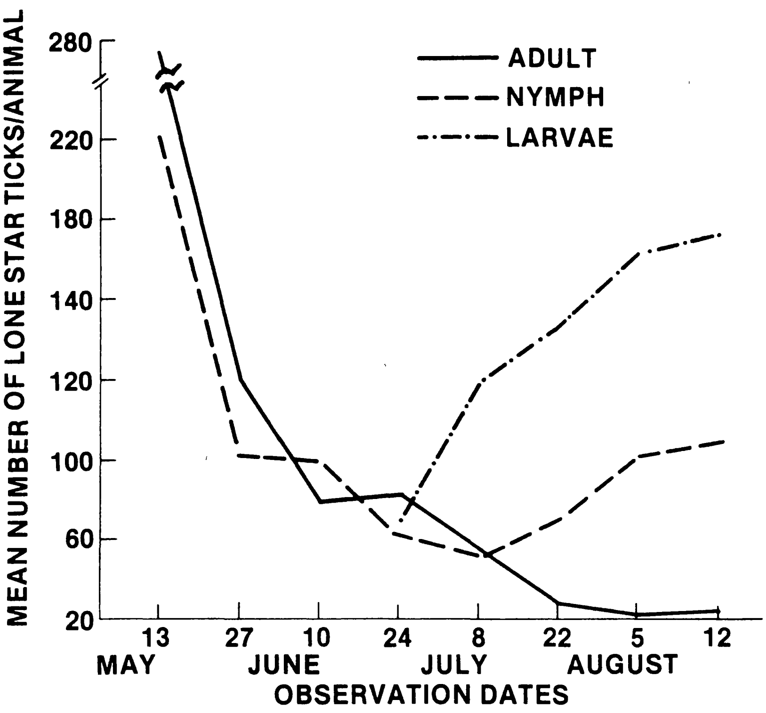

MEAN NUMBER OF LONE STAR TICKS/ANIMAL
280
220
180
140
120
100
60
20
ADULT
NYMPH
LARVAE
13
27
10
24
8
22
5
12
MAY
JUNE
JULY
AUGUST
OBSERVATION DATES

TABLE V

MEAN ($\bar{x}$) LONE STAR TICK ENGORGEMENT ON ANGUS CATTLE PASTURED ON THE VEGETATIVELY UNMANAGED STUDY AREA OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1980

Month	% Female Repletion[a]	% Nymphal Repletion[b]	% Larval Repletion[b]
May	Unfed - 25	48	45
	A - 50		
	B - 17		
	C - 8		
June	Unfed - 29	55	43
	A - 45		
	B - 16		
	C - 10		
July	Unfed - 21	56	49
	A - 53		
	B - 18		
	C - 8		
Aug	Unfed - 24	49	51
	A - 49		
	B - 21		
	C - 6		

[a] Letters represent stage of repletion beyond unfed female tick (Unfed≃<100mg, A≃100-200mg, B≃200-400mg, C≃>400mg)

[b] Nymphs and larvae attached were observed as being either unfed or replete

nymphal and larval stages was similar with 52 and 47% repletion for nymphs and larvae, respectively.

Considering the fecundity and reproductive potential of lone star ticks as described by Williams (1976), successful engorgement of ticks on these susceptible Angus cattle would theoretically result in an increased future re-infestation pressure within this unmanaged study area.

1981 Post-Treatment Observations

The seasonal abundance of each parasitic life stage surveyed on Hereford and Brahman x Hereford cattle inhabiting the vegetatively improved and unimproved study units during 1981 indicated that the effects due to cattle breed were significant (Tables VI-VIII; Figures 9-11). Animal examination procedures indicated that the cattle inhabiting the improved study units supported significantly ($P<.05$) fewer lone star ticks of all life stages than cattle inhabiting the unimproved study units. Data also showed that Brahman x Hereford cattle inhabiting these study units supported significantly ($P<.05$) fewer ticks than the Hereford cattle inhabiting these same type study units.

Adults. Data collected from Hereford and Brahman x Hereford cattle inhabiting the unimproved study units indicated that the adult life stage peaked in abundance (Figure 9) on or prior to the first observation date of June 10. During this period, the Hereford cattle supported 154.1 adults/animal compared to 55.1/animal for the Brahman x Hereford cattle. Adult infestation levels rapidly declined as the season progressed until numbers subsided in early-August with counts

TABLE VI

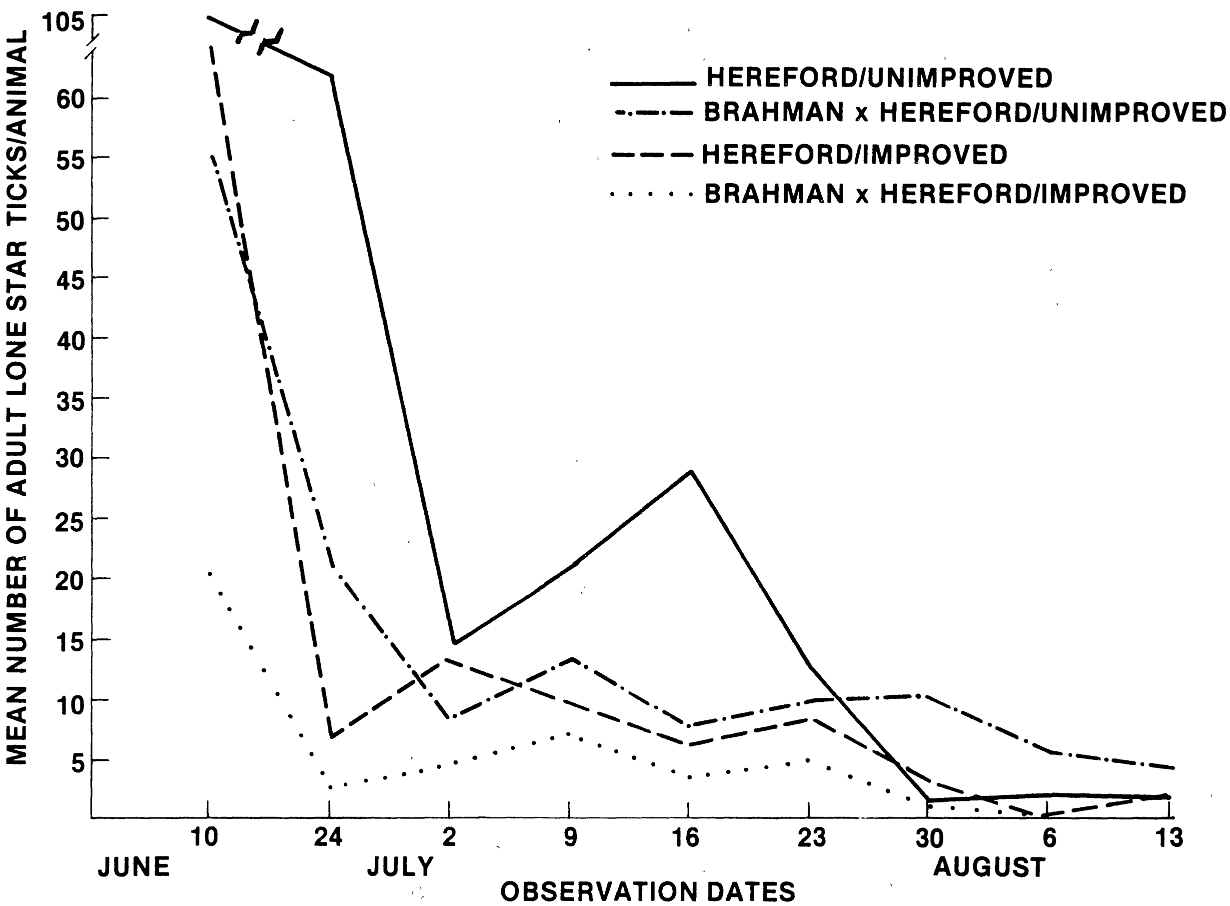
MEAN ($\bar{x}$) NUMBER OF ADULT LONE STAR TICKS ON BRAHMAN X HEREFORD AND HEREFORD CATTLE PASTURED ON VEGETATIVELY IMPROVED AND UNIMPROVED STUDY UNITS OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1981[a]

	Cattle Breed/Study Unit*			
Date	H/U	BXH/U	H/I	BXH/I
June 10	154.1d	55.1b	65.6c	20.5a
24	62.1d	20.7c	6.2b	2.6a
July 2	14.2c	8.0b	13.1c	4.7a
9	22.1d	13.0c	9.4b	6.8a
16	29.1c	7.7b	6.4b	3.4a
23	12.6c	9.9b	8.1b	4.3a
30	0.2a	10.4b	3.0a	1.0a
Aug 6	0.7a	6.1b	0.0a	0.0a
13	1.1ab	4.0b	1.9b	0.0a

[a] Numbers in rows within dates followed by the same letter are not significantly (P>.05) different.

* H/U = Hereford/Unimproved
BXH/U = Brahman x Hereford/Unimproved
H/I = Hereford/Improved
BXH/I = Brahman x Hereford/Improved

Figure 9. Seasonal Activity and Abundance of Adult Lone Star Ticks on Brahman x Hereford and Hereford Cattle Pastured on Vegetatively Improved and Unimproved Study Units of Cherokee Wildlife Refuge, Oklahoma During June-August, 1981



105
60
55
50
45
40
35
30
25
20
15
10
5
MEAN NUMBER OF ADULT LONE STAR TICKS/ANIMAL
HEREFORD/UNIMPROVED
BRAHMAN x HEREFORD/UNIMPROVED
HEREFORD/IMPROVED
BRAHMAN x HEREFORD/IMPROVED
10
24
2
9
16
23
30
6
13
JUNE
JULY
AUGUST
OBSERVATION DATES

averaging <0.7 adults/animal for the Hereford cattle and 6.1/animal for the Brahman x Hereford cattle.

Examination of Hereford and Brahman x Hereford cattle inhabiting the improved study units indicated that the abundance of all life stages was significantly reduced with Brahman x Hereford cattle almost invariably supporting lower infestations than Hereford cattle. Adults peaked in abundance on or prior to June 10 with an infestation of 65.6 and 20.5 adults/animal for Hereford and Brahman x Hereford cattle respectively, inhabiting these improved study units. Following a decline in abundance to 6.2 and 2.6 adults/animal for Hereford and Brahman x Hereford cattle respectively, infestation levels remained relatively constant during July with Hereford cattle supporting a mean of 8.0 adults/animal while Brahman x Hereford cattle supported 4.0 adults/animal. Adult activity had ceased to exist in early-August for the Brahman x Hereford cattle, however the Hereford cattle supported 1.9 adults/animal on August 13.

Nymphs. The abundance of nymphs (Figure 10) infesting Hereford and Brahman x Hereford cattle inhabiting the vegetatively improved and unimproved study units indicated that the Brahman x Hereford cattle supported significantly fewer nymphs than the Hereford cattle. The mean number of nymphs infesting the Hereford cattle inhabiting the unimproved study unit was 28.4/animal during their peak in early-June while 7.7 nymphs/animal were recorded for the Brahman x Hereford cattle during this period. Nymphal numbers declined after this peak until early-August when a second peak occurred with Hereford and Brahman x Hereford

TABLE VII

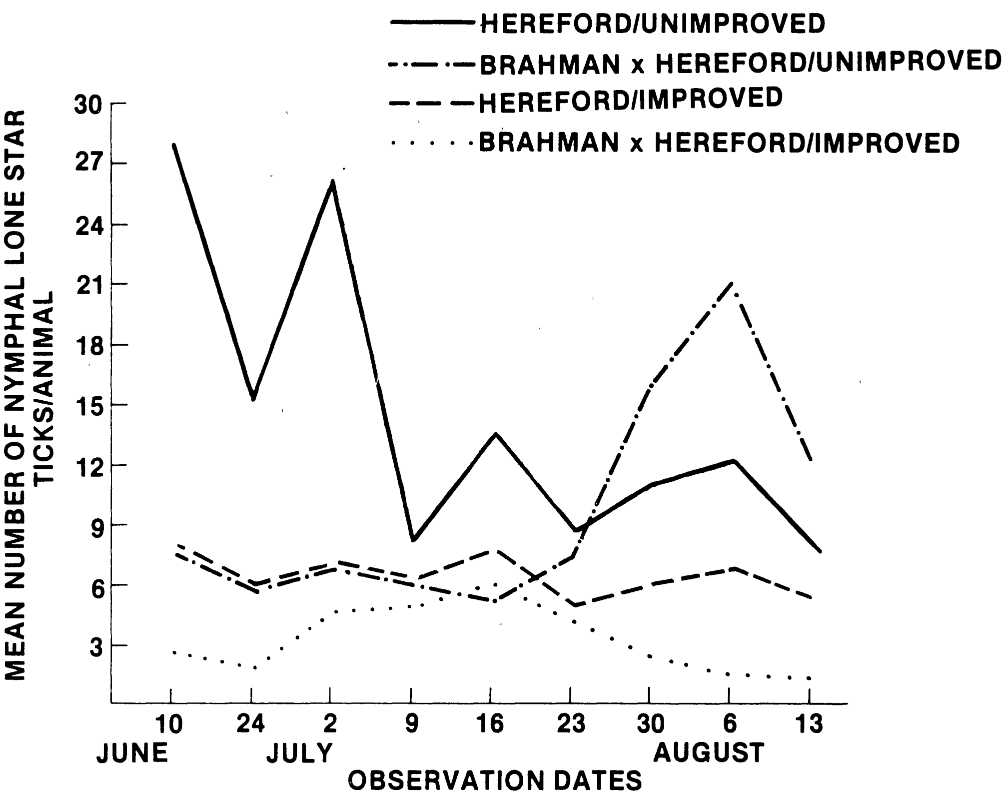
MEAN ($\bar{x}$) NUMBER OF NYMPHAL LONE STAR TICKS ON BRAHMAN X HEREFORD AND HEREFORD CATTLE PASTURED ON VEGETATIVELY IMPROVED AND UNIMPROVED STUDY UNITS OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1981[a]

	Cattle Breed/Study Unit*			
Date	H/U	BXH/U	H/I	BXH/I
June 10	28.4c	7.7b	8.1b	2.7a
24	15.2c	5.7b	6.1b	2.0a
July 2	26.4b	6.9a	6.9a	4.8a
9	8.1b	6.1ab	6.4ab	4.9a
16	13.5b	5.2a	7.7b	6.0ab
23	8.6b	7.5b	5.0a	4.1a
30	11.1c	16.0d	6.0b	2.2a
Aug 6	12.2c	21.0d	6.7b	1.4a
13	8.0c	12.0d	5.2b	1.2a

[a] Numbers in rows within dates followed by the same letter are not significantly (P>.05) different.

