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Environmental and host interrelationships and life history of the Gulf Coast tick (Amblyomma maculatum Koch) in southern Georgia

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ENVIRONMENTAL AND HOST INTERRELATIONSHIPS AND LIFE HISTORY OF THE GULF COAST TICK
(AMBLYSOMMA MACULATUM KOCH)
IN SOUTHERN GEORGIA

BY

Homer Hixson

A Thesis submitted to the Graduate Faculty for the Degree of
DOCTOR OF PHILOSOPHY
Major subject Entomology

Approved
Signature was redacted for privacy.

In charge of Major work
Signature was redacted for privacy.

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Signature was redacted for privacy.

Dean of Graduate College

Iowa State College

1937
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INTRODUCTION

As early as 1912 the Gulf coast tick, *Amblyomma maculatum* Koch, was known to create conditions in the ears of domestic animals conducive to screw worm infestations. The importance of this tick as a predisposing factor to screw worm infestations apparently was not realized, however, until revealed by the investigation of the recent screw worm outbreak in the south-eastern section of the United States.

Farmers of southern Georgia have cited cases where flocks of from two to three hundred sheep were practically exterminated by the screw worm during the progress of this outbreak. It was not uncommon to hear of flocks that were reduced to less than half their original number.

Livestock farmers in general expressed the belief that ticks were the major cause of heavy screw worm infestations, and that the screw worm would be of minor importance if the ticks were controlled. Their opinion was biased by the local conditions.

Twenty-six sheep, from a flock of less than three hundred, were observed in Berrien County, Georgia, September 25, 1935, under treatment for screw worms. The cases were all in the ears and evidently caused by tick infestations. The range rider reported that forty head were up for treatment about a
week earlier. This flock of sheep was heavily infested with ticks at that time.

Considering the lack of care that range sheep receive in the southeast, it becomes apparent why the tick is of such major importance in building up the screw worm incidence. Sheep are usually turned onto open range after being shorn in May, and receive no further attention, especially during the summer. Sheep were managed in this way, especially before the screw worm outbreak. Thus, through tick infestations the conditions became optimum for screw worm activity. This management accounts for the fact that farmers lost so many of their sheep. The majority of sheep owners in southern Georgia sold their sheep on account of the heavy losses.

The influence of the tick in the screw worm outbreak in the southeastern region was also shown by the Screw Worm Control Division through its classification of the predisposing causes of screw worm cases reported in 1935. Over fifty percent of the cases reported in Georgia during August were listed as originating from tick bite. The percentage was even higher in Louisiana. This estimate is probably low since the tick operates under range conditions where many cases are never seen, while other predisposing causes such as surgical operations and injuries caused by dogs, and birth of young are more likely to come under the observation of the owner.
As soon as the part the Gulf coast tick played in the high incidence of screw worm cases was realized, its control was seriously considered in the fight against the unusual activity of this wound-infesting fly, *Cochliomyia americana* Cushing and Patton.

The sudden realization of the economic importance of the Gulf coast tick created a need for further information on the methods of control. The problem, as a consequence, was considered from every angle that offered a possibility of practical control. Winter-burning of range areas, host eradication, and ear treatment of domestic animals offered possibilities as methods of control.

In order to make a fair study of these possibilities, further information concerning the activities of this tick in nature was essential. Consequently, the life history, habits, and host and environmental relationships of this tick in the field were studied in order that the information might be applied in developing the control methods.

The methods used in making this study under natural conditions are interesting since the data obtained at the laboratory correspond so closely with those taken in the field. The rainless periods that occurred in the spring and summer of 1936 were such that the effect of the climatic factors on the existence of this tick gave some interesting results. This information gave a clue to the major causes of the restricted
distribution of this species.
Publications on the Gulf coast tick previous to 1936 have recorded only a few observations on oviposition, engorgement, development and longevity. Listing of hosts of the immature stages has been somewhat limited.

Bishopp (2) reports that this species occurs along the seacoast in the United States from the southern part of South Carolina to the region along the Gulf of Mexico in Texas. Robinson (9) lists it as having been recorded from Mexico, Jamaica, West Indies, Colombia, Peru, Ecuador, Chili, Brazil, Paraguay, Uruguay, Argentine Republic and Patagonia.

Hunter and Hooker (6) record cattle, horses, dogs and man as hosts of the Gulf coast tick. Hooker, Bishopp and Wood (5) add sheep, goat, and wolf to the host list. Bishopp and Hixson (2) add coyote, skunk and deer.

