C46.2:T43
PSU#

no

Final Report

On

CONTROL OF TICKS TO INCREASE THE
TOURISM AND RECREATIONAL
POTENTIAL OF TICK INFESTED AREAS

Submitted to

U. S. DEPARTMENT OF COMMERCE
ECONOMIC DEVELOPMENT ADMINISTRATION
CONTRACT # 7-35268

By

B. Howell
Project Coordinator

J. Alexander Hair
Project Director

DEPARTMENT OF ENTOMOLOGY

OKLAHOMA STATE UNIVERSITY

STILLWATER, OKLAHOMA

"This technical assistance study was accomplished by professional consultants under contract with the Economic Development Administration. The statements, findings, conclusions, recommendations, and other data in this report are solely those of the Contractor and do not necessarily reflect the views of the Economic Development Administration."

Final Report

On

CONTROL OF TICKS TO INCREASE THE
TOURISM AND RECREATIONAL
POTENTIAL OF TICK INFESTED AREAS

Submitted to

U. S. DEPARTMENT OF COMMERCE
ECONOMIC DEVELOPMENT ADMINISTRATION

CONTRACT # 7-35268

By

Project Coordinator

Project Director

DEPARTMENT OF ENTOMOLOGY
OKLAHOMA STATE UNIVERSITY
STILLWATER, OKLAHOMA

"This technical assistance study was accomplished by professional consultants under contract with the Economic Development Administration. The statements, findings, conclusions, recommendations, and other data in this report are solely those of the Contractor and do not necessarily reflect the views of the Economic Development Administration."

TABLE OF CONTENTS

	Page
I INTRODUCTION	1
II LONE-STAR TICK CONTROL STUDIES	4
A. Chemical, Mechanical and Integrated Methods for Tick Control in Recreation Areas	4
B. A Comparison of the Efficacy of Gardona ^R Formulations as Acaracides	12
C. The Potential Role of Animal Exclusion in Tick Control	16
D. Deer Herd Treatment as an Aid in Area Tick Control	19
E. Integrated Control Methods Involving Cattle as "Mop-up" Organisms	26
F. Useage and Treatment Costs Estimates on Existing Recreation Areas	29
III LONE-STAR TICK BIOLOGICAL STUDIES	33
A. Seasonal Activity of Lone-Star Ticks in Eastern Oklahoma and it's Importance in Control Procedures	33
B. Detrimental Effects of Lone-Star Ticks on White-tailed Deer Populations	35
C. Hosts of Ticks in Eastern Oklahoma	40
D. The Relationship of <u>Amblyomma americanum</u> to Vegetation in Cookson Game Refuge, Cherokee County, Summer 1968.	45
IV SUMMARY AND CONCLUSIONS	48

Digitized by the Internet Archive
in 2012 with funding from
LYRASIS Members and Sloan Foundation

LIST OF FIGURES

Figure		Page
1	TEN THOUSAND REACHING HANDS. Several thousands of larval ticks await anxiously for a warm body to brush the blade of grass that they cling to.	2
2	Average numbers of adult and larval ticks occurring in woodland areas receiving an acaracide, a herbicide or no treatment during 1968	9
3	Average numbers of adult and larval ticks occurring in woodland areas receiving either clearing and acaracide, clearing and herbicide, clearing only, or no treatment during 1968	10
4	Average numbers of nymphal ticks occurring in woodland areas receiving clearing and acaracide, clearing and herbicide, acaracide only, or no treatment during 1968.	11
5	Comparative control of lone-star tick larvae in partially cleared woodland areas receiving an acaracide or either an acaracide followed by the application of an animal repellent.	17
6	White-tailed deer visiting feed boxes containing a bait and a systemic insecticide for tick control	20
7	Box-trap in "set" position. This device is used in the live-trapping and examining of white-tailed deer during the evaluation of tick control procedures	22
8	A deer is restrained while an estimate of the parasites present is made	23
9	A calf prepares to leap into an eight-foot-deep insecticidal bath.	27
10	An infrequently used camping area such as this photo shows, normally requires twice the tick control efforts that a "well" established park requires	30

LIST OF FIGURES
(Cont.)

Figure		Page
11	Seasonal distribution of various stages of the lone-star tick (<u>Amblyomma americanum</u>) in Cherokee County, Oklahoma during 1968	34
12	Part of 1300 nymphs and adults infesting a three-week-old deer fawn in the Cookson Hills Game Refuge, Summer 1968	36
13	A deer fawn totally blinded as a result of tick attachment near and around the eyes	37
14	Freshly killed deer are examined for ectoparasites during a survey to determine tick distribution and prevalence	41

LIST OF TABLES

Table		Page
1	Larval counts and percent change in tick populations at simulated recreational areas following chemical and cultural - mechanical treatment. Counts represent number of larval ticks per 225 square feet of surface area.	5
2	Percent control of lone-star ticks obtained in plots receiving mechanical, chemical, and mechanical - chemical control methods	7
3	Average number of larvae per sample and percent change in tick populations in areas treated with five formulations of Gardona ^R during 1967 and 1968. Average represents number of seed ticks per 225 square feet of surface area	14
4	Average number of ticks present on deer receiving either no treatment, or Ronnel ^R , and degree engorgement of attached ticks, Cookson Hills Refuge, Summer 1968.	21
5	Percent mortality of nymphal and seed ticks collected from treated or untreated deer in Cookson Hills Game Refuge, Summer 1968.	24
6	Monthly visitations at eight recreation areas involved in <u>A Tick Control Demonstration</u> on Tenkiller Ferry Reservoir, Summer 1968	31
7	Estimated costs for controlling ticks and chiggers on 125 acres of semi-wooded recreation area (Tenkiller State Park) in eastern Oklahoma during six summer months, 1968	32
8	Number of fawns collected from the Cookson Hills Wildlife Refuge during June and July, 1968, their physical condition and degree of infestation with lone-star ticks.	39
9	Numbers and relative abundance of several species of ticks on various animals collected in Cherokee County, Oklahoma, 1967 and 1968.	42

LIST OF TABLES
(Cont.)

Table		Page
10	The range, average number, and species composition of ticks parasitizing white-tailed deer in five eastern Oklahoma refuges, Fall 1967 and 1968.	44
11	Total number of ticks collected from four vegetative types in sample area number one, June - September, 1968.	46

I

INTRODUCTION

INTRODUCTION

Eastern Oklahoma has very rapidly developed into one of the leading water vacationlands in the United States. Few other states have the vast mileage of beautiful picturesque lake shore-line found in eastern Oklahoma. Fishermen, hunters, campers, water-lovers, sight-seers; there's recreation for anyone, anytime of the year.

Eastern Oklahoma should be a vacationer's paradise - but it is not ! ! !

Perhaps there are a number of reasons why tourists do not spend more time in Oklahoma, but it's a fairly safe bet that ticks play a very important part in dictating what tourists do while they are here. During most of the summer months land activity is almost totally restricted in many areas for many pest conscious adventurers (Figure 1) . Many areas are so heavily infested with ticks that laborers cannot properly carry on their duties. Few recreationists will tolerate such conditions and consequently tourists do not return from year to year.

Over the past 18 months the Department of Entomology at Oklahoma State University, working under USDC Contract No. 7-35268, has been actively engaged in tick control demonstrations on State or Federally operated recreation lands in eastern Oklahoma. By operating on public lands, efforts spent could be immediately effective in encouraging tourism and providing better utilization of the entire area.

At the present time it is the general consensus of all responsible informed citizens in eastern Oklahoma that ticks perhaps constitute the most important limiting factor to the growth of this area of Oklahoma and to the entire Ozark region. During the past year and one-half we have watched campers, fishermen and picnickers hurriedly retreat from tick infested recreation areas; we have seen domestic and wild animals succumb to the ravages of this arthropod pest; and we have had dozens of citizens ask for help in ridding their premises of these pests. We have also observed recreationist occupying nearly 1,000 acres of tick and chigger free recreation areas on the beautiful shores of Tenkiller and Greenleaf Lakes in eastern Oklahoma. We have watched our efforts spark local, state and national attempts to devise means by which the tick burden can be overcome. Numerous state and national agencies have asked advice on approaches to be taken in setting up tick abatement districts over these past few months. Southeastern State College in Durant, Oklahoma currently is planning research work on ticks in their area, and are being joined by the National Forest Service in southeastern Oklahoma and southwestern Arkansas.

Figure 1. TEN THOUSAND REACHING HANDS - Several thousands of larval ticks await anxiously for a warm body to brush the blade of grass that they cling to.

Tick abatement efforts in Oklahoma now seems to be receiving the support of hundreds ! There is but little doubt that it will take years of devotion on the part of communities, counties, the State, and the Federal Government before eastern Oklahoma's ticks will cease to create problems for man and beast.