* H/U = Hereford/Unimproved
BXH/U = Brahman x Hereford/Unimproved
H/I = Hereford/Improved
BXH/I = Brahman x Hereford/Improved

Figure 10. Seasonal Activity and Abundance of Nymphal Lone Star Ticks on Brahman x Hereford and Hereford Cattle Pastured on Vegetatively Improved and Unimproved Study Units of Cherokee Wildlife Refuge, Oklahoma During June-August, 1981


HEREFORD/UNIMPROVED
BRAHMAN x HEREFORD/UNIMPROVED
HEREFORD/IMPROVED
BRAHMAN x HEREFORD/IMPROVED
MEAN NUMBER OF NYMPHAL LONE STAR TICKS/ANIMAL
30
27
24
21
18
15
12
9
6
3
10
24
2
9
16
23
30
6
13
JUNE
JULY
AUGUST
OBSERVATION DATES

cattle supporting 12.0 and 21.0 nymphs/animal, respectively.

Nymphal infestations on these cattle inhabiting the improved study units indicated that the Brahman x Hereford cattle supported significantly fewer nymphs than the Hereford cattle on all observation dates. Although nymphal infestation levels on Hereford cattle failed to indicate a definite peak in abundance, the highest number of nymphs was recorded on June 10 with 8.1 nymphs/animal. Thereafter, the Hereford cattle supported 5.0-7.7 nymphs/animal from June 24-August 13. The number of nymphs infesting the Brahman x Hereford cattle inhabiting the improved study unit increased from 2.7/animal on June 10 to a high of 6.0 nymphs/animal on July 16. Thereafter, nymphal numbers subsided to a low of 1.2 nymphs/animal on August 13.

Larvae. Lone star tick larvae were first observed on the Hereford and Brahman x Hereford cattle inhabiting the unimproved study units on July 9 with 16.0 and 0.1 larvae/animal, respectively (Figure 11). Similar to data recorded during 1980, larval infestation levels increased over time until they peaked in abundance during early-August. During this larval peak, Hereford cattle supported 105.0 larvae/animal and Brahman x Hereford cattle supported 60.9/animal.

The abundance of larvae on cattle inhabiting the improved study units was substantially reduced. Larvae were first observed on the Hereford cattle on July 9 with counts of 0.1 larvae/animal while initial detection of this life stage on the Brahman x Hereford cattle occurred one week later with 7.4 larvae/animal. Data indicated that the mean number of larvae infesting these cattle increased over time with peaks occurring in early-August. Infestation levels on August 13 were 48.5

TABLE VIII

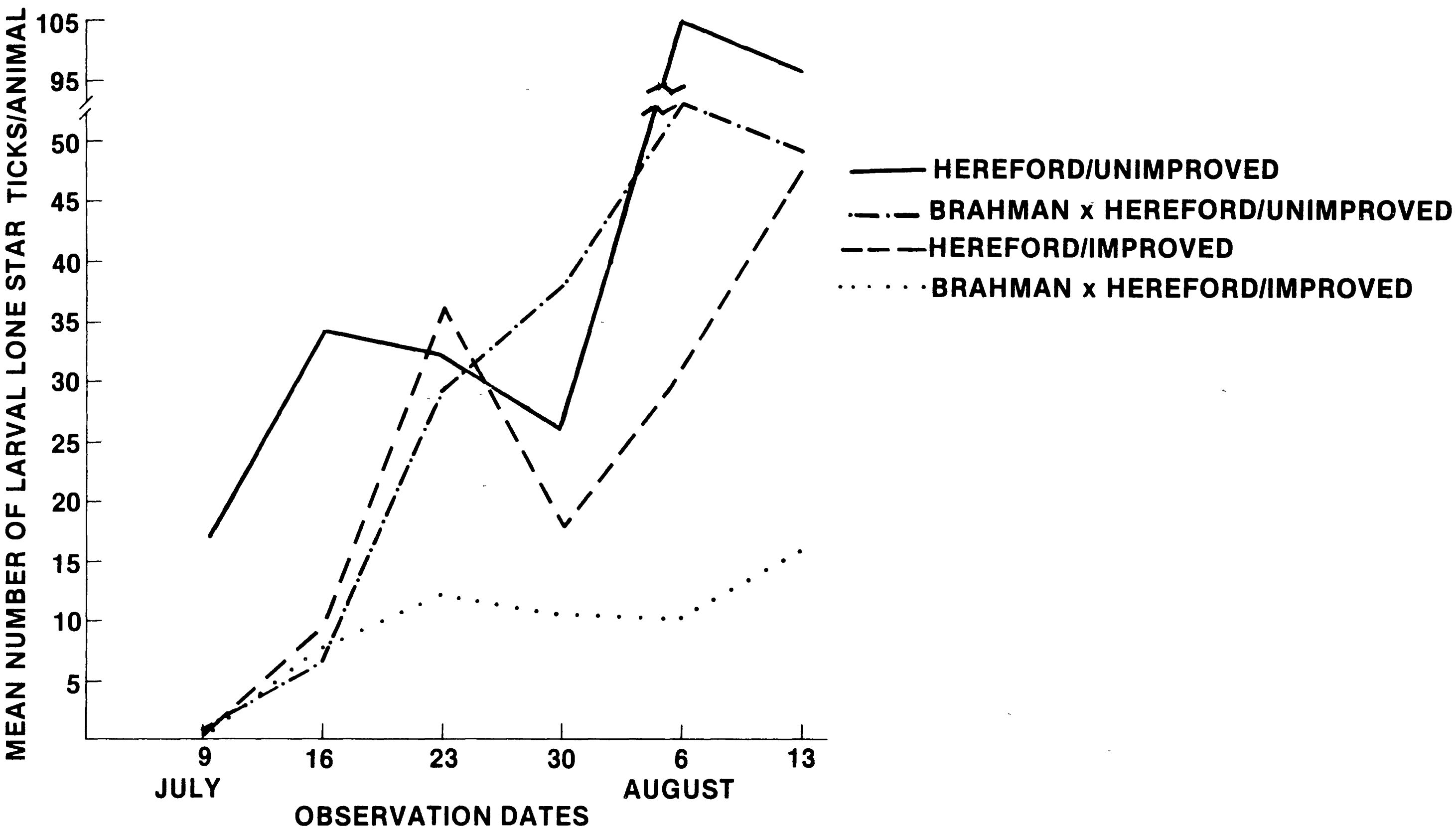
MEAN ($\bar{x}$) NUMBER OF LARVAL LONE STAR TICKS ON BRAHMAN X HEREFORD AND HEREFORD CATTLE PASTURED ON VEGETATIVELY IMPROVED AND UNIMPROVED STUDY UNITS OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1981[a]

	Cattle Breed/Study Unit*			
Date	H/U	BXH/U	H/I	BXH/I
July 9	16.0b	0.1a	0.1a	0.0a
16	34.1c	6.7a	9.9b	7.4ab
23	32.0bc	29.2b	36.0c	12.3a
30	26.5c	38.0d	18.5b	10.8a
Aug 6	105.0d	60.9c	31.2b	10.5a
13	96.0c	49.0b	48.5b	16.5a

[a] Numbers in rows within dates followed by the same letter are not significantly (P>.05) different.

* H/U = Hereford/Unimproved
BXH/U = Brahman x Hereford/Unimproved
H/I = Hereford/Improved
BXH/I = Brahman x Hereford/Improved

Figure 11. Seasonal Activity and Abundance of Larval Lone Star Ticks on Brahman x Hereford and Hereford Cattle Pastured on Vegetatively Improved and Unimproved Study Units of Cherokee Wildlife Refuge, Oklahoma During June-August, 1981


MEAN NUMBER OF LARVAL LONE STAR TICKS/ANIMAL
105
95
50
45
40
35
30
25
20
15
10
5
9
16
23
30
6
13
JULY
AUGUST
OBSERVATION DATES
HEREFORD/UNIMPROVED
BRAHMAN x HEREFORD/UNIMPROVED
HEREFORD/IMPROVED
BRAHMAN x HEREFORD/IMPROVED

and 16.5 larvae/animal for the Hereford and Brahman x Hereford cattle, respectively.

1982 Post-Treatment Observations

During 1982, periodic animal examination procedures indicated similar results to those recorded in 1981 (Tables IX-XI; Figures 12-14). These data indicated that the cattle inhabiting the improved study units supported significantly ($P<.05$) fewer lone star ticks than cattle inhabiting the unimproved study units. Data also showed that the Brahman x Hereford cattle within these study units were less susceptible to lone star tick infestation than the Hereford cattle inhabiting the same type of study units.

Adults. Examination of Hereford and Brahman x Hereford cattle inhabiting the unimproved study units indicated that adult abundance (Figure 12) was greater on the Hereford cattle. When sampling first began, the Hereford cattle were supporting 57.0 adults/animal compared with 21.0/animal on the Brahman x Hereford cattle. The adults peaked in abundance during May with a high of 80.3 and 30.3 adults/animal recorded for Hereford and Brahman x Hereford cattle, respectively. Adult lone star ticks declined in numbers as the season progressed and were found to have to subsided in early-August when both cattle breeds had $\leq$1.0 adults/animal.

The number of adults examined on Hereford and Brahman x Hereford cattle inhabiting the improved study units indicated a distinct peak in abundance during early-May. The highest number of adults sampled on these cattle was recorded on May 4 for the Hereford cattle and on May 18

TABLE IX

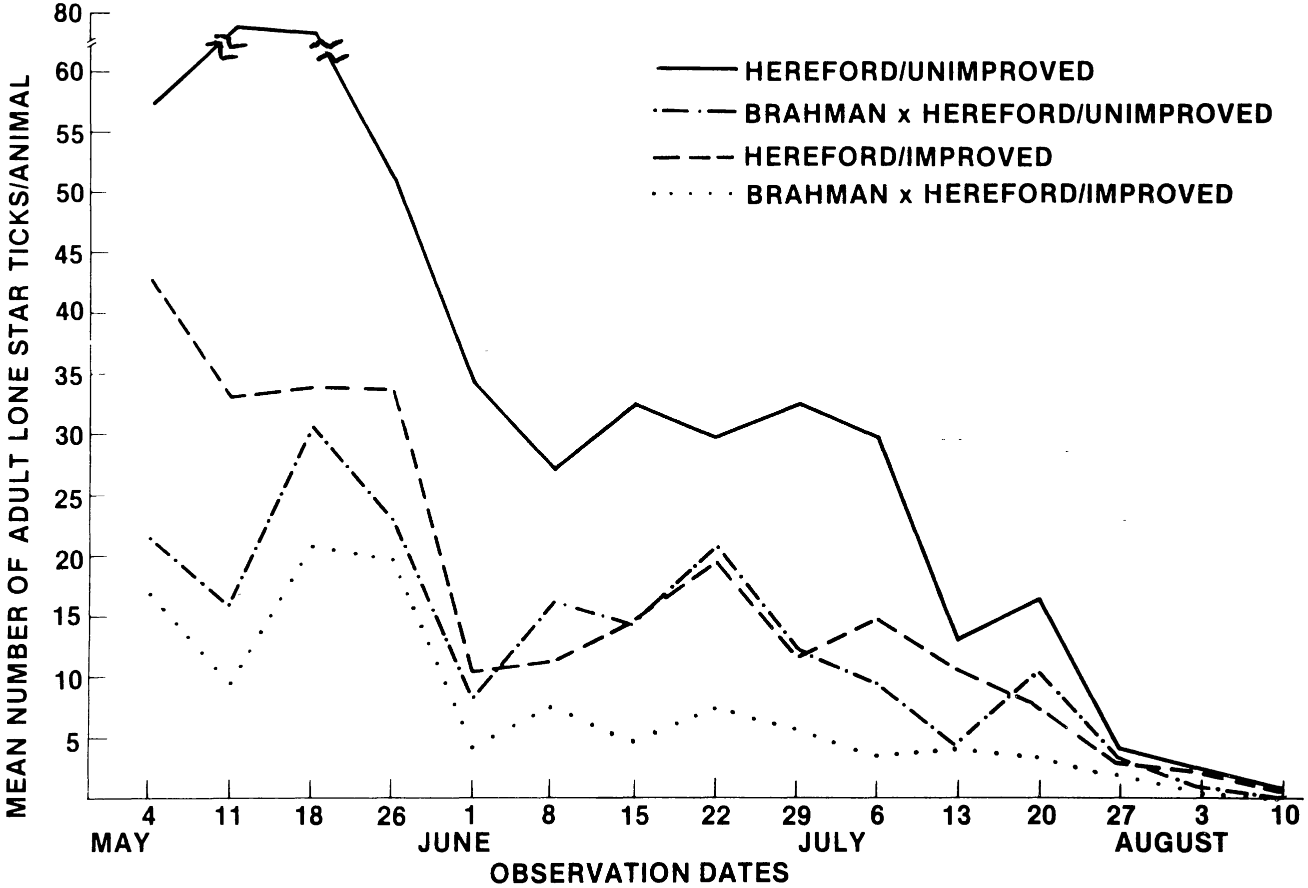
MEAN ($\bar{x}$) NUMBER OF ADULT LONE STAR TICKS ON BRAHMAN X HEREFORD AND HEREFORD CATTLE PASTURED ON VEGETATIVELY IMPROVED AND UNIMPROVED STUDY UNITS OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1982[a]