Bishopp (1) records the meadowlark, Sturnella magna; red-winged blackbird, Agelaius phoeniceus; Brewer’s blackbird, Euphagus cyanocephalus; jack rabbit, Lepus californicus merriami; and the quail as hosts of the nymph. Hooker, Bishopp and Wood (5) add fox to the list. Bishopp and Hixson (2) add the Carolina wren, Troglocytes ludovicianus.

Bishopp and Hixson (2) record the meadowlark, Sturnella
magna; bobwhite, Colinus virginianus; house wren, Troglodytes aedon; towhee, Pipilo erythrophthalmus; migrant shrike, Lanius ludovicianus; gray squirrel; Sciurus niger; cotton rat, Sigmodon hispidus; sheep as hosts of the larva.

Robinson (9) lists the following hosts as having been recorded from foreign countries: Cervus canadensis; Podinema teguixin; Hydrochoerus hydrochoerus; dogs; horses; cattle; Canis azarae, Canis griseus; Notilura maculosa (?); and Rhynchotus rufescens.

The biology has been studied by Lahille (1905), Hunter and Hooker (1907), Hooker (1908), Newstead (1909), Hooker, Bishop and Wood (1912), and Bishop and Hixson (1936).

Hunter and Hooker (6) found that 5 to 8 days were required for the engorgement of larvae. The incubation period of the eggs ranged from 26 to 31 days. Longevity of seed ticks was approximately five months.

Hooker (4) found that the larva may engorge in 3 days and molt in 11. The nymph engorged in 5 days. The maximum number of eggs deposited was recorded as 11,265.

Hooker and Bishop (7) state that this tick attaches in clusters and causes considerable irritation.

Hooker, Bishop and Wood (5) found that the larva may live 6 months in the winter and 112 days in the summer. Engorged larvae molt in 7 days. Engorged nymphs molt in 17 days.
The longevity of the adult was recorded as 388 days. They observed that mating occurs on the host. Females engorge as soon as 14 days following attachment and begin ovipositing as early as the third day after dropping. Eggs hatch as soon as 21 days after deposition. They also observed that injuries in the ears of hosts, caused by the adult, are vulnerable to screw worm attack.

Bishopp and Hixson (2) record the female depositing 18,497 eggs. Larvae attach on the head and neck of the hosts. Engorged larvae and nymphs develop among vegetation.

The investigations recorded concerning the Gulf coast tick have given a partial account of the field activity of the different phases. Definite information on sexual activity and engorgement of the female has not been recorded. The relation of climatic factors on the existence of this tick has only been surmised.
PLAN OF STUDY

In this investigation the plan of study was developed as each problem presented itself. The field investigation preceded and acted as a guide in developing the study at the laboratory and experimental farm. The forms extant in nature were studied at the laboratory as a complement to the field investigation.

This investigation was begun the latter part of September, 1935 while the parasitic forms of the adult stage were still showing considerable activity; consequently, field biology was neglected at the time in favor of the ear treatment investigation which was the primary object of the project assigned. The incidence study, pertinent to the ear treatment investigation, served as a basis, nevertheless, from which to develop the biological study in general.

In seeking the natural interrelationship of this species, the fauna, flora, and topography of the range of the principal hosts were studied. The vegetative cover and soil conditions were of interest since they constitute the habitat of every phase of this tick. A knowledge of the habits and relative abundance of the hosts of each stage was sought in order to determine the host relationship. The relationship of the parasite to the host was studied at the laboratory and experimental farm under conditions simulating those on the range.
The natural adjustment of each biological form of this tick was studied in high concentrations in outdoor enclosures constructed in a plant association typical of the range of the principal hosts. In this arrangement the ticks were exposed to conditions characteristic of their natural habitat; consequently, their adjustment, development and longevity was almost certain to coincide with that of those existing in nature.

The climatic factors were studied through their effects on the tick environment and population in the field and confirmed through contemporary studies made under laboratory conditions. Records of the climatic conditions were obtained from the United States Weather Bureau and the experimental farm at Valdosta, Georgia.

The meadowlark, which was found to be the most important host of the immature stages in southern Georgia, was collected more or less regularly in order to determine the seasonal activity and abundance of the parasitic forms of these stages.