State and Federally supported projects such as this Tick Control Demonstration Project will be of tremendous value in formulating and demonstrating solutions to this aged problem of citizens of the Ozark region.

The support of many public officials who have given freely of their time and efforts is gratefully acknowledged. Senators Harris, Monroney and Bellmon, Representatives Carl Albert and Ed Edmundson, State Senator Hamilton, and a host of others are due special thanks. The support of the entire State Legislature is very greatly appreciated.

Many organizations in Oklahoma have been very helpful in the execution of this program and it is difficult to single out any for special praise but the devoted work of Oklahoma North-East, Cherokee Rural Coordination and Development, Oklahoma Department of Wildlife Conservation and others must be cited.

The kind assistance and advice of the following members of the Oklahoma Department of Wildlife Conservation are greatly appreciated: Joe Fletcher, Foreman Carlile, O. Cy Curtis, Bill Scherman, Wendell Bever, Farrell Copelin, and others.

II

LONE-STAR TICK CONTROL STUDIES

A. CHEMICAL, MECHANICAL AND INTEGRATED METHODS FOR TICK CONTROL IN RECREATION AREAS

In this series of demonstrations, efforts were made to properly evaluate various chemical, mechanical and integrated control methods for tick control in recreational areas. It was hoped that a practical and economical solution for tick control could be derived and that a list of recommendations formulated which would aid supervisors of recreation areas in reducing tick populations to tolerable levels.

These demonstrations included the field evaluation of a chemical compound which could be used safely around recreation areas while providing adequate and long-lasting control, and the evaluation of cultural and mechanical measures as immediate and long-term approaches to tick control.

Demonstration areas were established in the Cherokee Wildlife Refuge, Cherokee County on July 15, 1967. Areas were especially selected for their isolation on restricted lands and the enormous tick populations available to work with. Three areas in the refuge were involved in these demonstrations and each of the three test areas consisted of six, one-acre plots, or experimental units.

Individual plots in each area received one of the following treatments: (1) mechanical clearing of all undergrowth and enough of the larger vegetation to allow penetration of sunlight, (2) mechanical clearing with the addition of an acaricide (1 pound Gardona^R per acre), (3) mechanical clearing with the addition of a herbicide (Esteron^R at recommended rate for basal bark treatment), (4) application of an acaricide to existing vegetation and ground cover, (5) application of a herbicide to existing vegetation, and (6) no treatment.

The theory behind treatments involving mechanical or chemical removal of vegetation was that if the ecosystem, or microhabitat, of the tick was unfavorably altered, the pest would soon succumb to the elements. This theory is based on our limited knowledge of the temperature and humidity requirement of this arthropod. Theoretically, the addition of a pesticide to these cleared areas should rapidly reduce the tick population and the unfavorable environment should suppress future generations.

The three test areas were located within a one-mile radius, but differed considerably as to terrain, tick reinfestation pressure, etc. Area one was open woodland, area two, creek bottom subject to creek overflow, and area three was dense woodland bottom with heavy animal activity.

Table 1. Larval counts and percent change in tick populations at simulated recreational areas following chemical and cultural-mechanical treatment. Counts represent number of larval ticks per 225 square feet of surface area.

Weeks post-treatment	T r e a t m e n t					
	Clear + 8447	Clear + 245-T	Clear	8447	245-T	Control
	No. of Larvae/% Change					
0	316/---	411/---	269/---	705/---	101/---	540/---
1	0/-100 ^a	124/-70	109/-60	0.2/-100	21/-80	547/+1 ^b
2	8/-97	53/-87	152/-45	10/-99	65/-35	64/-88
3	66/-79	3/-92	107/-60	16/-98	96/-4	513/-5
4 ^c	0/-100	323/-21	19/-93	56/-92	38/-63	111/-79

^a (-) = Decrease

^b (+) = Increase

^c Excludes Mackey Crossing counts

In preliminary tests during 1967 the acaricide and herbicide was applied with hand equipment. During 1968 studies, hand sprayers were used to apply herbicide in touch-up procedures, but high-pressure vehicle-towed power sprayers were used in the application of the acaricide. Vehicle mounted sprayers allowed large acreages to be covered fairly rapidly and effectively.

Preliminary results (Table 1) indicated that an acaricide, when applied to the existing woodland or to simulated recreation areas as a wettable powder, gave excellent control of larval ticks for a period of more than a month. Clearing an area, or clearing with the addition of an herbicide also showed some promise as a means of tick reduction.

Follow-up studies on all experimental areas were made during the summer of 1968. These results appear in Table 2 and Figures 2, 3 and 4. As can be seen in Figures 2, 3 and 4, only the treatments involving the application of an acaricide directly to the existing vegetation were effective in satisfactorily controlling adult lone-star ticks in areas of high reinfestation pressure. Unfortunately, test areas selected were subjected to unnatural, extremely high animal activity. This was due to the fact that following clearing procedures, manually or with chemicals, lush grasses and/or browse plants appeared throughout the experimental areas as a result of light

penetration to the forest floor. This abundance of tender vegetation quickly attracted large numbers of cattle, deer, rabbits, etc., which subjected the test area and its entire surroundings to unnatural animal activity. Considering these findings we can safely say that under normal circumstances it would probably require only one application of Gardona^R at one pound per acre to effectively control adult lone-star ticks throughout their spring and early summer activities.

We do notice a peak of nymphal tick activity as adult populations begin to decline about the middle of June. As a result it might be necessary, under rare circumstances to make an application of pesticide for nymphal control at this time. The necessity of such an application would probably arise only in areas not well established (i.e., our simulated recreation areas which were only one and one-half years old, or newly established parks).

Control measures against larval ticks must be taken near the end of June or the first of July since the application of a short lived pesticide for adults earlier in the season would probably no longer be effective. Under most circumstances a single application of Gardona^R would yield satisfactory results for the balance of the tick season. Again, under heavy pressure a second application of pesticide for larval control may be necessary.

One could generally expect that an application of Gardona^R at the beginning of the adult season and an application at the beginning of the larval season would maintain ticks at a tolerable level in most established resort areas.

If the reader is referred to several other phases of this work (Useage and Treatment Costs Estimates) it can be shown that when the applications are properly timed, two applications of Gardon^R at the rate of one pound per acre, or less, are sufficient to control the normal tick burden in most established recreation areas throughout the summer.

Table 2. Percent^a control of lone-star ticks obtained in plots receiving mechanical, chemical, and mechanical-chemical control methods.

		Cleared & Acaricide	Cleared & Herbicide	Cleared	Acaricide	Herbicide
Date						
4-15	L ^b	0	0	0	0	0
	N ^b	100%	* ^c	100%	50%	0
	A ^b	100%	*	100%	*	*
	T ^b	100%	*	100%	*	17%
4-30	L	*	*	0	0	0
	N	74%	*	*	82%	100%
	A	87%	0	16%	64%	89%
	T	78%	*	*	75%	*
5-28	L	0	0	0	0	0
	N	96%	75%	21%	89%	63%
	A	100%	*	84%	90%	57%
	T	97%	54%	26%	90%	62%
6-7	L	0	0	0	0	0
	N	81%	48%	49%	93%	37%
	A	74%	3%	*	67%	15%
	T	81%	44%	44%	91%	35%
6-17	L	0	0	0	0	0
	N	99%	77%	29%	99%	71%
	A	100%	64%	48%	92%	28%
	T	99%	76%	31%	99%	67%
6-28	L	97%	88%	100%	75%	71%
	N	99%	93%	*	99%	*
	A	100%	77%	46%	85%	*
	T	97%	89%	16%	79%	*
7-9	L	*	*	47%	*	55%
	N	100%	47%	55%	97%	*
	A	78%	*	100%	89%	*
	T	*	2%	48%	*	*
7-23	L	74%	6%	38%	62%	39%
	N	100%	91%	*	100%	*
	A	100%	100%	100%	100%	*
	T	75%	7%	37%	63%	34%

Table 2. Cont.

		Cleared & Acaricide	Cleared & Herbicide	Cleared	Acaricide	Herbicide
8-1	L	98%	64%	48%	100%	37%
	N	97%	78%	50%	100%	*
	A	100%	68%	68%	100%	0
	T	98%	64%	48%	100%	31%
8-19	L	99%	68%	57%	88%	38%
	N	90%	98%	70%	95%	97%
	A	0	0	0	0	0
	T	99%	69%	57%	89%	40%
8-26	L	93%	85%	46%	78%	32%
	N	95%	88%	90%	78%	87%
	A	*	0	0	0	0
	T	93%	85%	47%	78%	33%
9-5	L	99%	94%	58%	96%	17%
	N	95%	*	95%	92%	53%
	A	0	0	0	0	0
	T	99%	91%	59%	96%	18%
9-21	L	97%	99%	99%	98%	95%
	N	88%	*	100%	88%	25%
	A	0	0	0	0	0
	T	97%	99%	99%	98%	95%
10-6	L	98%	80%	80%	100%	100%
	N	100%	100%	100%	100%	100%
	A	0	0	0	0	0
	T	98%	80%	80%	100%	100%
10-20	L	96%	86%	78%	100%	61%
	N	0	0	0	0	0
	A	0	0	0	0	0
	T	96%	86%	78%	100%	61%
11-4	L	100%	100%	100%	98%	100%
	N	100%	100%	100%	100%	100%
	A	0	0	0	0	0
	T	100%	100%	100%	99%	100%

^a Percent net control calculated by a modification of Abbott's formula:

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

^b Larvae, nymphs, adults, combined total.