Date	Cattle Breed/Study Unit*			
	H/U	BXH/U	H/I	BXH/I
May 4	57.0d	21.0b	42.6c	16.6a
11	80.3d	15.5b	32.8c	9.0a
18	70.6d	30.3b	33.6c	20.5a
26	51.5d	22.8b	33.6c	19.6a
June 1	34.3c	8.0b	10.1b	4.1a
8	27.0d	16.1c	11.1b	7.0a
15	32.6c	14.3b	14.5b	4.5a
22	29.5c	20.8b	19.0b	7.3a
29	32.8c	12.0b	11.5b	5.5a
July 6	29.6d	9.5b	14.8c	3.6a
13	13.3c	4.1a	10.6b	4.1a
20	16.6d	10.6c	7.6b	3.3a
27	4.3a	3.5a	3.1a	2.0a
Aug 3	2.6a	1.3a	3.0a	0.5a
10	1.0a	0.3ac	1.0a	0.2a

[a] Numbers in rows within dates followed by the same letter are not significantly (P>.05) different.

* H/U = Hereford/Unimproved
BXH/U = Brahman x Hereford/Unimproved
H/I = Hereford/Improved
BXH/I = Brahman x Hereford/Improved

Figure 12. Seasonal Activity and Abundance of Adult Lone Star Ticks on Brahman x Hereford and Hereford Cattle Pastured on Vegetatively Improved and Unimproved Study Units of Cherokee Wildlife Refuge, Oklahoma During May-August, 1982



HEREFORD/UNIMPROVED
BRAHMAN x HEREFORD/UNIMPROVED
HEREFORD/IMPROVED
BRAHMAN x HEREFORD/IMPROVED
MEAN NUMBER OF ADULT LONE STAR TICKS/ANIMAL
80
60
55
50
45
40
35
30
25
20
15
10
5
4
11
18
26
1
8
15
22
29
6
13
20
27
3
10
MAY
JUNE
JULY
AUGUST
OBSERVATION DATES

for the Brahman x Hereford cattle. The Hereford cattle were supporting 42.6 adults/animal while the Brahman x Hereford cattle were supporting 20.5 adults/animal. Their abundance gradually declined following this period with the number of adults subsiding in early-August to 1.0 adults/animal on the Hereford cattle and <0.5 adults/animal on the Brahman x Hereford cattle.

Nymphs. Infestation patterns for lone star tick nymphs infesting Hereford and Brahman x Hereford cattle inhabiting the unimproved study units were similar (Figure 13), although the Hereford cattle generally supported a higher number of nymphs. Nymphal abundance was greater in early-May with a peak of 110.1 and 65.6 nymphs/animal recorded for Hereford and Brahman x Hereford cattle, respectively. Nymphal numbers declined beyond this period ranging from 30.0-80.5 nymphs/animal during June. The highest number of nymphs were observed on 15 and 22 June with Hereford cattle supporting 80.5 nymphs/animal and Brahman x Hereford cattle supporting 49.3 nymphs/animal, respectively. Further observations indicated that the number of nymphs subsided to 16.0 and 4.7 nymphs/animal for Hereford and Brahman x Hereford cattle, respectively.

Initial observations for the nymphal life stage on Hereford and Brahman x Hereford cattle inhabiting the improved study units indicated that the number of nymphs peaked on May 18 with both cattle breeds supporting ca 20.0 nymphs/animal. During the next four observation dates, nymphal abundance declined to <7.1 nymphs/animal, thereafter numbers increased to a high in late-June with 13.8 and 10.3 nymphs/animal recorded for Hereford and Brahman x Hereford cattle,

TABLE X

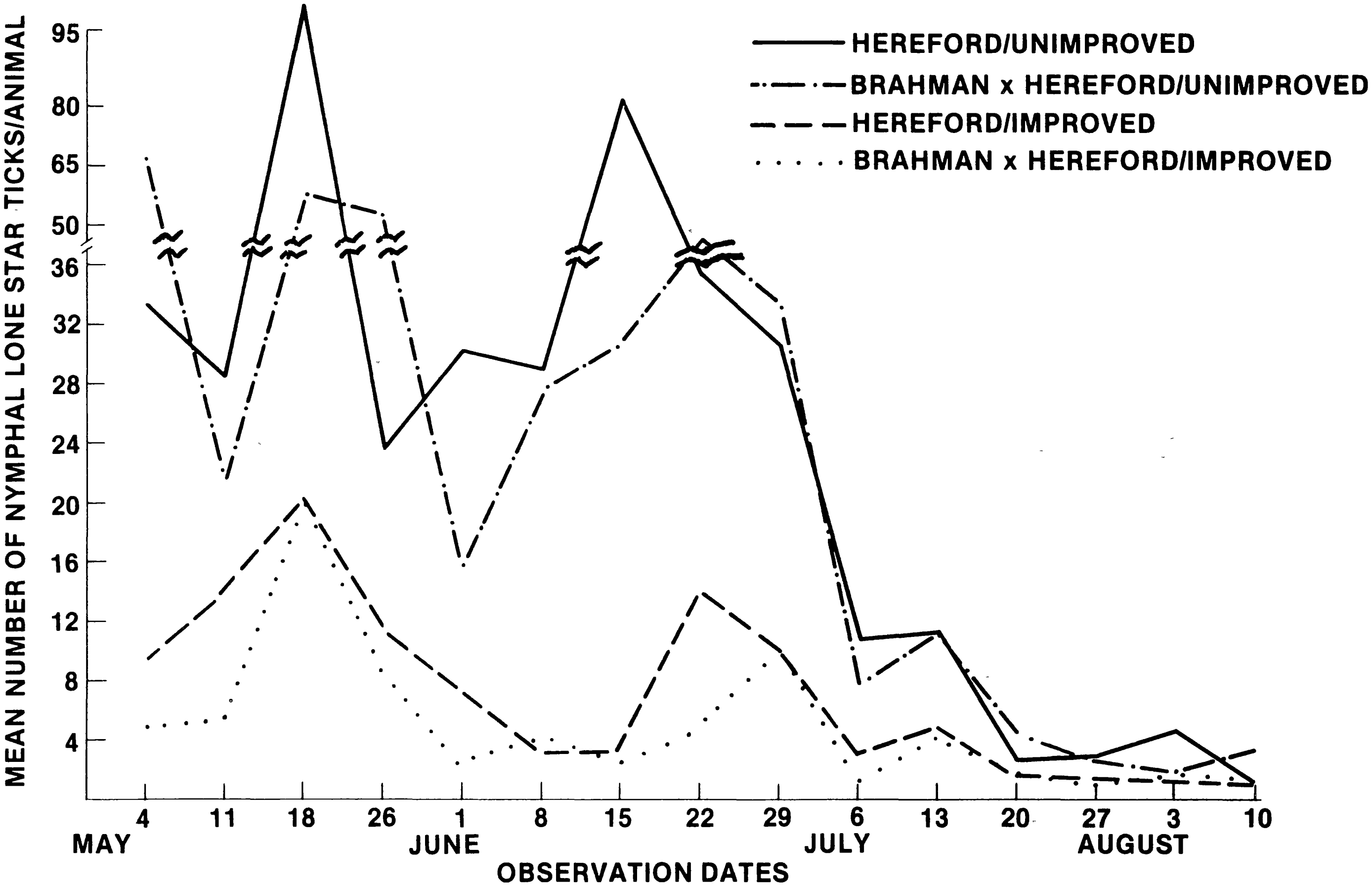
MEAN ($\bar{x}$) NUMBER OF NYMPHAL LONE STAR TICKS ON BRAHMAN X HEREFORD AND HEREFORD CATTLE PASTURED ON VEGETATIVELY IMPROVED AND UNIMPROVED STUDY UNITS OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1982[a]

Date	Cattle Breed/Study Unit*			
	H/U	BXH/U	H/I	BXH/I
May 4	33.5c	65.6d	9.6b	4.8a
11	28.5d	21.5c	14.1b	5.0a
18	110.1c	62.8b	20.0a	20.3a
26	23.6c	51.6d	11.6b	8.5a
June 1	30.1c	15.0b	7.1a	2.5a
8	29.0b	27.3b	3.1a	4.1a
15	80.5c	30.5b	3.3a	2.6a
22	35.3c	49.3d	13.8b	4.8a
29	30.8b	33.6b	9.8a	10.3a
July 6	10.5b	7.6b	3.1a	1.0a
13	11.3b	11.3b	4.8a	4.0a
20	2.6a	4.5a	2.8a	2.0a
27	2.8a	2.5a	0.8a	1.0a
Aug 3	4.6a	1.6ab	1.5a	1.5a
10	1.3a	3.1a	1.1a	1.1a

[a] Numbers in rows within dates followed by the same letter are not significantly ($P>.05$) different.

* H/U = Hereford/Unimproved
BXH/U = Brahman x Hereford/Unimproved
H/I = Hereford/Improved
BXH/I = Brahman x Hereford/Improved

Figure 13. Seasonal Activity and Abundance of Nymphal Lone Star Ticks on Brahman x Hereford and Hereford Cattle Pastured on Vegetatively Improved and Unimproved Study Units of Cherokee Wildlife Refuge, Oklahoma During May-August, 1982


HEREFORD/UNIMPROVED
BRAHMAN x HEREFORD/UNIMPROVED
HEREFORD/IMPROVED
BRAHMAN x HEREFORD/IMPROVED
MEAN NUMBER OF NYMPHAL LONE STAR TICKS/ANIMAL
95
80
65
50
36
32
28
24
20
16
12
8
4
4
11
18
26
1
8
15
22
29
6
13
20
27
3
10
MAY
JUNE
JULY
AUGUST
OBSERVATION DATES

respectively. Further observations showed that the nymphal infestation level subsided to 1.1 nymphs/animal for Hereford and Brahman x Hereford cattle inhabiting these improved study units.

Larvae. Lone star tick larvae (Figure 14) infesting Hereford and Brahman x Hereford cattle pastured on the unimproved study units were first detected in late-June for the Hereford cattle and early-July for the Brahman x Hereford cattle. The Hereford cattle were supporting 4.8 larvae/animal while 3.6 larvae/animal were recorded on the Brahman x Hereford cattle. Further examinations indicated that larval numbers rapidly increased to a peak during late-July with 98.1 and 36.1 larvae/animal recorded on the Hereford and Brahman x Hereford cattle, respectively. Numbers of larvae declined after this period to 68.0 and 12.3 larvae/animal on the Hereford and Brahman x Hereford cattle, respectively.

Larval infestations on these cattle inhabiting the improved study units were first noticed on June 29 with 3.6 and 4.1 larvae/animal recorded for Hereford and Brahman x Hereford cattle, respectively. Larval abundance rapidly rose to a peak of 51.6 larvae/animal for the Hereford cattle on July 27, however a suppressed peak in abundance was observed on the Brahman x Hereford cattle with numbers ranging from 8.3-9.1 larvae/animal. Following this period, larval numbers declined to 5.6 and 3.5 larvae/animal for Hereford and Brahman x Hereford cattle, respectively.