^c (*) Represents higher populations in treatment than control.

Fig 2. Average number* of adult and larval ticks occurring in woodland areas receiving an acaricide, a herbicide or no treatment during 1968.

*Estimates represent average numbers of ticks occurring in twelve 75 x 3 ft areas

Fig 3 Average numbers* of adult and larval ticks occurring in woodland areas receiving either clearing and acaricide, clearing and herbicide, clearing only, or no treatment during 1968

*Estimates represent average numbers of ticks occurring in twelve 75 x 3 ft areas

Fig. 4. Average number* of nymphal ticks occurring in woodland areas receiving clearing and acaricide, clearing and herbicide, acaricide only and no treatment during 1968.

*Estimates represent average numbers of nymphal ticks occurring in twelve 75 x 3 ft. areas

B. A COMPARISON OF THE EFFICACY OF GARDONA^R FORMULATIONS AS ACARICIDES

One of the major problems facing entomologists today is the development of a safe, economical pesticide which will be effective in suppressing tick populations without adding long-lasting residues to the environment.

It appears as if most of our materials are either too short-lived, or last too long, thus adding harmful stable residues which soon build up in the ecosystem. Organic phosphates frequently fall into the first category and chlorinated hydrocarbons in the latter.

Gardona^R, an organic phosphate manufactured by Shell Chemical Company, has been shown to be a very safe and effective acaricide. However, this material, when applied as a wettable powder, (sprayable liquid) has a rather short effective residual and tick populations build back up rather rapidly following application, depending on reinfestation pressure by animals. This material would be more desirable if it had a slightly longer residual. Since chlorinated hydrocarbons are undesirable to use around recreational areas, Gardona^R is perhaps one of the best materials available at this time.

Since this is a relatively new chemical, apparently no work has been done on evaluating the various formulations of Gardona^R for tick control. It was the aim of this demonstration to compare the efficacy of dusts, wettable powders and granules. In addition to efficacy, longevity of the formulations was of paramount importance.

Five one-half-acre plots were set up in a transitory zone between open pastureland and moderately vegetated oak forest in the Cookson Hills Game Refuge. In addition to heavy wildlife activity, the experimental area was subjected to the activity of a small herd of beef cattle. Wettable powder was applied to similar habitat in Cherokee Game Refuge. Both cattle and deer were abundant in this wooded pastureland.

Dusts and granules were applied at the rate of one-half pound actual material per acre and wettable powders were applied at the rate of one pound actual per acre. Large, heavy-duty, crank-type Hudson^R dusters were used in the application of dusts, Cyclone^R seeders were used in granule application and a high pressure John Bean^R sprayer was employed in applying the wettable powder.

Efficacy data could only be collected on the larval stage of Amblyomma americanum in this study due to the seasonal occurrence of the various stages. Adult activity, and to a great degree, nymphal, had subsided by the time this test was set up. Future plans include tests on the other stages.

In these tests, the 5 and 10% dust formulations appeared to be much more effective as a killing agent and residual acaricide than either the wettable powder or granular formulations (Table 3). Both the 5 and 10% Gardona^R dust were essentially 100% effective in controlling larval ticks for a period of nine weeks. Observations were discontinued at the end of nine weeks due to the low incidence of larvae. This overall reduction in tick numbers at the end of nine weeks was due to seasonal changes.

As can be seen in Table 3, granules were extremely slow in reducing the tick populations. Based on our observations of lone-star tick behavior, this lack of reduction is understandable. In this instance the larval tick populations were high in numbers at the time of insecticidal application, and were found well up on the grasses and other vegetation. Since the larvae migrate downward to the soil litter very seldom, and thus have little opportunity of coming in contact with the granules in the soil surface, there is little opportunity for the acaricide to be effective.

The gradual reduction of tick numbers in the granule test areas is thought to have been due to the fact that during wind and rains many larvae were dislodged from their resting place on the vegetation, and upon landing on the soil were killed by the granules which had leached out in the soil. It is also fairly evident that the granules were effective in preventing reinfestation. This would be expected since newly hatched larvae would have to crawl on the soil or leaf litter before finding a host plant.

In Table 3, data would indicate that under heavy reinfestation pressure wettable powder needs to be applied at approximately 6 weeks intervals. Longer residual has been obtained with the wettable powder when applied at the same rate (one pound per acre) in other areas. Several factors determine effectiveness: (1) Animal activity - With heavy animal useage a treated area is constantly being reinfested with ticks. As soon as the acaricide begins to break down, ticks tolerate the low residual and survive, then rapidly build up to large numbers; (2) Application time - If one is fortunate enough to apply a pesticide immediately following or very near the cessation of adult tick activity on animals, then a single application of Gardona^R, if properly applied, will be sufficient to produce 100% control for the balance of the season; (3) Climatic factors - Heavy rains cause the acaricide to be broken down and washed away very rapidly. Warm, dry weather assists the acaricide in destroying many ticks present and fair results frequently look excellent.

If one refers to 1968 biological data on the lone-star tick in Oklahoma and refers to the application date of Gardona^R dusts in these tests, it can be seen that adult tick activity had ceased at the time of application of Gardona^R. Consequently if one kills the existing tick larvae and those hatch for a period of several weeks after adult activity has ceased, there is little chance of reinfestation for that year since engorged larvae dropped in the area apparently over-winter without molting into host seeking nymphs.

Table 3. Average number of larvae per sample and percent change in tick populations in areas treated with five formulations of Gardona^R during 1967 and 1968. Average^a represents number of seed ticks per 225 square feet of surface area.

Weeks post-treatment	Treatment					
	5% Dust	10% Dust	5% Granules	10% Granules	1# W. Powder	Control
0	150/...	415/...	663/...	1063/...	705/...	1173/...
1	0/-100 ^{b,c}	0/-100	660/-1	1225/+12 ^d	0.2/-100	825/-29
2	0/-100	0/-100	295/-56	188/-82	10/-99	2525/+216
3	--	--	--	--	16/-98	--
4	0/-100	13/-97	125/-81	2600/+244	56/-92	1550/-128
5	0/-100	0/-100	0/-100	600/-44	125/-82	1125/-4
6	0/-100	0/-100	0/-100	175/-83	retreated	725/-38
7	0/-100	0/-100	0/-100	100/-91	--	710/-39
8	0/-100	0/-100	0/-100	0/-100	--	360/-69
9	0/-100	0/-100	0/-100	0/-100	--	193/-84

^a Represents four replicates

^b Average number of larvae/% change from initial population

^c (-) = Decrease

^d (+) = Increase

Granules should by no means be ruled out as a possible tool for combating adult and nymphal stages of the lone-star tick. Referring to our knowledge on the behavior of these stages, we recall that for from two to four weeks in the early spring of the year, prior to 50°F temperatures, adult and nymphal ticks crawl extensively on the surface of the soil and soil litter, and as temperatures warm up these pests become more active and venture up on the vegetation. If granules were applied during this period there is a good possibility that many of these would be killed during the early spring months.

Adults and nymphs apparently do more migrating up and down vegetation than do larvae and consequently are more liable to come in contact with granules, even if applied in the early summer.

Current plans are to conduct future tests on the potential of various formulations in the control of all stages of the lone-star tick.

C. THE POTENTIAL ROLE OF ANIMAL EXCLUSION IN TICK CONTROL

Animals serve as mobile hosts which rapidly disseminate ticks throughout their habitat and also serve as a source of blood to perpetuate the species. Without suitable hosts in a given area, ticks would perish over a period of months and reinfestation would not occur.

It was the objective of this demonstration to ascertain the practicality of chemically excluding tick hosts from recreation areas which had previously been declared "tick-free" through the use of acaricides. Hopefully, an animal repellent would prevent reinfestation of these areas.

Over the past 20 years a number of mammal and rodent repellents have been marketed which are supposedly effective in minimizing animal damage to orchards, field crops, sismograph cables, packaging, and a variety of other items. One such material, "ZIP"^R, a Morton Chemical Product, has been labeled as a deer and rodent repellent. Since this material was readily available in fairly large quantities, it was selected for use in these studies.

Zip^R was applied to one-acre simulated recreation areas at the recommended concentration of one-gallon per 25 gallons of water. Prior to the application of Zip^R, each plot to receive Zip^R was treated with one pound of Gardona^R per acre to destroy the existing tick population. Other work under this project suggests that this quantity of Gardona^R is sufficient to produce essentially 100% mortality of ticks present at the time of treatment.

Areas receiving Zip^R and Gardona^R were compared to areas receiving (1) only Gardona^R, and (2) no treatment. By setting up the plots in this fashion, any additional longevity received through the use of Zip^R could be detected.

As can be seen from Figure 5, very erratic results were obtained in these tests. In an attempt to explain these results the following facts are offered: (1) Plots were established in an area of extremely high animal activity (primarily deer); (2) Following clearing operations and treatment of the areas, the areas were perhaps more attractive to deer and other animals since the "border effect" was produced, consequently animal activity was increased in the immediate area; (3) Even though visiting animals were not necessarily feeding in the treated plots, these areas were attractive to the animals since these openings afforded the deer "security" or "protection" while loafing in these areas.

As erratic as the control figures may be it is still worthwhile to note that in the plots treated with the acaricide followed by the repellent, an additional 13 percent control was obtained for a period of 6 weeks when compared with the plots receiving only the acaricide.

Fig. 5. Comparative control of lone-star tick larvae in partially cleared woodland areas receiving an insecticide or either an insecticide followed by the application of an animal repellent.

Future demonstrations involving repellents are planned. Other materials will be used on existing recreation areas in an effort to avoid habitat modification; thus making the area more attractive to hosts. Olfactory as well as taste repellents should be evaluated. Zip^R was considered primarily a taste repellent and consequently animals continued to pass through the treated areas. Olfactory repellents would possibly prevent tick hosts from entering treated areas.

Since deer seem to be one of the most important links in the natural cycle of ticks (See Hosts of Ticks) in non-rangeland of eastern Oklahoma, the exclusion of this species from recreation areas would have a marked effect on reinfestation by reproductive forms (adults). On rangeland, cattle and horses, and to a much lesser extent racoon, fox, coyote and bob-cat, serve for hosts of reproductive forms.

Thus, we can see that once an effective deer repellent is found much progress can be made around recreation areas by excluding one host species.

D. DEER HERD TREATMENT AS AN AID IN AREA TICK CONTROL

One phase of this project has helped demonstrate a major reason for the tremendous number of lone-star ticks in eastern Oklahoma. This pest has been collected from at least 25 hosts over the past year. The tremendous numbers of hosts in the brushy woodlands of eastern Oklahoma, plus this lack of host specificity, greatly enhances the chance of these parasites obtaining a blood meal. Blood is necessary for maturation and reproduction. Without blood the tick cycle would likely be broken within one to two years. A number of hosts such as cotton-tailed rabbit, racoon, coyote, cattle, horse and deer are very important as hosts since they are large bodies and can support large numbers of ticks. The reproductive stages are almost always confined to the animals, as large as, or larger, than the racoon. Consequently, this reduces considerably the number of hosts for the reproductive stages. It was our hope to demonstrate under this grant that certain wild hosts could be eliminated as effective hosts by administering a systemic insecticide in a bait to these potential hosts. We have concentrated solely on deer since they are perhaps most easily worked with. We have gathered information that would indicate that racoon also lends itself to this type of treatment. It can readily be seen that if cattle, horses, deer and racoon were removed as hosts, adult ticks would perhaps die before a suitable host passed by, or the number reaching a suitable host would greatly be reduced.

During the fall of 1967 the first treatment device (i.e., dust stations and feeders) were installed in the Cookson Hills Game Refuge in an effort to demonstrate the practicality of treating the deer herd in tick control procedures. Various baits were formulated and tested as deer attractants to be used in feed stations. Cotton-seed meal was found to be the most economical and effective carrier for Korlan^R, a systemic, organophosphorus insecticide.

Untreated bait was applied in approximately 20 stations situated at less than one mile intervals over some 9,000 acres of refuge. This area was designated to later serve as the area receiving treated bait. The other half of the game refuge served as a control zone, from which untreated animals could be examined for comparative purposes.

One August 14, 1968 untreated bait was replaced with cotton-seed meal containing Ronnel^R, the systemic from Dow Chemical Company. The percentage of systemic in the meal was determined by first conducting bait consumption tests on the deer herd. The mixture was then prepared so that the average deer would receive 0.2 pounds of 18 percent Ronnel^R per 100 pounds of animal over a 14 day feeding period.

In one 500 acre portion of the treatment area, approximately 300 deer were exposed to five of the feed stations. Observations revealed that 70-80% of the animals were visiting the stations at regular intervals after the treated food was offered (Figure 6).

Figure 6. White-tailed deer visiting feed boxes containing a bait and a systemic insecticide for tick control.

It is very difficult to accurately evaluate the effectiveness of trials involving wild animals. This is due chiefly to the fact that they are constantly being subjected to massive reinfestation pressure. Consequently, the animal may be heavily infested with pests which might ultimately succumb. Systemics vary in time required to kill the parasite, depending on several factors (i.e., rapidity at which, and volume of blood taken by parasite).

Several factors tend to offer support to this method for deer parasite control. A very important hurdle was overcome by enticing a large percentage of the deer herd to partake from the stations. A second factor of considerable importance was the observation that deer louse-flies and deer throat bots have been almost totally eliminated from the deer in the treatment area. These are two host specific parasites of deer in the area and serve beautifully as indicator organisms.

Counts were made on ticks present and state of engorgement on blood recorded (Table 4; Figures 7 and 8).

Table 4. Average^a number of ticks present on deer receiving either no treatment, or Ronnel^R, and percent engorgement^b of attached ticks, Cookson Hills Game Refuge, Summer 1968.

	Average No. Ticks/Deer	Estimated Degree Engorgement		
		25	25-75	75
Untreated ^c	495	10	70	20
Treated ^d	370	65	30	5

^a Average represents both nymphal and larval stages, adults not in season during this evaluation.

^b Percent engorgement is used to express the degree to which attached ticks have fed to fulfillment.

^c Four deer examined.

^d Seven deer examined.

A marked reduction in the degree of repletion was noted in ticks infecting deer in the treated area. Approximately 65% of the ticks observed on deer exposed to Ronnel^R were less than 25% engorged, whereas near 90% on untreated deer were over one-fourth fed. These differences are difficult to explain unless mortality or repellancy was occurring in the case of treated deer. Table 5 also suggests that of those ticks on treated deer reaching

Figure 7. Box-trap in "set" position. This device is used in the live-trapping and examining of white-tailed deer during the evaluation of tick control procedures.

Figure 8. A deer is restrained while an estimate of the parasites present is made.

repletion, many may die during the process of molting. In our tests an additional 43% mortality was observed in ticks dropping from deer in the treated area.

Results obtained from this demonstration would tend to indicate that Ronnel^R is only partially effective in killing lone-star ticks on deer under field conditions. At best this figure would probably be less than 75%. However, these data need further substantiation. Efficacy tests under penned conditions are also to be run during the summer of 1969. This information would be quite appropriate since under field conditions deer are constantly being subjected to reinfestation by ticks, and under penned conditions this could be prevented.

During the summer of 1968, a three acre "Deerproof" pen was constructed, with divisions, and pen-reared deer have been obtained for experimental use.

Even though 100% mortality of ticks on treated deer apparently does not occur under field conditions it is felt that this effort with systemics is deserving of more attention in future demonstrations. This statement can be substantiated and supported when one reviews the importance of deer as a blood supply for reproductive forms (adults) of the lone-star tick. Where cattle were not present in the experimental area, deer were by far the most important hosts for adult ticks. This demonstration has shown that the majority of a given deer herd can be enticed to partake from feed stations and that the addition of Ronnel^R has no repelling action when applied in the bait.

Several alternatives exist which could be tried and which could result in increased tick mortality. These include an increase in dosage of Ronnel^R and the evaluation of other systematics such as Co-Ral^R, a Chemagro Chemical Company product.

Samples of ticks were also collected alive from feed stations serving treated and untreated deer and held under laboratory conditions for approximately one month in an effort to determine the survival rate before and during molting. These data appear in Table 5.

Table 5. Percent mortality of nymphal and seed ticks collected from treated or untreated deer in Cookson Hills Game Refuge, Summer 1968.

	<u>Observation Date</u> ^a					
	<u>3 Days</u>	<u>7 Days</u>	<u>14 Days</u>	<u>20 Days</u>	<u>28 Days</u>	<u>35 Days</u>
UNTREATED	0	6	10	12	28	30
TREATED	12	21	26	34	72	73

^a Indicates time elapse after collection before mortality check made.

Four samples were collected from each of the two areas and each sample consisted of approximately 50 seed ticks and 50 nymphal ticks.