Influence of Habitat Modification, 1981-1982

Interpretation of the data collected during 1981 and 1982 indicated that the treatment strategies involving habitat modification had the

TABLE XI

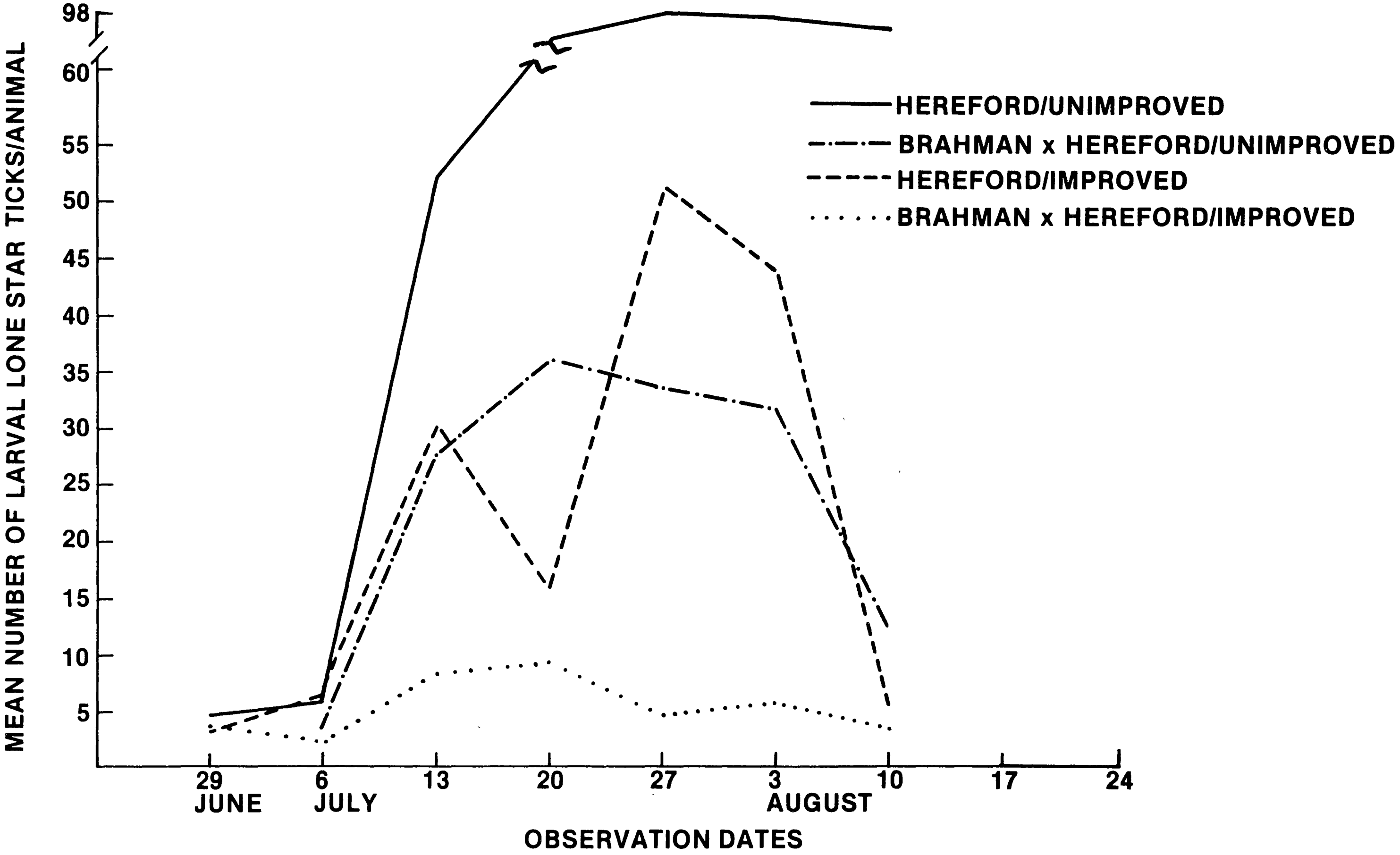
MEAN ($\bar{x}$) NUMBER OF LARVAL LONE STAR TICKS ON BRAHMAN X HEREFORD AND HEREFORD CATTLE PASTURED ON VEGETATIVELY IMPROVED AND UNIMPROVED STUDY UNITS OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1982[a]

	Cattle Breed/Study Unit*			
Date	H/U	BXH/U	H/I	BXH/I
June 29	4.8b	0.0a	3.6ab	4.1b
July 6	5.1a	3.6a	5.5a	2.6a
13	52.0c	27.5b	30.1b	8.3a
20	63.0d	36.1c	15.6b	9.1a
27	98.1d	33.5b	51.6c	4.5a
Aug 3	79.5d	31.6b	43.8c	5.5a
10	68.0c	12.3b	5.6a	3.5a

[a] Numbers in rows within dates followed by the same letter significantly (P>.05) different.

* H/U = Hereford/Unimproved
BXH/U = Brahman x Hereford/Unimproved
H/I = Hereford/Improved
BXH/I = Brahman x Hereford/Improved

Figure 14. Seasonal Activity and Abundance of Larval Lone Star Ticks on Brahman x Hereford and Hereford Cattle Pastured on Vegetatively Improved and Unimproved Study Units of Cherokee Wildlife Refuge, Oklahoma During May-August, 1982



MEAN NUMBER OF LARVAL LONE STAR TICKS/ANIMAL
98
60
55
50
45
40
35
30
25
20
15
10
5
HEREFORD/UNIMPROVED
BRAHMAN x HEREFORD/UNIMPROVED
HEREFORD/IMPROVED
BRAHMAN x HEREFORD/IMPROVED
29
JUNE
6
JULY
13
20
27
3
AUGUST
10
17
24
OBSERVATION DATES

most significant effect on the parasitic life stages infesting Hereford and Brahman x Hereford cattle (Tables VI-XI). Since mechanical alteration of existing vegetation significantly reduced the number of free-living lone star ticks, cattle inhabiting these improved study units would obviously have fewer lone star ticks than cattle on the unimproved study units, primarily because of the lower infestation pressure within these study units. This is most obvious in regard to lone star tick infestations on Hereford cattle inhabiting the improved and unimproved study units.

Improved vs Unimproved/Hereford. Comparing the effects of habitat modification in combination with Hereford cattle indicated that the Hereford cattle inhabiting the improved study unit supported significantly ($P<.05$) fewer lone star ticks than the cattle inhabiting the unimproved study unit during 1981 and 1982. During the peak in adult abundance, the Hereford cattle on the improved study unit supported 74 and 45% fewer adults than Hereford cattle on the unimproved study units during 1981 and 1982, respectively. Although there was a decline in abundance beyond this period, these cattle continued to support 45-47% fewer adults than the Hereford cattle on the unimproved study unit.

The effects of habitat modification on the nymphal population on these Hereford cattle were greater than that recorded for the adult stage. Hereford cattle on the improved study unit consistently supported fewer nymphs than those on the unimproved study unit. Examinations during the first nymphal peak in 1981 and 1982 indicated that the Hereford cattle pastured on the improved study unit supported

68 and 82% fewer nymphs respectively, than cattle on the unimproved study unit. These cattle continued to support fewer nymphs with reductions of 45-72% being recorded.

Infestations of larvae on these Hereford cattle indicated the cattle inhabiting the improved study unit supported fewer larvae than those on the unimproved study unit. These cattle generally supported one-half as many larvae as those on the unimproved study unit. However, at the beginning of the larval season during 1981 and at the end of the 1982 season, the Hereford cattle on the improved study unit had 99 and 92% fewer larvae respectively, than Hereford cattle on the unimproved study unit.

Improved vs Unimproved/Brahman x Hereford. The seasonal abundance of each life stage surveyed on the Brahman x Hereford cattle inhabiting the vegetatively improved and unimproved study units indicated that the effects of habitat modification were similar to those reported on the Hereford cattle. Observations during 1981 indicated that Brahman x Hereford cattle on the improved study unit were supporting ca 63% fewer larvae than those on the unimproved study unit. During 1982, observations in early-May indicated that these cattle supported 21-42% fewer adults than Brahman x Hereford on the unimproved study unit. The percent reduction increased after this period with 61% fewer adults surveyed on the Brahman x Hereford cattle inhabiting the improved study unit.

Differences in the nymphal population on these Brahman x Hereford cattle were greater than those reported for the Hereford cattle inhabiting the same type study units. The percentage reductions in the number of nymphs infesting these cattle during the first peak in abundance were 64 and 80% during 1981 and 1982, respectively. Further observations showed that the Brahman x Hereford cattle on the improved study unit continued to support 76-91% fewer nymphs than those on the unimproved study unit.

Comparisons between the larval infestations indicated that Brahman x Hereford cattle supported fewer larvae when pastured on the improved study unit. A reduction of 9% was observed during 1981 compared to a 28% reduction during 1982. Larval abundance increased over time and as a result, the percentage reduction in the number of larvae increased. Brahman x Hereford cattle on the improved study unit during 1981 and 1982 supported 82 and 77% fewer larvae respectively, than those cattle in the unimproved study unit.

Influence of Cattle Breed, 1981-1982

Evaluation of these data indicated that cattle breed had a great influence on the parasitic life stages of the lone star tick (Tables VI-XI). Results showed that the Brahman x Hereford cattle inhabiting the vegetatively improved and unimproved study units supported significantly ($P<.05$) fewer ticks than the Hereford cattle inhabiting the same type study units. Theoretically, this was due to the difference in susceptibility to lone star tick infestations as described by Garris (1979).

Brahman x Hereford vs Hereford/Unimproved. The greatest reductions in lone star tick infestations due to the effects of cattle breed were observed within the unimproved study units. Comparison of the data during 1981 and 1982 indicated that the Brahman x Hereford cattle inhabiting the unimproved study unit had a lower infestation of adults than the Hereford cattle on the unimproved study unit. These Brahman x Hereford cattle were supporting 64-68% fewer adults during the adult peaks in 1981 and 1982. These cattle continued to support 53-73% fewer adults than the Hereford cattle until early-August of 1981 when the Brahman x Hereford cattle had a higher number of adults. This was probably due to sample variation since adult counts were <3.0/animal.

The percentage reduction in the nymphal population was greater than that recorded for the adults. During the first peak in abundance, the Brahman x Hereford cattle on the unimproved study unit were supporting 73 and 43% fewer nymphs than the Hereford cattle during 1981 and 1982, respectively. Throughout the decline in abundance of the nymphal stage, the Brahman x Hereford cattle generally supported fewer nymphs than the Hereford cattle with reductions averaging 60% during 1981 and 34% during 1982.

Differences in the larval infestation levels indicated that the Brahman x Hereford cattle supported 99% fewer larvae than the Hereford cattle on July 9, 1981 and only 15% on June 29, 1982. As the season progressed the percentage difference decreased during 1981 and increased in 1982. During the peak in larval abundance, observations indicated that the Brahman x Hereford cattle on the unimproved study unit had 45-65% fewer larvae than the Hereford cattle on the same type study unit during both seasons. The largest difference was recorded in early-August of 1982 when 82% fewer larvae were infesting the Brahman x Hereford cattle.

Brahman x Hereford vs Hereford/Improved. Comparisons between Hereford and Brahman x Hereford cattle inhabiting the improved study units indicated that infestations of all life stages were significantly reduced. Data collected from these cattle showed that Brahman x Hereford cattle on the improved study unit supported 53-63% fewer adults than the Hereford cattle throughout 1981 and 1982. In early-August of both seasons, adult infestations were extremely low and therefore made it difficult to accurately determine differences due to cattle breed.

The effects of cattle breed on the nymphal population were similar to those recorded for the adult stage. Brahman x Hereford cattle on the improved study unit generally supported 50-66% fewer nymphs than the Hereford cattle. However, on several occasions during 1982 the Hereford cattle supported fewer nymphs than the Brahman x Hereford cattle due to sample variation.

Comparing the abundance of larvae infesting these cattle indicated that differences were similar to those reported for cattle inhabiting the unimproved study units. Data showed that Brahman x Hereford cattle supported fewer larvae than the Hereford cattle with the greatest differences occurring during peaks in larval abundance. During this period, these cattle supported 66 and 91% fewer larvae in 1981 and 1982, respectively.

Lone Star Tick Engorgement on Hereford and Brahman x Hereford Cattle, 1981

The estimated percentage female engorgement on Hereford and Brahman x Hereford cattle inhabiting each study unit indicated that differences between cattle breeds were not statistically significant, however

TABLE XII

MEAN ($\bar{x}$) LONE STAR TICK ENGORGEMENT OF HEREFORD AND BRAHMAN X HEREFORD CATTLE PASTURED ON THE VEGETATIVELY IMPROVED AND UNIMPROVED STUDY UNITS OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1981

Month	Cattle Breed/Study Unit*	% Female Repletion[a]	% Nymphal Repletion[b]	% Larval Repletion[b]
June	H/U	Unfed - 40	53	45
		A - 34		
		B - 18		
		C - 8		
	BXH/U	Unfed - 53	58	41
		A - 30		
		B - 7		
		C - 10		
	H/I	Unfed - 52	42	35
		A - 31		
		B - 9		
		C - 8		
	BXH/I	Unfed - 59	40	30
		A - 30		
		B - 8		
		C - 3		
July	H/U	Unfed - 31	58	49
		A - 38		
		B - 21		
		C - 10		
	BXH/U	Unfed - 41	62	37
		A - 37		
		B - 13		
		C - 9		
	H/I	Unfed - 44	45	39
		A - 33		
		B - 13		
		C - 10		
	BXH/I	Unfed - 53	36	33
		A - 34		
		B - 10		
		C - 3		

TABLE XII CONTINUED

Month	Cattle Breed/Study Unit*	% Female Repletion[a]	% Nymphal Repletion[b]	% Larval Repletion[b]
Aug	H/U	Unfed - 31	54	47
		A - 39		
		B - 18		
		C - 12		
	BXH/U	Unfed - 49	60	42
		A - 35		
		B - 10		
		C - 6		
	H/I	Unfed - 48	45	40
		A - 35		
		B - 8		
		C - 9		
	BXH/I	Unfed - 61	38	30
		A - 29		
		B - 6		
		C - 4		

* H = Hereford, BXH = Brahman x Hereford; U = Unimproved, I = Improved

[a] Letters represent stage of repletion beyond unfed female tick (Unfed≃<100mg, A≃100-200mg, B≃200-400mg, C≃>400mg)

[b] Nymphs and larvae attached were observed as being either unfed or replete

biological trends were evident (Table XII). Data showed that the percentage engorgement was greater for lone star ticks feeding on Hereford cattle, primarily because of the Hereford cattles' greater susceptibility as suitable lone star tick.