Even though 100% mortality did not occur in ticks collected from treated animals, it is felt that the 73% mortality observed in these preliminary tests represents more than just natural mortality. The 30% mortality observed in the untreated sample can be attributed to natural mortality as a result of unstable relative humidity and temperature. The net percent mortality observed plus the pronounced results obtained in the case of the other deer parasites, suggest that systemic insecticides in baits might appreciably reduce tick populations in a given area.

E. INTEGRATED CONTROL METHODS INVOLVING CATTLE AS "MOP-UP" ORGANISMS

Even though the main objective of this grant was to demonstrate tick control procedures around recreational areas, tick control on an area basis was kept in mind at all times since this would be the only long-term solution to the tick problem.

The Oklahoma Department of Wildlife Conservation has been actively engaged in a cooperative grazing-tick control project since 1963. The Oklahoma State University Entomology Department joined forces with the Wildlife Department in the summer of 1967 in an effort to more effectively evaluate the role of the grazing program in area tick control.

The main principle in these control efforts involved using livestock as mobile hosts for the collection of ticks from their natural habitat. Animals were then treated with an acaricide and the ticks destroyed. The pesticide remained on the treated animal for a short period after treatment and ticks that came in contact with the host during this time were also likely to be killed.

In this demonstration 32,000 acres in the Cherokee Game Refuge was divided into eight 4,000 acre pastures. Four herds of animals, consisting of approximately 400 animals in each herd, were used in this series of tests. Each herd was allowed to graze one of the 4,000 acre pastures for one month. At the end of the month, the cattle were examined, dipped in a pesticide and rotated to a new pasture. This procedure was repeated every month and one herd of animals occupied a given pasture every other month between April and October.

Dipping vats (Figure 9) were used in the Cherokee area during 1968 for the first time by the Wildlife Department since this program was initiated. Much better coverage of the animals was obtained with the use of the vats than in past years when animals were sprayed with a high pressure sprayer.

Results obtained during 1968 were most encouraging. In almost all cases ticks were drastically reduced for periods of approximately two weeks after dipping. Based on our observations we are recommending to the Wildlife personnel that cattle be dipped at least every two weeks in an effort to more rapidly achieve the goals set. Apparently, the acaricide is breaking down about 10 days after treatment. This allows ticks to attach to the cattle, feed to repletion, and drop off before the next dipping. If animals were dipped at two week intervals, many ticks would not be allowed to return to the pasture and serve as a source for the next generation of ticks.

The relationship of tick control on cattle-grazing lands to tick control in recreational areas is extremely important. Cattle, horses, and other domestic animals in close proximity to recreation areas help serve as a constant source from which ticks can be reintroduced into recreation areas previously rendered tick-free.

Figure 9. A calf prepares to leap into an eight-foot-deep acaricidal bath during animal manipulation studies for tick control.

By widening efforts to include tick control on livestock, wildlife and around recreational areas, lasting area tick control could be achieved around resort areas.

Our efforts during 1968 have shown that ticks can be greatly reduced on deer, cattle and woodlots. It seems that an effort is needed and required, in all these areas prior to the achievement of our ultimate goal --- area tick control.

F. USEAGE AND TREATMENT COSTS ESTIMATES ON EXISTING RECREATION AREAS

During the summer "tick-season" of 1968 approximately 700 acres of existing recreation area on the shores of Tenkiller and Greenleaf Lakes were involved in a tick control demonstration. This demonstration entailed a number of objectives, including the following: (1) to ascertain the effectiveness and longevity of Gardona^R as an acaricide when used on a large, established recreation area; (2) to determine costs per acre, or per 100 acres, of applying Gardona^R to established recreation areas; and (3) to view public reaction to areas which were tick and chigger free.

Gardona^R was applied to existing recreation areas at the rate of 0.25 pound per acre and the first application was made at the beginning of tourist season in late April. Applications were made with a vehicle mounted John Bean^R Livestock Power Sprayer equipped with #4 nozzle washers under 350 pounds pressure.

Recreation areas treated were accessible to vehicles which facilitated the application of Gardona^R and reduced costs as a result of the rapidity of application.

Only two applications of Gardona^R were required on existing recreation areas during the summer of 1968 to essentially render the areas "pest free". It should be pointed out that tick populations were low in all areas prior to treatment, thus it was difficult, almost impossible, to properly estimate the populations by using normal survey methods. It should be further pointed out, however, that these populations were high enough to create a deterrent for tourist in these areas since "one tick seems to be too many" for many tourist unaccustomed to these pests.

In many of the areas treated under this demonstration, evaluation of efforts were partially dependent on interviews with visitors, park rangers, etc. Two applications of Gardona^R were sufficient to relieve all complaints of ticks and chiggers in treated areas. In areas sampled after treatment during the past two summers, it was impossible to pick up meaningful numbers of ticks, even after 8 weeks post-treatment, and consequently, interviews were perhaps the best approach in evaluation.

Approximately one million (Table 6), visitors were recorded as persons utilizing treated recreation areas during this study in the summer of 1968. Tenkiller State Park, consisting of 125 acres, recorded almost one-half of all activity. Since this was perhaps the most representative of the average recreation area found in the Ozark region, tick control cost figures were kept on this area and presented in Table 7.

Figure 10. An infrequently used camping area such as this photo shows normally requires twice the tick control efforts that a "well" established park requires.

Table 6. Monthly visitations at eight recreation areas involved in A Tick Control Demonstration on Tenkiller Ferry Reservoir, Summer 1968.

Month	Elk Creek	Cookson Bend	Six- shooter	Chicken Creek	Snake Creek	Stray- horn	Greenleaf State Park	Tenkiller State Park
<u>Visitation</u>								
Apr	6,000	5,700	2,500	3,000	5,700	8,000	16,885	26,080
May	8,000	6,500	3,200	6,500	8,000	7,700	21,129	70,068
Jun	18,500	15,000	6,000	11,200	14,000	13,000	26,385	118,000
Jul	13,500	15,700	6,000	12,000	21,700	20,700	52,600	113,600
Aug	9,700	19,000	1,700	11,700	15,500	29,700	31,800	96,340
Sept	-	-	-	-	-	-	21,650	56,640
TOTAL	55,700	62,400	19,400	44,400	64,900	79,100	170,449	480,728

As can be seen in Table 7, 125 acres of Tenkiller State Park was maintained during the summer of 1968 at a cost of less than \$2.30 per acre or at a cost of \$1.75 per thousand visitors.

Visitors were highly receptive of these "tick free" recreation areas. Park managers made mention of "dozens" of favorable comments, especially by long-time visitors of these normally tick infested areas.

Managers of newly established parks of other facilities (Figure 10) might expect costs to be doubled since related studies have shown that newly established areas are more attractive to transports (hosts) of the lone-star tick. These costs might in turn be reduced by more powerful, better mechanized sprayers which would utilize fewer operators while covering more area per swath.

Gardona^R is still in the developmental stage as an acaricide and one would normally expect the costs to drop rather rapidly following its appearance on the commercial market in 1969.

Table 7. Estimated Costs for controlling ticks and chiggers on 125 acres of semi-wooded recreation area (Tenkiller State Park) in eastern Oklahoma during six summer months, 1968.

Insecticidal Costs		
82 pounds of 75% Wettable Gardona ^R		
@ \$1.25 per pound		\$ 102.50
Labor Costs		
6 man-days (8 hr/day) @ \$1.75 per hour		84.00
Power Sprayer depreciation/year		
(over 10 year period)		50.00
Misc. costs (i.e., tractor or pickup for		
towing sprayer, gasoline, etc.)		50.00
ESTIMATED TOTAL		286.50

$$\begin{array}{rclcl} \# \text{ Thousands visitors} & & \text{Total costs/year} & & \\ 500 & \div & \$286.50 & = & \$1.75 \end{array}$$

Costs for maintaining tick free area/1000 persons using Tenkiller Park during 1968 = \$1.75.

III

BIOLOGICAL STUDIES ON LONE-STAR TICKS
IN EASTERN OKLAHOMA

A. SEASONAL ACTIVITY OF LONE-STAR TICKS IN EASTERN OKLAHOMA AND IT'S
IMPORTANCE IN CONTROL PROCEDURES

In order to effectively and economically control lone-star ticks in recreation areas of the Ozard region it is important that we understand the basic life history of this pest in this region. Of particular importance is a knowledge of when activity for a particular stage begins, peaks, and ends.

We now know that from April 1 through April 15 of each year (this may vary depending on weather condition) adult and nymphal stages are closely associated with the soil litter. During this time we find very few ticks on the vegetation, but as the temperatures rise near the end of April these pests become more aggressive and actively seek a blood meal.

Apparently the emergence of overwintering adults from soil litter continues for a period of over six weeks. Consequently, if the area is treated with an acaricide that is too short-lived, the toxicant may not be available to act on those ticks emerging near the end of the adult emergence season. Nymphs evidently have a longer "emergence" period since they appear in relatively large numbers beyond the disappearance of adults.