The Hereford cattle pastured on the unimproved study unit over the entire study period averaged 37% females at engorgement stage A, 19% at stage B and 10% at stage C. The percentage female engorgement on Brahman x Hereford cattle inhabiting the same type study unit measured engorgement stage A, B and C at 34, 10 and 8%, respectively. The trend for nymphal and larval repletion indicated that these Hereford cattle had 55% of the nymphs engorged and 47% of the larvae engorged. The percent nymphal and larval engorgement for the Brahman x Hereford cattle was 60 and 40% respectively.

When the degree of lone star tick engorgement was measured on the Hereford and Brahman x Hereford cattle pastured on the improved study units, data indicated that these cattle had fewer ticks engorging. The Hereford cattle on the improved study unit averaged 33% females at stage A, 10% at stage B and 9% at stage C. The Brahman x Hereford cattle had engorgement at stage A, B and C measured at 31, 8 and 3%, respectively. These Hereford cattle averaged 44 and 38% nymphal and larval engorgement respectively, while the Brahman x Hereford cattle averaged 38% nymphal engorgement and 31% larval engorgement.

Lone Star Tick Engorgement on Hereford and Brahman x Hereford Cattle, 1982

The estimated percent female engorgement on Hereford and Brahman x Hereford cattle inhabiting each study unit indicated similar results to those reported during 1981 (Table XIII). The Hereford cattle pastured on the unimproved study unit over the entire study period had females at engorgement stages A, B and C averaging 35, 13 and 8%, respectively. The Brahman x Hereford cattle on the same type study unit averaged 32% females at stage A, 11% at stage B and 5% at stage C. The trend for immature engorgement was also similar to that recorded in 1981 with these Hereford cattle averaging 48 and 41% nymphal and larval engorgement, respectively. The Brahman x Hereford cattle had the percent nymphal engorgement measured at 43% while the larval engorgement averaged 34%.

When these cattle were pastured on the improved study units, the percent female engorgement decreased. The Hereford cattle on the improved study unit averaged 31, 8 and 6% female engorgement for stages A, B and C respectively, compared with 31, 5 and 3% at stages A, B and C respectively, for the Brahman x Hereford cattle. The Hereford cattle averaged 45 and 36% engorgement for nymphs and larvae respectively, while the Brahman x Hereford cattle had nymphal engorgement measured at 37% and larval engorgement at 29%.

Interpretation of these data substantiate the findings of Stacey et al. (1978), Williams et al. (1977) and Garris (1979) who reported that Brahman x Hereford cattle supported fewer ticks than purebreed cattle and the biotic potential of female ticks feeding on these cattle was significantly reduced. The engorgement behavior of female lone star ticks recorded for Brahman x Hereford and Hereford cattle indicated that the breed of cattle had an effect on the ticks ability to take in blood. Since differences between cattle breeds were found, the use of Brahman x Hereford cattle in an integrated tick management program should reduce

TABLE XIII

MEAN ($\bar{x}$) LONE STAR TICK ENGORGEMENT OF HEREFORD AND BRAHMAN X HEREFORD CATTLE PASTURED ON THE VEGETATIVELY IMPROVED AND UNIMPROVED STUDY UNITS OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1982

Month	Cattle Breed/Study Unit*	% Female Repletion[a]	% Nymphal Repletion[b]	% Larval Repletion[b]
May	H/U	Unfed - 40	49	42
		A - 34		
		B - 17		
		C - 9		
	BXH/U	Unfed - 48	42	33
		A - 34		
		B - 12		
		C - 6		
	H/I	Unfed - 52	42	34
		A - 33		
		B - 10		
		C - 5		
	BXH/I	Unfed - 53	39	30
		A - 35		
		B - 8		
		C - 4		
June	H/U	Unfed - 40	45	39
		A - 40		
		B - 12		
		C - 8		
	BXH/U	Unfed - 52	41	31
		A - 30		
		B - 13		
		C - 5		
	H/I	Unfed - 54	46	38
		A - 30		
		B - 8		
		C - 8		
	BXH/I	Unfed - 61	35	34
		A - 31		
		B - 5		
		C - 3		

TABLE XIII CONTINUED

Month	Cattle Breed/Study Unit*	% Female Repletion[a]	% Nymphal Repletion[b]	% Larval Repletion[b]
July	H/U	Unfed - 52 A - 37 B - 13 C - 8	51	43
	BXH/U	Unfed - 54 A - 31 B - 10 C - 5	46	36
	H/I	Unfed - 58 A - 30 B - 7 C - 5	45	39
	BXH/I	Unfed - 63 A - 30 B - 4 C - 3	42	27
Aug	H/U	Unfed - 54 A - 29 B - 10 C - 7	47	40
	BXH/U	Unfed - 54 A - 33 B - 9 C - 4	43	36
	H/I	Unfed - 55 A - 31 B - 7 C - 7	47	33
	BXH/I	Unfed - 66 A - 28 B - 3 C - 3	32	25

* H = Hereford, BXH = Brahman x Hereford; U = Unimproved, I = Improved

[a] Letters represent stage of repletion beyond unfed female tick (Unfed≃<100mg, A≃100-200mg, B≃200-400mg, C≃>400mg)

[b] Nymphs and larvae attached were observed as being either unfed or replete

the future population of ticks by supporting fewer numbers and limiting their engorgement success.

ACARICIDES

Data in tables XIV and XV show the results of the field evaluation of the acaricides applied to the Brahman x Hereford and Hereford cattle pastured on the improved and unimproved study units during 1981. The experimental acaricide, Amitraz, was much more efficacious in controlling adult and nymphal lone star ticks than the registered acaricide, Delnav. This was thought to be due to the short residual commonly observed in most commercially available acaricides (Barnard and Jones 1981).

Delnav at a concentration of 0.125% provided 66 and 53% control of adult lone star ticks on Brahman x Hereford and Hereford cattle respectively, at one week post-treatment. This acaricide provided unsatisfactory control (<50% net control) at two weeks post-treatment with <20% control observed on these cattle.

The application of Amitraz to Brahman x Hereford and Hereford cattle pastured on these same unimproved study units provided satisfactory control (>50% net control) of adult lone star ticks for two weeks post-treatment. Amitraz at concentrations of 0.0125 and 0.0250% provided 85-87% control on Hereford cattle at one week post-treatment and 63-66% control at two weeks post-treatment. Thereafter, the efficacy began to diminish with ca 33 and 11% control obtained at three and five weeks post-treatment, respectively.

The effectiveness of Amitraz treatments applied to the Brahman x Hereford cattle pastured on the unimproved study unit was greater than

TABLE XIV

NET PERCENTAGE CONTROL OF ADULT LONE STAR TICKS ON ACARICIDE TREATED CATTLE PASTURED ON VEGETATIVELY IMPROVED AND UNIMPROVED STUDY UNITS OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1981

			Net % Control**				
		%	Wks Post-Treatment				
Breed/Study Unit*	Acaricide	Conc.	1	2	3	4	5
H/U	Delnav	0.1250	53	14	--	--	--
	Amitraz	0.0125	85	66	31	22	12
		0.0250	87	63	36	28	10
BXH/U	Delnav	0.1250	66	18	--	--	--
	Amitraz	0.0125	92	73	31	12	5
		0.0250	94	70	40	27	9
H/I	Amitraz	0.0125	94	78	38	40	12
		0.0250	100	97	57	46	41
BXH/I	Amitraz	0.0125	96	79	41	50	33
		0.0250	100	96	58	50	42

* H = Hereford, BXH = Brahman X Hereford, U = Unimproved, I = Improved

** Net % Control derived from modified Abbotts formula:

$$\text{Net \% Control} = \frac{\text{No. in control} - \text{No. in treatment}}{\text{No. in control}} \times 100$$

that recorded on the Hereford cattle inhabiting the same type study unit. Concentrations of 0.0125 and 0.0250% provided 92-94% control of adults at one week post-treatment and 70-73% control at two weeks post-treatment. Thereafter, <50% control was obtained with these treatment levels.

Amitraz treatments were most effective and had a greater longevity when applied to Brahman x Hereford and Hereford cattle pastured on the improved study units. Data also showed that the 0.0250% concentration provided satisfactory control one week longer than the 0.0125% concentration.

Examinations for lone star ticks on the Hereford cattle at one week post-treatment revealed that 94-100% control was obtained at these treatment levels and 78-97% control at two weeks post-treatment. At three weeks post-treatment only the 0.0250% concentration provided >50% control of adult lone star ticks. Thereafter, both treatment levels provided <50% control.

Amitraz treatments applied to the Brahman x Hereford cattle pastured on the improved study unit provided similar results as those reported for the Hereford cattle, however an additional one week post-treatment control was obtained. Observations at one week post-treatment revealed that 96 and 100% control of lone star tick adults was obtained at concentrations of 0.0125 and 0.0250%, respectively. These treatment levels continued to provide satisfactory control for ca four weeks post-treatment at which time 50% control was obtained.

The efficacy of Amitraz was greater on the immature stages of the lone star tick as shown in Table XV. Data also showed that a greater

TABLE XV

NET PERCENTAGE CONTROL OF NYMPHAL AND LARVAL LONE STAR TICKS ON ACARICIDE TREATED CATTLE PASTURED ON VEGETATIVELY IMPROVED AND UNIMPROVED STUDY UNITS OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1981

Breed/Study Unit*	Acaricide	% Conc.	Net % Control** Wks Post-Treatment 1	2	3	4
H/U	Amitraz	0.0125	95	81	20	19
		0.0250	100	95	30	23
BXH/U	Amitraz	0.0125	94	87	50	22
		0.0250	96	93	83	11
H/I	Amitraz	0.0125	96	88	82	40
		0.0250	100	94	91	51
BXH/I	Amitraz	0.0125	93	88	86	52
		0.0250	100	91	91	71

* H = Hereford, BXH = Brahman X Hereford, U = Unimproved, I = Improved

** Net % Control derived from modified Abbotts formula:

$$\text{Net \% Control} = \frac{\text{No. in control} - \text{No. in treatment}}{\text{No. in control}} \times 100$$

longevity occurred with treatments applied to the Brahman x Hereford and Hereford cattle pastured on the improved study units.

Amitraz treatments applied to the Hereford cattle inhabiting the unimproved study unit provided satisfactory control of nymphs and larvae for only two weeks post-treatment, whereas >50% control was obtained for three weeks post-treatment when applied to the Brahman x Hereford cattle. When Brahman x Hereford and Hereford cattle inhabiting the improved study units were treated, Amitraz at 0.0125% concentration provided >52% control on Brahman x Hereford cattle for four weeks post-treatment, however satisfactory control on the Hereford cattle was obtained for only three weeks post-treatment. Amitraz at 0.0250% concentration provided >50% control for four weeks post-treatment on both Brahman x Hereford and Hereford cattle.

Efficacy data for Amitraz in 1982 are shown in Tables XVI and XVII. Amitraz was most effective in controlling lone star ticks when applied to Brahman x Hereford and Hereford cattle inhabiting the improved study units. Data also showed that the effectiveness and longevity was greater for the Brahman x Hereford treatment cattle rather than the treated Hereford cattle.

The application of Amitraz to Brahman x Hereford and Hereford cattle inhabiting the unimproved study units provided satisfactory control of adult lone star ticks two weeks post-treatment. The effectiveness of Amitraz at 0.0125 and 0.025% concentrations applied to the Hereford cattle provided >97% control at one week post-treatment and 36-60% control at two weeks post-treatment. Further observations revealed that <30% control was obtained at both concentrations. Retreatment of these animals provided similar results with both

TABLE XVI

NET PERCENTAGE CONTROL OF ADULT LONE STAR TICKS ON ACARICIDE TREATED CATTLE PASTURED ON VEGETATIVELY IMPROVED AND UNIMPROVED STUDY UNITS OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1982

			Net % Control** Wks Post-Treatment								
Breed/Study Unit*	Acaricide	% Conc.	1	2	3	4	1	2	3	4	5
H/U	Amitraz	0.0125	97	36	10	5	89	59	16	23	3
		0.0250	98	60	27	9	95	78	36	45	17
BXH/U	Amitraz	0.0125	92	62	30	10	83	69	31	25	7
		0.0250	96	76	45	15	88	82	64	66	42
H/I	Amitraz	0.0125	96	79	52	12	94	75	50	21	29
		0.0250	98	80	54	15	98	84	51	32	11
BXH/I	Amitraz	0.0125	96	83	65	40	97	83	55	32	21
		0.0250	99	94	78	52	100	95	70	50	40

* H = Hereford, BXH = Brahman X Hereford, U = Unimproved, I = Improved

** Net % Control derived from modified Abbotts formula: $\frac{\text{No. in control} - \text{No. in treatment}}{\text{No. in control}} \times 100$

TABLE XVII

NET PERCENTAGE CONTROL OF NYMPHAL AND LARVAL LONE STAR TICKS ON ACARICIDE TREATED CATTLE PASTURED ON VEGETATIVELY IMPROVED AND UNIMPROVED STUDY UNITS OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1982

			Net % Control**						
		%	Wks Post-Treatment						
Breed/Study Unit*	Acaricide	Conc.	1	2	3	1	2	3	4
H/U	Amitraz	0.0125	92	49	9	88	47	30	5
		0.0250	99	64	16	91	56	35	15
BXH/U	Amitraz	0.0125	92	58	22	87	53	36	8
		0.0250	94	60	20	89	62	41	23
H/I	Amitraz	0.0125	91	60	20	93	61	32	11
		0.0250	94	68	45	90	76	40	21
BXH/I	Amitraz	0.0125	99	81	17	95	93	64	20
		0.0250	100	93	52	100	97	71	45

* H = Hereford, BXH = Brahman X Hereford, U = Unimproved, I = Improved

** Net % Control derived from modified Abbotts formula:

$$\text{Net \% Control} = \frac{\text{No. in control} - \text{No. in treatment}}{\text{No. in control}} \times 100$$

treatment levels providing >50% control. Similar results were obtained with Amitraz treated Brahman x Hereford cattle pastured on the unimproved study unit. Treatment at both concentrations provided >60% control of adults for two weeks post-treatment, however when these cattle were retreated the 0.0250% concentration provided >60% control for four weeks post-treatment.

The effectiveness of Amitraz treatments was greater when applied to cattle pastured on the improved study units. Concentrations of 0.0125 and 0.0250% provided >50% control of adult lone star ticks for three weeks post-treatment on the Hereford cattle. Retreatment of these animals provided essentially the same results. Amitraz treatments applied to the Brahman x Hereford cattle inhabiting the same type study unit provided >60% control of adults for three weeks post-treatment at a concentration of 0.0125% and >50% control for four weeks post-treatment at 0.0250% concentration. Similar results were obtained when these cattle were retreated.

In contrast to the 1981 data, the efficacy of Amitraz treatments on the immature life stages was not as great during 1982. Data showed that Amitraz treatments applied to Hereford cattle on unimproved and improved study units and to Brahman x Hereford cattle on the unimproved study unit provided >50% control of nymphs and larvae for only two weeks post-treatment. In comparison, Amitraz treatments applied to the Brahman x Hereford cattle inhabiting the improved study unit provided >50% control for three weeks post-treatment.

FORAGE YIELDS

An effective measurement of the economic value of pastureland is by its forage production and the performance of the livestock harvesting this forage. Animal performance is greatly influenced by its grazing preference, plant species present and dry matter yield.

The plant species surveyed from the unmanaged study area during 1980 revealed that a variety of native grasses, forbs and woody plants were available for livestock consumption (Table XVIII). Dry matter yields (Table XIX) indicated that an abundance of native grasses occurring in the study area accounted for ca 75% of the total forage produced. Of the native grasses, the tall grasses produced three times more forage than other grasses and grass-like plant species. The most abundant plant species were big bluestem, switchgrass and indiangrass. Forbs within the study area were relatively abundant with the most predominant species being lespedeza. Additionally, an enormous amount of woody plants were observed with blackjack oak, buckbrush and blackberry being most predominant.

The total amount of forage produced within the unmanaged study area during 1980 was 550 kg/ha. This represented a moderate yield for native pasture which resulted in a stocking rate of one animal unit/15-20 ha.

Forage production during 1981 and 1982 demonstrated a significant increase in the availability and amount of desirable forage for livestock utilization following forage improvement procedures. Fescue, ryegrass and arrowleaf clover were established in the cleared study units with great success. Fescue and ryegrass production was 450 and 525 kg/ha during 1981 and 1982 respectively, while the arrowleaf clover production was 2150 kg/ha in 1981 and 2275 kg/ha in 1982.

These data indicated that pasture forage improvement via fertilization and improved varieties resulted in increased amounts of

TABLE XVIII

PLANT SPECIES RECORDED IN THE VEGETATIVELY UNIMPROVED STUDY AREA OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1980

Scientific Name	Common Name
I. Grasses:	
Andropogon gerardi	Big bluestem*
Aristida sp.	Annual threeawn
Baptisia sp.	Wild indigo
Bouteloua gracilis	Blue grama*
Bromus sp.	Annual bromegrass
Bromus catharticus	Rescuegrass*
Carex sp.	Sedge
Cynodon dactylon	Bermudagrass*
Digitaria sanguinalis	Crabgrass*
Elymus canadensis	Canada wildrye*
Panicum virgatum	Switchgrass*
Panicum sp.	Rosette panicum
Schizachyrium scoparium	Little bluestem*
Sorghum halepense	Johnsongrass*
Sorghastrum nutans	Indiangrass*
Tridens flavus	Purpletop*
II. Forbs:	
Achillea lanulosa	Yarrow
Ambrosia psilostachya	Western ragweed
Aclepias sp.	Milkweed
Aster ericoides	Heath aster
Cassia fasciculata	Showy partridgepea
Cirsium sp.	Thistle
Erigeron strigosus	Daisy fleabane
Lespedeza cuneata	Lespedeza*
Parthenocissus sp.	Virginia creeper
Schrankia uncinata	Catclaw sensitivebrier*
Vernonia sp.	Ironweed
III. Woody Plants:	
Quercus marilandica	Blackjack oak
Rhus sp.	Sumac
Rubus sp.	Blackberry
Symphoricarpos orbiculatus	Buckbrush
Ulmus alata	Winged elm

* Indicates palatable plant species utilized for dry matter yield data.

TABLE XIX

FORAGE PRODUCTION AS REFLECTED BY DRY MATTER YIELDS (KG/HA) OF SPECIES CLASSES ON VEGETATIVELY IMPROVED AND UNIMPROVED STUDY UNITS OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1980, 1981 and 1982[a]

Species Class	1980	1981 Unimproved	1981 Improved	1982 Unimproved	1982 Improved
Grasses:					
Big bluestem	125	150	75	125	50
Little bluestem	125	100	50	125	50
Switchgrass	50	50	25	50	25
Indiangrass	25	50	25	50	25
Fescue/Ryegrass	0	0	450	0	525
Other	100	75	0	50	0
Forbs:					
Lespedeza	50	25	0	25	0
Arrowleaf clover	0	0	2275	0	2150
Other	75	50	0	50	0
TOTAL	550	500	2900	475	2825

[a] Total dry matter yields between improved and unimproved study units were significantly different ($P<.05$).

forage. Total forage production in the improved study units was ca 490% greater than production in the unimproved study units.

ANIMAL PERFORMANCE

The difference in forage production between improved and unimproved study units should result in an increase in animal performance due to the increased abundance of available forage and the apparent increase in the nutritional value of these improved varieties. Cumulative weight changes for control and Amitraz treated cattle inhabiting each study unit during 1981 and 1982 are shown in Tables XX and XXI.

These data indicated that lone star tick infestations affected the performance of Hereford and Brahman x Hereford cattle pastured on both types of study units. This was most obvious in regard to the significant trend in weight differences recorded between the control and treated animals.

During 1981, measurements of performance for Hereford and Brahman x Hereford cattle pastured on the unimproved study units indicated that the Amitraz treated cattle almost invariably gained more weight than the control cattle. The Hereford control animals exhibited a cumulative weight gain of 17.7 kg compared to 29.5 and 31.3 kg total weight gain for the 0.0125 and 0.0250% treatment animals, respectively. Data collected from the Brahman x Hereford cattle pastured on the same type study unit indicated that the control animals gained 15.0 kg weight and the Amitraz treated animals gained 16.3 and 26.3 kg weight.

Cumulative weight changes for the Hereford and Brahman x Hereford cattle inhabiting the improved study units indicated that the Hereford cattle exhibited higher weight gains than the Brahman x Hereford cattle.

TABLE XX

MEAN ($\bar{x}$) WEIGHT CHANGES (KG) OF CONTROL AND AMITRAZ® TREATED CATTLE PASTURED ON IMPROVED AND UNIMPROVED STUDY UNITS OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1981[a]

Breed/Study Unit*	Treatment (% Conc.)	Beginning Wt.	Ending Wt.	Cumulative Wt.[a]
H/U	Control	259.0	276.7	+17.7a
	0.0125	239.5	269.0	+29.5b
	0.0250	239.5	270.8	+31.3b
BXH/U	Control	230.4	245.4	+15.0a
	0.0125	227.7	244.0	+16.3a
	0.0250	227.7	254.0	+26.3b
H/I	Control	275.0	302.2	+27.2ab
	0.0125	281.3	305.8	+24.5a
	0.0250	254.5	286.7	+32.2b
BXH/I	Control	232.2	255.8	+23.6ab
	0.0125	219.5	239.9	+20.4a
	0.0250	209.0	235.3	+26.3b

[a] Weight changes within each breed followed by same letter are not significantly different ($P>.05$).

* H = Hereford, BXH = Brahman x Hereford, U = Unimproved, I = Improved

Hereford control animals had a total weight gain of 27.2 kg compared to weight gains of 24.5 and 32.2 kg for the 0.0125 and 0.0250% treatment animals. When the Brahman x Hereford cattle were monitored, the control animals were observed to have gained 23.6 kg while the 0.0125 and 0.0250% Amitraz treated animals gained 20.0 and 26.3 kg weight, respectively.

Observations during 1982 revealed similar results with significant differences in total weight gains occurring within treatments and between cattle breeds pastured on improved and unimproved study units (Table XXI). Measurements for Hereford and Brahman x Hereford cattle pastured on the unimproved study units demonstrated that the Amitraz treated cattle generally had higher total weight gains than the control cattle. The Hereford control animals exhibited a total weight gain of 34.0 kg compared to 45.0 kg for the treatment animals. The Brahman x Hereford cattle on this type study unit had a higher cumulative weight gain with the control animals gaining a total of 44.0 kg; whereas, the 0.0125 and 0.0250% treatment animals exhibited total weight gains of 49.5 and 60.9 kg, respectively.

Cumulative weight changes for Hereford and Brahman x Hereford cattle inhabiting the improved study units demonstrated that there were no significant differences within treatments, however Brahman x Hereford control animals had a higher total weight gain than the treated animals. Cumulative weight changes for the Hereford cattle were almost identical with treatment and control animals averaging 40.8-44.5 kg weight gained. The largest weight gains for the Brahman x hereford cattle pastured on the improved study unit were recorded from the control animals with a total weight gain of 66.4 kg. The treatment animals were observed to

TABLE XXI

MEAN ($\bar{x}$) WEIGHT CHANGES (KG) OF CONTROL AND AMITRAZ® TREATED CATTLE PASTURED ON IMPROVED AND UNIMPROVED STUDY UNITS OF CHEROKEE WILDLIFE REFUGE, OKLAHOMA, 1982[a]

Breed/Study Unit*	Treatment (% Conc.)	Beginning Wt.	Ending Wt.	Cumulative Wt.[a]
H/U	Control	253.1	287.1	+34.0a
	0.0125	273.1	317.6	+44.5b
	0.0250	264.5	309.9	+45.5b
BXH/U	Control	249.5	293.5	+44.0a
	0.0125	263.1	312.6	+49.5a
	0.0250	237.7	298.6	+60.9b
H/I	Control	253.1	293.9	+40.8a
	0.0125	255.9	300.4	+44.5a
	0.0250	268.1	309.9	+41.8a
BXH/I	Control	250.4	316.8	+66.4a
	0.0125	245.9	309.0	+63.1a
	0.0250	255.0	316.0	+61.0a

[a] Weight changes within each breed followed by same letter are not significantly different (P>.05).

* H = Hereford, BXH = Brahman x Hereford, U = Unimproved, I = Improved

exhibit similar weight changes with 61.0 and 63.1 kg total weight gained for 0.0250 and 0.0125% treatments, respectively.

Evaluation of the cumulative weight gains between Hereford and Brahman x Hereford cattle pastured on each study unit during 1981 and 1982 indicated that weight differences were greater for cattle pastured on the unimproved study units rather than those on the improved study unit. This was thought to be due to the theoretical increase in the nutritional level of cattle inhabiting the improved study units in combination with reduced tick infestation levels which precluded any effects due to lone star tick parasitism. Also, data collected between and within treatments indicated that Amitraz treated cattle gained more weight than untreated cattle and Brahman x Hereford cattle generally had higher total weight gains than Hereford cattle.

Comparisons between Hereford and Brahman x Hereford cattle pastured on the unimproved study units revealed that the Brahman x Hereford control animals had cumulative weight gains 13 and 29% higher than the Hereford control animals during 1981 and 1982, respectively. The utilization of acaricides on these cattle demonstrated that the treated Hereford cattle gained 65% more weight than Brahman x Hereford treated cattle during 1981. However, during 1982 the Brahman x Hereford treated cattle gained 23% more weight than the treated Hereford cattle.