Theoretically nymphs could arise from larval stages after August 1, but since there is a gradual decrease in nymphal activity after this date this is thought not to occur as a rule.

As can be seen from Figure 11, adult and larval stages are definitely seasonal whereas the nymphal stage is more generally drawn out throughout the summer. This information dictates that when using a short-lived acaricide, application must be made around the middle of April for the adult season and again near the first of July for the larval season. With luck these two applications will also take care of the nymphal activity if areas under treatment are well established.

Under heavy reinfestation pressure certain recreation areas might have to be treated twice during the adult season and twice during the larval season.

Further investigations are needed on timed applications of various acaricidal formulations for tick control before rigid application dates are set up. One or two weeks difference in the application date can have a considerable impact on the long-term control obtained in a specific area.

Fig. 11. Seasonal distribution of various stages of the lone star tick (*Amblyomma americanum*) in Cherokee County, Oklahoma, during 1968

B. DETRIMENTAL EFFECTS OF LONE-STAR TICKS ON WHITE-TAILED DEER POPULATIONS

For a number of years wildlife biologist in eastern Oklahoma have postulated that approximately 25% of the deer crop was lost annually as a result of the blood sucking habits of ticks. These losses are more evident in larger animals such as deer than in smaller animals, but the toll in rabbits, racoon, quail, etc., must also be quite large.

It should be kept in mind that game animal losses represent recreation losses. Eastern Oklahoma draws deer hunters from all over the United States and realized considerable revenue from their activity during the hunting seasons. Equally as important, perhaps, is that Oklahoma provides its own hunters with excellent recreation, thus preventing dollars from leaving this state.

Until the spring of 1968 any figures on wild animal losses due to ticks in Oklahoma were strictly guesses. It was the objective of this study to ascertain deer fawn losses in eastern Oklahoma suffered from tick infestations. No attempt was made in this study to estimate losses in animals more than six weeks old because of the magnitude of and time involved in such a study. Future plans include the older animals. Animals a few days to several weeks old are especially susceptible to tick attack due to the animals' inadequacy in grooming themselves. For this reason the biggest loss probably occurs during the first month or six weeks after fawn drop begins.

A survey of deer fawns in Cookson Hills Wildlife Refuge was begun during late May, 1968. Specific objectives included: (1) to determine parasite (tick) load of all fawns collected; (2) to ascertain the condition (thriftness) of fawns collected by visual observations and through a correlation of blood readings (i.e., P.C.V. and Hgb.), parasite load, and appearance; (3) to determine tick load necessary to produce debilitating effects and/or death in young fawns; and (4) to estimate annual fawn losses due to ticks in the Cookson Hills Wildlife Refuge.

Several methods were used in collecting fawns for this study. These included an "on foot" examination of meadows, their margins, hedgerows and other probable hiding places of fawns. Horse-back riders were also used rather extensively in this survey. Most fawns were collected by using a throw-net or by directing the fawn into a four feet high commercial fish webbing (# 139). Fawns became entagled in the nets and could be restrained relatively easily.

All fawns collected were examined carefully for ticks and this information recorded. Blood samples were taken and transported to the field laboratory where P.C.V. (Pac-Cell-Volume) and Hgb. (Haemaglobin) readings of the blood were made. Notes were also made on the general appearance of each fawn collected, and abnormalities recorded.

Figure 12. Part of 1300 nymphal and adult ticks infesting a three-week-old deer fawn in the Cookson Hills Game Refuge, Summer 1968.

Figure 13. A deer fawn totally blinded as a result of tick attachment near and around the eye.

The number of fawns collected in this survey was small due to the amount of time required to properly develop animal collecting techniques and due to the very short time that fawns are highly susceptible to tick attack. Once fawns reach the age of 6 weeks, they become relatively active and start grooming themselves. A high percentage of the ticks that crawl on these older fawns are dislodged before they become attached, and consequently fawn losses are less in animals over six weeks old.

Eighteen fawns were examined during the course of this study and animals were grouped, depending upon physical condition, into five general categories (Table 8). As can be seen from this preliminary data, approximately 17% of all fawns examined were lost as a result of tick infestations. Another 17% were in such a condition as to lead the examiners to believe that they, too, might be lost. The three fawns in category V were penned after collection and fed on Pet^R canned milk. They lived for an average of four days, one succumbed within 36 hours after collection. There were no problems associated with pen rearing of uninfested fawns.

Efforts to duplicate fawn losses from tick infestations under penned conditions were highly successful. The only problem encountered in these preliminary tests was that the fawns used in these tests were over six weeks of age and some difficulty was encountered in infesting them with ticks. As was mentioned previously, these fawns were capable of grooming themselves, and consequently dislodged most adult ticks placed on them.

From this study it was shown that ticks were directly responsible for tissue destruction in fawns near points of attachment, and that this necrosis, solely, or in conjunction with secondary infection, invariably caused massive lesions which caused a loss of sight when in close proximity of the eyes (Figures 12 and 13).

Infection set up by tick infestations caused a rapid drop in Pac-Cell-Volume and Haemaglobin readings of the blood. It was also noted that tick infested penned animals with P.C.V. readings below 25, died.

Penned animals passed through a series of "post-infestation phases". After studying these "phases" of penned deer, it was postulated that up to 50% of all field collected fawns were in one or other of these "phases", and that these fawns (categories III and IV) could have degressed further, placing them in category V.

Our conclusion from this preliminary study during 1968 was that in certain areas of the Cookson Hills Refuge up to 50% of the new-born fawns could be lost as a result of tick infestation. A minimum figure of 20% was established. These studies must be substantiated with detailed observations in future years.

Considering that wildlife economists in Oklahoma estimate the value of each mature deer to the State at \$100, we can readily see that millions of dollars in recreation expenditures may be lost annually. Admittedly, this study was conducted in an area in which tick populations were extremely high. However, hundreds of thousands of similar areas exist in the Ozark region.

Table 8. Number of fawns collected from the Cookson Hills Wildlife Refuge during June and July, 1968, their physical condition and degree of infestation with lone-star ticks.

	Category & Condition	# Fawns Examined	Ave. # ^a Ticks/Fawn	Ave. ^b P.C.V.
I	- Tick free	4	25	34.9
II	- No ill effects Light Infestation	3	100	33.9
III	- Slight malformities i.e., nodules on muzzle	5	400	31.7
IV	- Eye missing, infection Death highly possible	3	225 ^c	24.5
V	- Both eyes missing, heavy infection Death ultimate	3	150 ^c	18.3

^a Adult and nymphal tick counts combined.

^b Pac-Cell-Volume

^c When fawn reached this category, many ticks had fed and dropped off. Infection reduced favorable attachment site near eyes.

C. HOSTS OF TICKS IN EASTERN OKLAHOMA

Animal surveys are extremely important in furnishing biological data pertinent in tick control efforts. Seasonal distribution, species composition, abundance, geographical distribution, etc., are part of the data obtained from such studies.

In July 1967, an animal collecting program was initiated. All species of animals and birds were sampled. A scientific collectors permit was obtained from the Department of Wildlife Conservation to make possible the collection and sampling of various types of animals during the year. Animals were collected for sampling in the following manner: live animal traps, 22 caliber rifle, road kills, tranquilizer gun, and checking game kills by hunters.

Small rodents were attracted and trapped in live animal traps by using a bait consisting of peanut butter, oatmeal and bacon grease. The traps were set in the general vicinity of high tick populations at periodic intervals during the study. Animals were removed from the traps once or twice daily and placed in a wide-mouth plastic gallon jug containing cotton which had been saturated in chloroform. As soon as the animal succumbed it was removed and placed in a plastic freezer bag which was labeled and sealed. The bag was then placed in an ice chest and allowed to cool for several hours.

Rodents were then removed from the bag and placed in a 50% ethanol bath and agitated vigorously. Close inspection was made of the plastic bag to remove ticks that might be present there. The animals were then removed from the alcohol bath and carefully inspected for ticks that still could be attached. The alcohol was strained through paper toweling and the ticks collected were placed in a vial for later identification.

Animals that were shot and that were small enough were processed in this manner. Larger animals that were collected were visually examined and disposed of without taking them into the laboratory. Many animals, such as racoon, were anesthetized with chloroform and released after a close visual inspection had been made.

During deer hunting season in the fall, personnel were maintained at various deer check stations throughout eastern Oklahoma and each deer that was brought to the stations was surveyed for ticks (Figure 14). An estimate of total populations was made and specimens were collected for later identification. From these specimens the percentage of the various species of ticks was computed.

Figure 14. Freshly killed deer are examined for ectoparasites during a survey to determine tick distribution and prevalence.