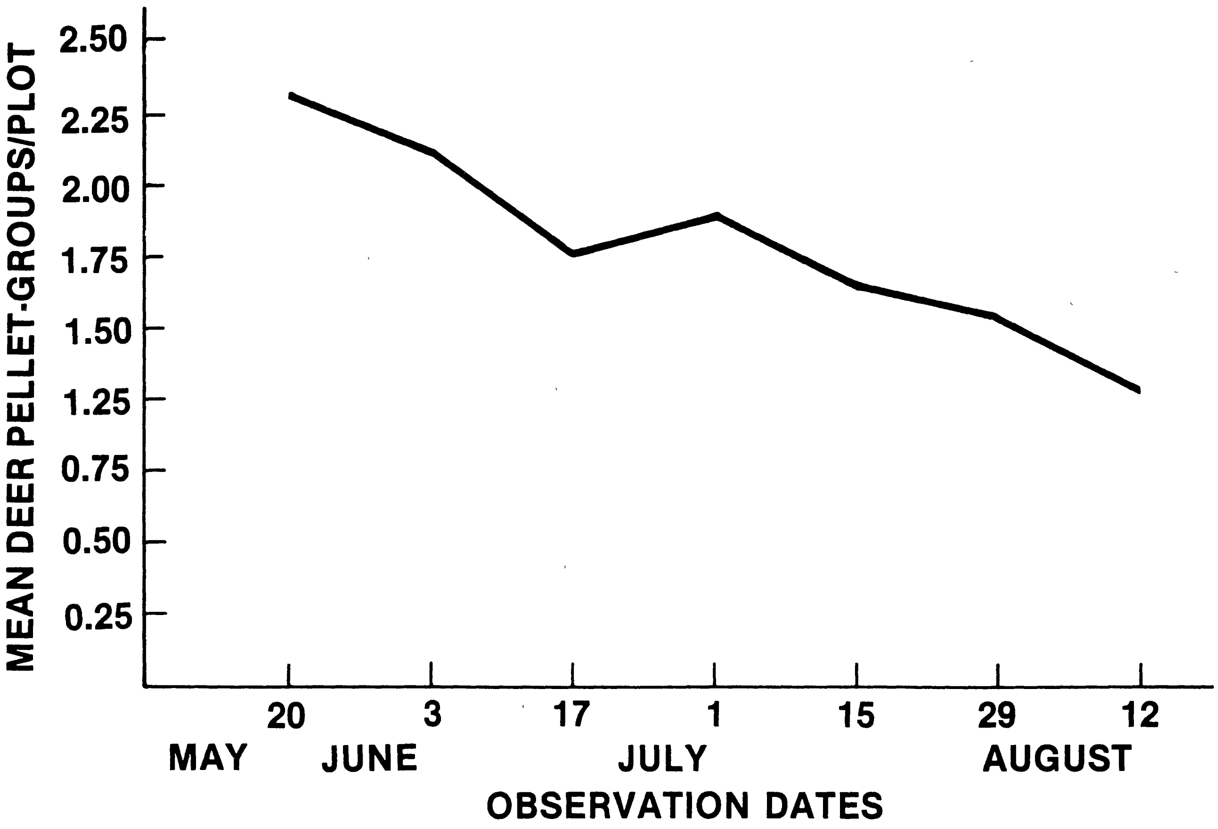
Data recorded for these cattle inhabiting the improved study units indicated that the Hereford control cattle gained 15% more weight than the Brahman x Hereford controls during 1981, however the Brahman x Hereford control cattle gained 63% more weight than the Hereford control cattle during 1982. Similarly, the treated Hereford cattle exhibited a 21% higher weight gain than the Brahman x Hereford treated animals during 1981, and during 1982 the Brahman x Hereford treated animals gained 41% more weight than the treated Hereford cattle.

Comparing the cumulative weight gains for the Hereford cattle inhabiting both the improved and unimproved study units revealed that the control animals on the improved study unit exhibited a 53 and 23% increase in weight gains compared to the control animals on the unimproved study unit during 1981 and 1982, respectively. However, treated Hereford cattle on the unimproved study unit had a 25 and 4% higher weight gain respectively, than those on the improved study unit. When Brahman x Hereford cattle were utilized on these same type study units, similar results were obtained. Brahman x Hereford control animals on the improved study unit had a total weight gain 18 and 30% higher than that recorded for the control animals on the unimproved study unit during 1981 and 1982, respectively. Total weight gains for the treated cattle indicated that these differences were reduced to ca 10%.

WILDLIFE UTILIZATION

White-tailed deer utilization within the unmanaged study area during 1980 is shown in Figure 15. Pellet-group survey data demonstrated that the heaviest deer usage was in areas of ecotones where a variety and abundance of food and wildlife cover was available. The frequency of use was greatest during May when a greater variety and abundance of young, succulent herbage and browse was present within the study area. The highest number of deer pellet-groups (2.3 pellet-groups/plot) were observed on May 20 when sampling first began. The frequency of utilization by deer steadily declined after this period as a result

Figure 15. Mean (x) Number of Deer Pellet-Groups Sampled in the Vegetatively Unimproved Study Area of Cherokee Wildlife Refuge, Oklahoma During May-August, 1980 .


MEAN DEER PELLET-GROUPS/PLOT
2.50
2.25
2.00
1.75
1.50
1.25
0.75
0.50
0.25
20
3
17
1
15
29
12
MAY
JUNE
JULY
AUGUST
OBSERVATION DATES

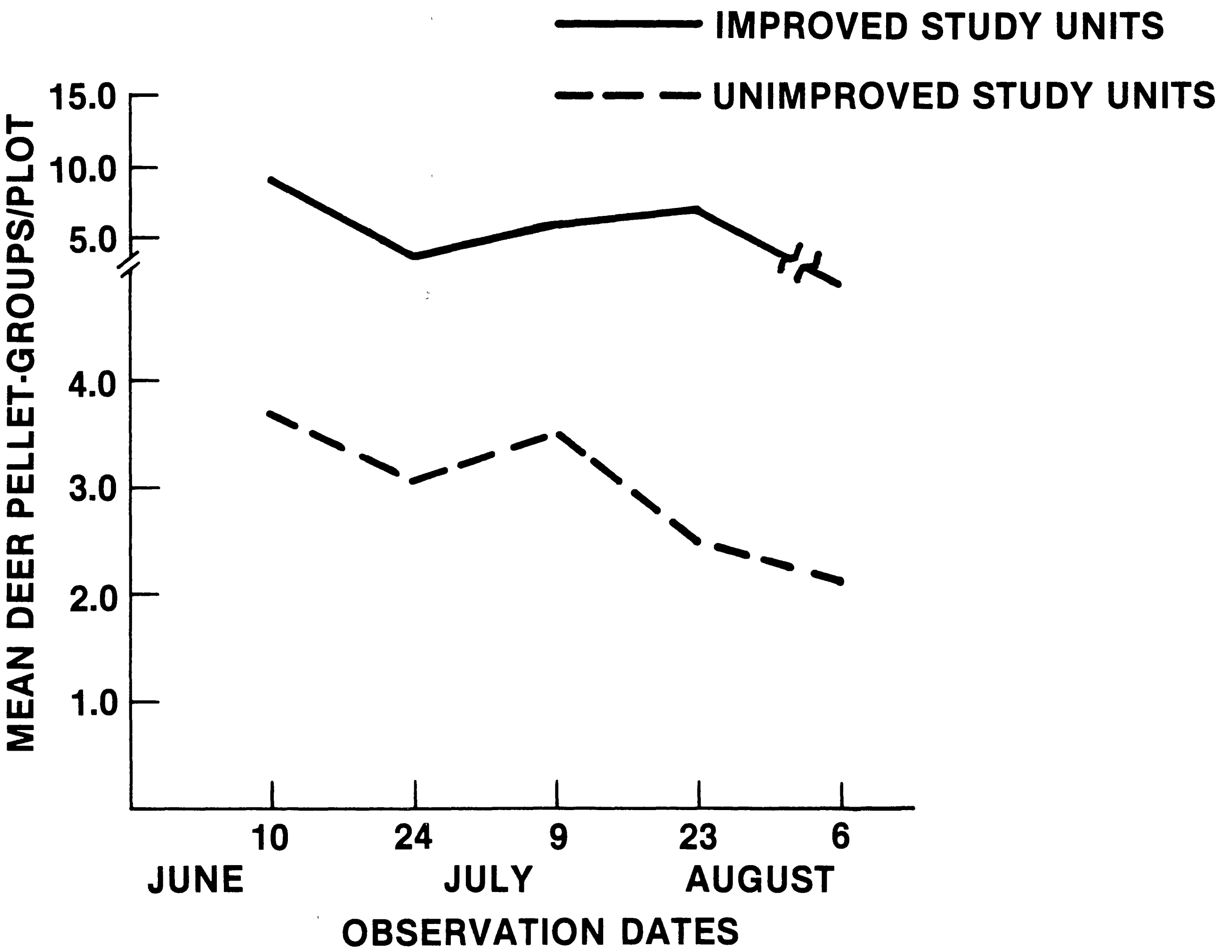
of the apparent seasonal changes in the source and growth of deer food. During this period, the mean number of pellet-groups sampled from this study area dropped to a low of 1.28 pellet-groups/plot on August 12.

Diversity of habitat is necessary for successful management of deer populations and where this is lacking, a system of clearings and pasture forage improvement techniques could provide "edges" and diversity of food species. The most obvious evidence for this was observed during 1981 and 1982 when habitat modification procedures were employed.

The frequency of white-tailed deer utilization within the improved and unimproved study units during 1981 and 1982 is shown in Figures 16 and 17. Analysis of data demonstrated significant differences ($P<.05$) in deer usage between these study units for both years. Deer pellet-groups within the unimproved study units were sampled primarily from ecotonal habitats located adjacent to the arrowleaf clover fields in the bordering improved study units. These areas which were between the open fields and tree-lined edges provided excellent cover for deer and thus, the frequency of use increased. In contrast, the frequency of deer utilization in the improved study units was greatest in and around the arrowleaf clover fields. These areas were frequented most during the early part of the season when the arrowleaf clover was at a young, succulent growth stage. As the clover began to mature to the flowering stage, the frequency of deer-use was reduced.

During 1981, sampling first began on June 10 at which time the mean number of pellet-groups sampled from the unimproved study units was 3.7 pellet-groups/plot. Thereafter, further observations revealed that deer-use patterns steadily declined with pellet-group counts on August 3

Figure 16. Mean (x) Number of Deer Pellet-Groups Sampled in the Vegetatively Improved and Unimproved Study Units of Cherokee Wildlife Refuge, Oklahoma During June-August, 1981


IMPROVED STUDY UNITS
UNIMPROVED STUDY UNITS
MEAN DEER PELLET-GROUPS/PLOT
15.0
10.0
5.0
4.0
3.0
2.0
1.0
10
24
9
23
6
JUNE
JULY
AUGUST
OBSERVATION DATES

averaging 2.2 pellet-groups/plot.

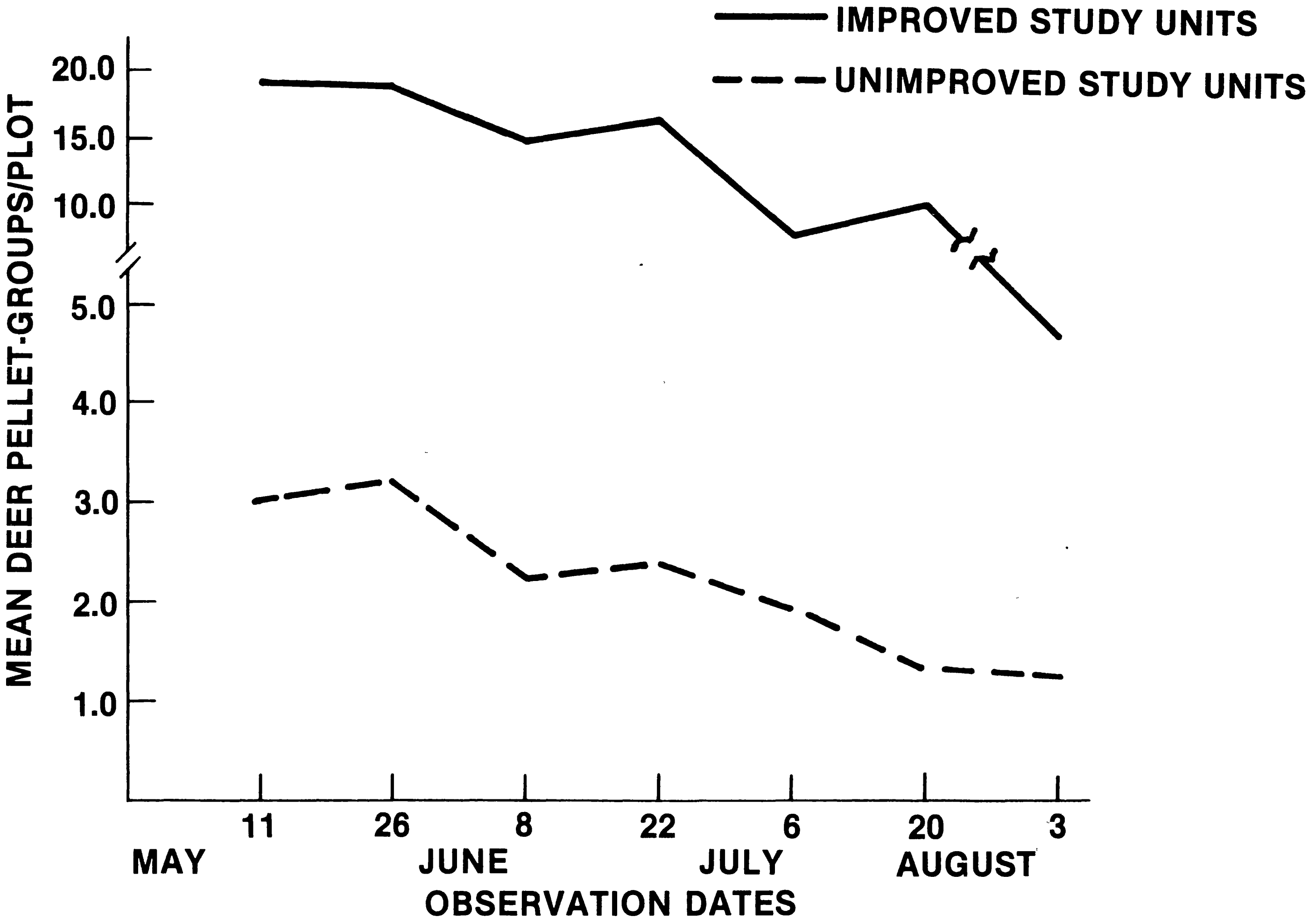
A similar trend was observed in the improved study units, however the frequency of utilization by deer was greater as demonstrated by an increase in deer-pellet group counts of 122-144%. Deer frequented these study units throughout the season with the highest usage observed on June 10. During this period, 9.0 pellet-groups/plot were recorded. Further observations from June 24-August 6, demonstrated a decline in deer utilization with pellet-group counts averaging 5.5 pellet-groups/plot.

Deer utilization patterns within these study units during 1982 closely resembled those reported for 1981. Sampling procedures were initiated one month earlier and as a result, deer usage in the improved study units was much higher.

Although regrowth of brushy vegetation within the improved study units was prevented, the pasture forage improvement, especially arrowleaf clover, had a great influence on the frequency of white-tailed deer utilization. Deer-use within the unimproved study units was greatest during May when 3.0-3.3 pellet-groups/plot were recorded. Deer utilization after this period, gradually declined with <1.4 pellet-groups/plot sampled in late-July and early-August.

The frequency of deer utilization within the improved study units was significantly ($P<.05$) higher than usage within the unimproved study units. On May 11, a six-fold increase in deer use was observed with pellet-group counts averaging 19.0/plot. Deer utilization remained high throughout the season with pellet-group counts ranging from 7.5-18.0 groups/plot. On August 3, deer-use had decreased by 50% with a mean low of 4.7 pellet-groups/plot recorded from these study units.

Figure 17. Mean (x) Number of Deer Pellet-Groups Sampled in the Vegetatively Improved and Unimproved Study Units of Cherokee Wildlife Refuge, Oklahoma During May-August, 1982


IMPROVED STUDY UNITS
UNIMPROVED STUDY UNITS
MEAN DEER PELLET-GROUPS/PLOT
20.0
15.0
10.0
5.0
4.0
3.0
2.0
1.0
11
26
8
22
6
20
3
MAY
JUNE
JULY
AUGUST
OBSERVATION DATES

A definite correlation between the frequency of wildlife utilization of specific plant communities and tick abundance seem to exist (Hair, 1982). Since the frequency of deer-use significantly increased in the improved study units, it was anticipated that the lone star tick population would also increase. However, this did not occur because any theoretical increase in the number of ticks introduced within the improved study units were more apt to be dropped in the areas exposed to increased sunlight penetration and eventually perished due to a lack of favorable habitat.

CHAPTER V

SUMMARY AND CONCLUSIONS

An integrated management program for the lone star tick, *Amblyomma americanum* (L.) on cattle was initiated in the Cherokee Wildlife Refuge, Cherokee County, Oklahoma. Combinations of management strategies against lone star ticks entailing: (1) habitat modification, (2) pasture forage improvement, (3) Brahman crossbreeding of cattle and (4) selective use of acaricides were evaluated individually and collectively to determine their value in an integrated tick management program.

An assessment of lone star tick activity and abundance was conducted utilizing two evaluation procedures. Free-living, host-seeking life stages of this tick were monitored by systematically sampling the study units with CO_2 baited traps. This procedure was synchronized with animal examination counts of parasitic life stages of this tick on cattle.

The influence of these management components against lone star ticks were evaluated with regard to the effects on populations of the free-living and parasitic life stages within the management areas and animal health and performance in comparison to the management system. In addition, forage production and the frequency of white-tailed deer utilization within the management area were monitored.

The results of these management strategies substantiate earlier studies (Wharton et al. 1969, Hoch et al. 1971) which indicated that lone star tick control was obtained with habitat modification and utilization of resistant cattle. Habitat modification of the study units by mechanical and chemical means produced a microenvironment unsuitable for lone star tick development, activity and survival. As a result of 85-90% overstory reduction and elimination of undesirable regrowth of brush and broadleaf plants, an increase in sunlight penetration theoretically caused higher temperatures and lower humidities to occur within the ticks' microenvironment. Consequently, a reduction in the free-living and parasitic life stages as well as an increase in the productive capacity of the pastureland was realized.

When the free-living, host-seeking life stages of the lone star tick were monitored, the study units receiving habitat modification yielded significantly fewer ticks than the wooded study units. Comparisons between these study units when Hereford cattle were utilized, demonstrated that the improved study unit yielded 88-94% fewer lone star ticks than the unimproved study unit. With Brahman x Hereford cattle inhabiting these study units, results demonstrated that the improved study unit supported 75-91% fewer ticks than the unimproved study unit.

Evaluating the effect of cattle breed on each study unit revealed that habitat modification in combination with Brahman x Hereford cattle had the greatest influence on the free-living lone star tick population. The utilization of Brahman x Hereford cattle within the unimproved study units, resulted in a 35-45% reduction in the lone star tick population compared to the utilization of Hereford cattle. The number of lone star ticks collected from the improved study units demonstrated that the study unit pasturing Brahman x Hereford cattle supported 26-43% fewer ticks than the study unit pasturing Hereford cattle.

As a result of this vegetative alteration and utilization of Brahman x Hereford cattle, the parasitic life stage population was greatly affected. Periodic examination of cattle inhabiting these study units demonstrated that cattle pastured on the improved study units supported significantly fewer lone star ticks than those on the unimproved study units.

Hereford cattle pastured on the unimproved study unit without an application of acaricides were found to support the highest population of lone star ticks. If the effects due to habitat modification are measured, we find Hereford cattle on the improved study unit to support 60% fewer lone star ticks than Hereford cattle on the unimproved study unit.

The utilization of Brahman x Hereford crossbreed cattle as a management factor demonstrated significant differences in the susceptibility to lone star tick infestations. Brahman x Hereford cattle pastured on the unimproved study unit were found to support 55-65% fewer lone star ticks than Hereford cattle on the unimproved study unit. If these Brahman x Hereford cattle are pastured on improved study units, we find that they support 50-60% fewer ticks than Hereford cattle on the improved study unit and 70-80% fewer lone star ticks than Brahman x Hereford cattle pastured on the unimproved study unit. Consequently, with regard to the success and fecundity of lone star ticks, Brahman x Hereford cattle reduced the population of ticks available for re-infestation by suppressing the biotic potential and thereby the survival of this species.

Brahman x Hereford cattle inhabiting the improved study unit were supporting an average of <20 lone star ticks/animal which indicated that resistance to lone star tick infestations was not sufficient to disregard completely the necessity to use acaricides. However, Brahman x Hereford cattle on the improved study unit required less frequent application of Amitraz than the Hereford cattle. Therefore, to aid in reducing the biotic potential and future re-infestation pressures, acaricides applied to these animals as a spray were capable of providing two-four weeks control post-treatment. This approach has definite advantages since the use of acaricides and the possibility of developing acaricide-resistant strains is reduced. In addition, tick control is achieved with less handling of cattle.

Forage transect surveys demonstrated the complexity of grasses and forbs present within the study units. Availability and abundance of desirable plants was determined with dry matter yields of native grasses and forbs within the unimproved study units being moderately low, ranging from 475-500 kg/ha. This represented an estimated carrying capacity of one animal unit/15-20 ha. A considerable and significant increase in forage production was demonstrated in the improved study units. Fescue and ryegrass yields ranged from 450-525 kg/ha while the arrowleaf clover production was 2150-2275 kg/ha. This five-fold increase in forage production represented an increase in the carrying capacity to one animal unit/5 ha.

Animal performance as reflected by weight gains, within these study units demonstrated that treatment cattle exhibited higher cumulative weight gains than untreated cattle. Comparisons between Hereford and

Brahman x Hereford cattle on improved and unimproved study units demonstrated that Brahman x Hereford cattle gained 23-68% more weight than the Hereford cattle with the exception the Hereford cattle had a 15-21% higher total weight gain than the Brahman x Hereford cattle during 1981. In comparing the difference in weight gains within cattle breeds pastured on improved and unimproved study units, it became apparent that cattle pastured on the improved study units gained more weight than those on the unimproved study units. With Brahman x Hereford cattle, those on the improved study unit had cumulative weight gains 10-30% higher than those on the unimproved study unit; whereas, the difference for Hereford cattle was 23-53%. The failure to demonstrate significantly higher cumulative weight gains within treatments for Hereford and Brahman x Hereford cattle pastured on improved study units was disappointing. However, there is little doubt that the reduced tick infestations and increased forage quantity resulted in higher weight gains.

The frequency of white-tailed deer utilization within each study unit was greatest during early-May when available forage and browse was immature and actively growing. Survey data revealed that deer frequented the improved study units much more than the unimproved study units. Comparison of this data demonstrated that deer pellet-groups sampled from the improved study units were 122-144% greater than deer pellet-groups sampled from the unimproved study units, primarily because of the presence of arrowleaf clover.

The livestock industry in most of the Ozark Mountain region is represented by producers pasturing susceptible English breeds of cattle in a woodlot situation. Depending on the producers management regimen, these cattle generally receive inadequate treatment for lone star ticks.

Although current recommendations for lone star tick control on livestock have been shown to effectively reduce and control severe infestations, the feasibility and practicality of these treatment regimens have not been demonstrated. The implementation of an IPM program for lone star ticks offers an approach which could potentially solve many of the problems associated with current control methods.

Based on the data collected from this integrated approach for management of the lone star tick, susceptible Hereford cattle pastured on the vegetatively unimproved study area supported the highest number of lone star ticks. Mean infestation levels ranged from 200-300 lone star ticks/animal throughout the season. As a result of this infestation, the performance of these animals reflected by total weight gained was the lowest recorded during these studies. The application of the acaricide, Amitraz, was 85-95% effective against lone star ticks. However, satisfactory control (>50% net control) was obtained for only two weeks post-treatment. These treated cattle exhibited an increase in total weight gained of 25-50% compared to the untreated cattle.

When these Hereford cattle were pastured on a vegetatively improved study unit yielding 80-90% fewer free-living lone star ticks, the effects of habitat modification reduced the parasitic population by ca 65%. And as a result, these cattle had a total weight gain which was ca 20-25% more than those pastured on the unimproved study unit. With the application of acaricides, satisfactory control of lone star ticks was obtained for three weeks post-treatment. This resulted in a 10-15% increase in weight gained compared to the untreated cattle.

The utilization of Brahman x Hereford cattle as a management factor for lone star ticks indicated a significant difference in the susceptibility to lone star tick infestations. Brahman x Hereford cattle pastured on the unimproved study area supported 55-65% fewer lone star ticks than the Hereford cattle on the same type study area. The cumulative weight gains for these cattle were ca 29% higher than weight gains for the Hereford cattle. The application of acaricides to these Brahman x Hereford cattle provided satisfactory control of lone star ticks for two weeks post-treatment. The performance of these Amitraz treated cattle was 38-70% greater than the untreated cattle.

If these Brahman x Hereford cattle are pastured on an improved study area, one finds that they support 70-80% fewer lone star ticks than the Brahman x Hereford cattle on the unimproved study area and 40-60% fewer than the Hereford cattle on the improved study unit. As a result, these cattle gained 45% more weight than the Brahman x Hereford cattle on the unimproved study area and an increase of 60% compared to the Hereford cattle on the improved study unit. The application of acaricides to these cattle provided satisfactory control of lone star ticks for up to four weeks post-treatment. As a result, these cattle gained ca 15% more weight than the treated Brahman x Hereford cattle on the unimproved study area and 40% more than the Hereford cattle on the same type study unit.

It is evident, that integrated approaches significantly reduce and control all life stages of the lone star tick. Since habitat conditions are unfavorable for tick development and survival, and Brahman x Hereford cattle limit the success and reproductive potential of lone star ticks, enduring control of lone star ticks can be achieved under a management regimen using Brahman x Hereford cattle with only an occasional application of acaricides.

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VITA

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