Table 9 summarizes host preference data for the lone-star tick obtained during 1967 and 1968. As can be seen from this data, the lone-star tick expresses little or no host preference while larvae or nymphs. However, for some undetermined reason the adults (reproductive forms) are seldom found on animals smaller than a racoon or fox. In reviewing this data it should be kept in mind that no effort has been made in the table to date the time of host examination. Also it should be mentioned that a host which appears to be relatively unimportant in the table may, at a different time of the year, play an important part in the perpetuation of the lone-star tick. An example would be the horse. When the survey of those horses shown in Table 9 was made, lone-star ticks were not present. Had these animals been examined from April through September it is most likely that lone-star ticks would have been present.

Table 9. Numbers and relative abundance of several species of ticks on various animals collected in Cherokee County, Oklahoma, 1967 and 1968.

Host	No. of Hosts	Ticks Present	Larvae	Nymphs	♀	♂
Whip-poor-will	2	<u>A. americanum</u>	170	0	0	0
Chaparral Cock	7	<u>A. americanum</u>	320	10	0	0
		<u>H. leporispalustris</u>	33	4	0	0
Calf	11	<u>A. americanum</u>	1176	121	9*	3*
White-tailed deer	30	<u>A. americanum</u>	1870	1309	12*	11*
		<u>D. albipictus</u>	0	9	0	0
		<u>I. scapularis</u>	0	0	1	0
Squirrel	9	<u>A. americanum</u>	509	62	0	0
		<u>D. variabilis</u>	1	0	0	0
Racoon	43	<u>A. americanum</u>	660	281	2	1
		<u>D. variabilis</u>	0	0	15	21
		<u>I. scapularis</u>	24	22	26	4
		<u>D. albipictus</u>	0	0	1	2
Woodchuck	2	<u>A. americanum</u>	+	+	-	+
		<u>D. variabilis</u>	-	-	+	-
Quail	7	<u>A. americanum</u>	78	46	0	0
		<u>H. leporispalustris</u>	220	20	0	0

Table 9. Cont.

Host	No. of Hosts	Ticks Present	Larvae	Nymphs	♀	♂
Skunk	1	<u>A. americanum</u>	12	8	0	0
Cottontail rabbit	26	<u>H. leporispalustris</u>	299	123	51	59
		<u>A. americanum</u>	871	215	0	0
		<u>D. variabilis</u>	27	1	0	0
		<u>I. scapularis</u>	0	1	0	2
Horse	5	<u>I. scapularis</u>	10	20	70	20
		<u>D. albipictus</u>	0	2	3	0
Cotton rat	139	<u>A. americanum</u>	25	3	0	0
Wood rat		<u>I. scapularis</u>	1	2	0	0
		<u>H. leporispalustris</u>	1	0	0	0
		<u>D. variabilis</u>	15	3	0	0
White-footed mouse	66	<u>A. americanum</u>	4	3	0	0
		<u>I. scapularis</u>	1	2	0	0
		<u>D. variabilis</u>	25	0	0	0
Grey fox	2	<u>A. americanum</u>	0	1	0	0
		<u>I. scapularis</u>	40	15	17	17
Coyote	1	<u>I. scapularis</u>	1	0	13	5
Chipmunk	2	<u>A. americanum</u>	1	0	0	0
Opossum	6	<u>I. scapularis</u>	0	0	1	0
		<u>D. albipictus</u>	1	0	1	0
Lizard	4	<u>I. scapularis</u>	4	19	-	-
Hawk	2	None	-	-	-	-

* These animals were examined at a time in which adult activity had almost subsided. A deer in June could easily have had several thousand adults.

+ Present

- Absent

The reader is reminded, however, that many factors other than season are responsible for the presence of these parasites on a given host (i.e. Host habitat).

As can be seen from Table 9, this data is far too preliminary to break down on a month by month basis, due to the small number of hosts examined. If this was possible one could pinpoint the important host for any stage at a particular time of year. It is impossible to obtain meaningful data of this type in the short span of a year. However, a very good basis for further studies has been laid through this study.

The range, average number, and species composition of ticks parasitizing white-tailed deer in five eastern Oklahoma refuges is presented in Table 10. These observations were made at deer hunter check stations during 1967 and 1968 and represent observations ranging from November 15 through December 1. One would expect a predominance of the winter species of ticks during this observation period as Table 10 shows. Ixodes scapularis and Dermacentor albipictus are not problem species in recreation areas during the spring and summer. Quite important during this winter period is the presence of almost 10% lone-star adults since this represents pertinent biological data for this species.

Table 10. The range, average number, and species composition of ticks parasitizing white-tailed deer in five eastern Oklahoma refuges, Fall 1967 and 1968.

Refuge	Ticks		Species Composition (%)		
	Range	Ave/Deer	<u>I. s.</u> ^a	<u>D. a.</u> ^a	<u>A. a.</u> ^{a,b}
Cherokee	25-500	180	67	24	9
Cookson	0-300	100	70	18	12
Spavinaw	100-300	100	72	23	5
Ft. Gibson	0-100	20	57	40	3
McAlester A. D.	25-150	60	60	34	6

^a Ixodes scapularis, Dermacentor albipictus, Amblyomma americanum

^b This species, the lone-star tick, comprises over 95% of all ticks appearing on deer from April through September.

D. THE RELATIONSHIP OF AMBLYOMMA AMERICANUM TO VEGETATION IN COOKSON HILLS
GAME REFUGE, CHEROKEE COUNTY, OKLAHOMA; SUMMER 1968

The purpose of this work was to determine whether or not A. americanum preferred certain vegetative types, and to study the movement of this tick on plants. Such biological data could assist scientists in developing control procedures for this pest. For instance, present information suggests that alteration of the vegetation might markedly reduce tick population in certain environments. This information could also dictate the formulation of chemical (i.e., dust, granule) to be used in controlling certain stages of ticks.

Ticks in heavily infested areas were observed on various plants during the summer of 1968. The number of adults, nymphs, and larvae, the height of the plant, the species of plant, and the temperature and humidity were recorded. Plants of the species being observed were collected for identification and reference in the laboratory.

Samples from general forested areas were taken to compare the tick population in several different vegetative types. Sample area number one was divided into four regions according to vegetative type: (1) Short grass (six inches to three feet tall); (2) Tall grass (three to six feet tall); (3) Persimmon grove; and (4) Oak-hickory woods.

Sample area number two was divided into two vegetative types: oak-hickory woods, and shadowed meadow.

Estimates of tick populations were taken using a sweep net with a standard 15 inch hoop and a drag made of a piece of canvas 36 inches wide by 72 inches long. The number of adults, nymphs and larvae on the net and drag were counted and the ticks were removed from the drag and sweep net by sweeping them vigorously with a whisk broom. Samples were taken about every two weeks.

The movements of lone-star larvae on plants were observed from August 3, 1968 to September 5, 1968. Masses of larvae were located by walking along game trails and checking the grasses and herbs near the trail. When a mass of larvae were located the area was marked with forester's tape and the masses of larvae were later surrounded by cylinders of woven wire 3 feet high and 12 feet in circumference. The purpose of these cylinders was to keep cattle, deer, or other wildlife from brushing them from their resting site.

The height and kind of plant that each mass of ticks was on was listed. Larvae were observed at irregular intervals, each observation consisting of the air temperature, the relative humidity, the percent of shade in the cylinders, the time of day, rain and the location of the ticks on the plants.

Preliminary samples of four different vegetative types showed that ticks occurred mainly in areas where there was an abundance of undergrowth and shade.

Table 11. Total number^a of ticks collected from four vegetative types in sample area number one, June - September, 1968.

Vegetative Type	<u># Ticks Collected</u>			
	♀	♂	Nymphs	Larvae
Shortgrass	1	1	50	100
Tallgrass	8	11	179	106
Persimmon	28	30	502	710
Woods	9	7	179	2168

^a Comparative area sampled in all areas.

A shaded meadow in area number two produced more than 20 times the number of adults and nymphs than the oak-hickory woods that surrounded it. This was assumed to be due to the high animal activity in the meadow. In this area ticks were observed on many different plants as well as on the ground. Adults and nymphs on plants ranged from the ground to five feet, while the larvae ranged to three and one half feet. Ticks were observed most often on grasses and herbaceous plants, and rarely on woody plants.

The number of adults on a single plant ranged from none to fifteen, nymphs ranged from 0-300 and larvae ranged from 0-2000.

It has been reported that eggs of the lone-star tick will not hatch at less than 47% relative humidity. A modification of the vegetative cover could help reduce the humidity in the ticks' microclimate and consequently reduce its chances for survival. A vegetative type study of this type could help a person locate and treat areas where nymphal and adult tick populations were high.

Of the groups of larval ticks observed for a month, all but one of 12 masses remained on or near the original plant. The mass that disappeared was in the hot sun from 12-7 p.m. while the others were in the shade much of the time.

In general there was very little up and down movement of larvae on the host plant and the only time ticks were noted down on the vegetation was during windy and/or rainy weather. Most groups of tick larvae stayed under the leaves of plants, but some were observed on the stem. Larvae always oriented themselves on the side of the plant opposite the sun. During cloudy weather the larval ticks could be found dispersed evenly around the stem of their host plant.

Other studies of this project have shown that Gardona^R wettable powder and Gardona^R 5% and 10% dust gave excellent control of seed ticks for four weeks in the summer, while granules gave very little control. A reason for the poor control obtained with granules could be that the seed ticks remained on the plants throughout the summer and didn't contact the acaracide granules on the soil surface, while the wettable powder and dust covered the vegetation and came in contact with the larval ticks. An application of Gardona^R granules in mid-summer when eggs are hatching may give adequate control of the young tick larvae.

If further studies show that ticks express a plant host preference they may then be eliminated by controlling the host plant species with a herbicide.

IV

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

Lone-star ticks (Amblyomma americanum) appear to be an important limiting factor in the economic development of many areas in the Ozark region. These pests restrict normal daily routines for inhabitants, recreationists and others visiting eastern Oklahoma, western Arkansas and other similar areas throughout the Ozark region. The problem is so vast that individuals, local and/or county governments can do little to fight the ravages of these bloodsuckers on an area basis.

Losses in revenue from recreation areas, wildlife production and livestock production are tremendous in these tick infested areas. The incidence of tick-borne diseases of man is also very high when compared to other areas of the United States.

The need for safe, economical, long-lasting control procedures against the lone-star tick in the Ozark region is very much evident. It has been the goal of this project over the past 18 months to set up various demonstrations on tick control in eastern Oklahoma and to evaluate the practicability of these various approaches under the existing circumstances.

Lone-Star Tick Control Studies. - Simulated recreation areas, one acre in size, were set up in areas heavily infested with lone-star ticks. Various mechanical-chemical treatments were applied to replicated plots subjected to various degrees of tick reinfestation pressure. Power and hand equipment was used to apply chemicals (acaricides and herbicides) to the test areas, and clearing of the plots was accomplished by hand equipment and herbicides.

Evaluation of results was accomplished with the use of a standard "drag-flag" and sweep-net. Four areas three feet wide and 75 feet long were sampled in each plot and an average figure of the tick population in each test area recorded.

Only two of five treatments produced results acceptable to a recreation area manager. These were: (1) the application of at least one-half pound of Gardona^R acaricide per acre after the area had been freed from underbrush and the grass clipped closely; and (2) the application of one pound of Gardona^R acaricide directly to the existing vegetation (brush and tall grasses) and earth surface.

In established recreation areas at least two applications of acaricide per year would probably be required for good control of ticks. These being applied at the beginning of adult tick season (about April 15) and one at the beginning of larval tick season (about July 1). The requirements of various areas may vary considerably, depending on factors such as weather conditions following application of the acaricide and animal activity in the area following treatment.

Five different formulations of the acaricide, Gardona^R, were applied to tick infested areas to evaluate the effectiveness and longevity of the various formulations. Five and ten percent granules, five and ten percent dusts and 75 percent wettable powders were applied at either one-half or one pound actual per acre.

Both dust formulations immediately produced 100% mortality and maintained over 99% control for over nine weeks (until end of tests). Granules were slow to act on larval ticks, but satisfactory results were eventually obtained. It is therefore suggested that these formulations of granules be distributed at least one month before the problem is expected to exist. Wettable powders produced effective control for slightly over four weeks. This could vary quite much depending on reinfestation pressure.

Animal exclusion by chemical repellents as a means of preventing recreation areas from becoming reinfested after acaricidal treatment was investigated. Test areas were ridded of ticks by treating the areas with one pound per acre of Gardona^R. In replicated plots the Gardona^R treatment was followed with an application of Zip^R, a deer and rodent repellent. Plots receiving Gardona^R plus Zip^R were compared to plots receiving only Gardona^R or either no treatment.

Though results were not especially impressive due to abnormal animal activity in the area, there was some indication that the repellent might have accounted for an additional 13% control for a period of six weeks.

Deer herd treatment as a means of area tick control now seems to be highly possible in areas where deer are already closely managed (i.e., recreation areas, National Forests, parks). Treatment stations for deer were set up in a 14,000 acre game refuge. A systemic insecticide, Ronnel^R, was administered to up to 75% of the deer herd in the test area at a time of year when deer are most difficult to manipulate. Seventy-three percent mortality occurred in ticks collected from treated deer. This was 43% higher than in the control group.

Approximately 65% of the ticks observed on deer exposed to Ronnel^R were less than 25% engorged, whereas near 90% on untreated deer were over one-fourth fed.

In the eradication of Boophilus annulatus (Texas Cattle Fever Tick) from the United States during the first half of this century, deer posed a major obstacle in this program. Now that there is some indication that this pest is back with us as of 1968, deer herds may not have to be eliminated in infested areas if the herd can be treated with an effective systemic pesticide.

Pasture rotation and cattle dipping should greatly reduce lone-star ticks on an area basis if procedures are properly carried out. In our tests

where cattle were allowed to occupy a given pasture for one month, treated, and then rotated to a second pasture, it was clearly shown that ticks were feeding to repletion and dropping off within 14 days after rotation and treatment. Thus the area was being reinfested before the cattle were dipped the next time. Since efforts being made by our project were of an advisory and evaluation nature, we could not change the set procedures of the Oklahoma Wildlife Conservation Department during 1968. However, based on our recommendations these animals will be dipped every two weeks during the summer of 1969. This method of tick control will be evaluated further at this time.

Cost estimates for treating 125 acres of established recreation area (Tenkiller State Park) in eastern Oklahoma during the summer of 1968 were assembled. Costs on acaracide, labor, equipment and miscellaneous expenses were kept, or estimated, for two applications of Gardona^R to a well used park.

One hundred twenty-five acres of Tenkiller State Park were maintained during the summer of 1968 at a cost of less than \$2.30 per acre, or at a cost of \$1.75 per thousand visitors.

Lone-Star Tick Biological Studies. - A study on the seasonal distribution of various stages of the lone-star tick showed adult activity in 1968 beginning between April 1 and April 15 and ceasing near the end of July. Nymphal activity began at essentially the same time as adult activity, peaked in early June some 10 days after the peak of adult activity, and numbers gradually decreased until a cessation of activity in early October. Like adults, larvae were more seasonal than nymphs, appearing in late June and remaining quite prevalent until late September. Numbers rapidly dropped in late September, but light activity was noted into early November.

Data on the seasonal distribution is of paramount importance when we are planning pre-emergence treatments for certain stages of the lone-star tick.

Young deer fawns were collected from their natural habitat in an effort to estimate losses of hunter recreation due to ticks in eastern Oklahoma. Blood samples were taken and blood readings correlated with tick infestations in an effort to ascertain the detriment caused by various intensities of infestations.

Findings indicated that a minimum of 20% of all fawns in the area surveyed are lost each year due to ticks. Work on artificially infested penned fawns, when correlated with field data, indicated that up to 50% of the field fawns are apt to be lost. These figures may vary considerably from year to year, depending on tick abundance for that particular year. As few as 30 adults were found to be capable of producing death in penned fawns.

Since animals are responsible for the presence of ticks in a particular area, it is of great importance to determine the principal hosts for the pest in that particular region. Biological data such as seasonal and geographic distribution, abundance and preference for hosts were collected in this study. Immature forms of the lone-star tick expressed no preference for particular hosts. Size was not a factor since immatures were found on animals ranging in size from the white-footed mouse to a mature cow. Lone-star adults seemed to express a definite preference for larger mammals. Seldom were reproductive forms found on animals as small or smaller than the racoon. Cattle, horses, and deer seemed to be the most important blood sources for adults.

Studies on the association between ticks and vegetation indicated that short-grass was not particularly favorable for any stage of the lone-star tick. Oak-hickory woods with a heavy canopy supported the largest numbers of adults and fair numbers of immatures.

Observations on masses of larvae on plants indicated that they move very little unless exposed to direct sunlight. Little up and down movement on the plant occurs unless the larvae are stimulated by a passing animal. If dislodged many fail to reappear on vegetation but some reassemble in small clusters on nearby vegetation.

Strong wind and heavy rains appear to be quite detrimental to masses of larval ticks since once dislodged many apparently perish. Direct sunlight is objectionable since larvae always appear on the plant surfaces opposite the side of impinging sun rays.

It should be evident to the average reader that many phases of these demonstrations are in bad need of further work before firm answers are formulated. It is our feeling that work has been started in several badly neglected areas and that with the continued support of local, state and federal officials, answers to many of our questions on tick control can be derived.

PENN STATE UNIVERSITY LIBRARIES

A000070941982