Sheep ranging in a pasture known to be heavily infested with the Gulf coast tick were examined at weekly and biweekly intervals in determining the seasonal activity and abundance of the adult stage.
APPARATUS

The apparatus used in the study of the Gulf coast tick was planned and developed to promote the efficiency of the task and still retain the natural association of the parasite.

Sheep were used as hosts in all the studies of the parasitic phase of the adult stage.

To facilitate the process of infesting sheep with adults, an apparatus which will be called an infesting stanchion was devised. A diagram of the top view is shown in figure 1. The mechanical part of this device was built in the top of a portable rectangular frame having a clearance about equal to the height of the average tall sheep.

To adjust it in this device, the animal was placed so the neck was between bars A and B and well forward so the front of the neck was in contact with bar C. Bar B was adjusted to take up the slack at the sides of the neck and bar D was swung around into position and fastened at the point where it rested against the back of the neck.

Sheep were able to stand in a natural position and readily adjusted themselves to this apparatus; consequently, very little resistance was offered and interference with the infesting procedure was practically nil.
Fig. 1. Infesting stanchion, top view.
The head of an animal retained in this device was held above and in the center of the front part of the framework. A cloth, with an opening in the center, through which the animal's head was inserted, covered the framework to form a platform around the animal's head. The opening in the cloth was arranged so that it could be drawn closely about the animal's neck in order to prevent the loss of ticks that fell or wandered away from the animal during the infesting process.

In order to collect fully engorged females, a collecting stanchion was arranged. This device was constructed with an ordinary stanchion attached to a shallow box in such a fashion that the head of the animal retained in the stanchion was held continuously over the box. The spaces on both sides, from the distal corners of the box to the top of the uprights of the stanchion, were inclosed with sheeting.

Engorged ticks that detached or were flung from an animal retained in this device, were caught in the box. Moist sand and hay kept in the box simulated somewhat the natural habitat of the engorged female, thereby abating its tendency to leave the box immediately after dropping.

Feed was kept in the box and water supplied in a container on a rack as high and as far to the front as the animal could conveniently reach in order that the animal could be retained in the device as long as desired.
By this arrangement the animal was able to lie or stand, but the freedom of the head, the mechanical action of which is ordinarily instrumental in detaching the engorged ticks, was somewhat restrained.

The outdoor enclosure which was the most important asset to this study was constructed with four glass window panes 8" x 12" set in the soil in such relation that the edge of pane number one was in conjunction with the side near one end of pane number two. The opposite end of pane number two was adjusted in the same fashion against the side of pane number three, and so on until each of the four panes stood in the same relative position to each other, forming an enclosure approximately a foot square. The vegetation within was not disturbed in setting up this enclosure.

The panes of this enclosure were fitted together so closely that escape at their juncture by any form of this tick was impossible. A ridge of white petrolatum was mounted along the rim of the enclosure to prevent escape by crawling over the glass walls. The vegetation that grew to extend over the walls was kept cut back in order to counteract that avenue of escape. This arrangement goes without criticism for study of the Gulf coast tick under natural conditions.

Outdoor studies were also made in wide mouthed bottomless fruit jars covered with sheeting and 25 mm. and 16 mm. glass tubing which were also inclosed with sheeting. These glass
instruments were set in the soil among vegetation. Vegetation was also enclosed by the container. The condensation of moisture on the inside of these containers was favorable to longevity but many larval specimens drowned in positions where the moisture condensed and remained for several days.

The medium-sized stender dish was used in indoor studies on oviposition and incubation. This chamber was prepared for the replete female by filling it to a depth of about a quarter of an inch with sand which had been scalded and washed free of organic matter. The sand was kept moderately moist with distilled water. The lid of the vessel was kept in place in order to retain a high humidity.

The device used in the laboratory for developmental studies was the same as that described and figured by Hixson (3), with one exception. Cloth covered one-hole corks were used, instead of cellu-cotton plugs, to inclose the animal chamber. Henceforth this device will be referred to as a sand humidor.

The meadowlark was used as the host in the studies of the engorgement of the immature stages. Hardware cloth cages 7" x 8" x 9" mounted over baking pans 2" x 9" x 13" were used to retain the hosts for studies of the engorgement of the immature stages.
PROCEDURE OF INVESTIGATION

The basis of the procedure used in this investigation evolved from a study of the adult forms of the Gulf coast tick on sheep at the close of their active season in 1935. The knowledge of this association led to the subsequent study of the range of sheep which yielded, after an extended study, a fairly complete perspective of the biological relationship of this species in nature.

The study of the cover and topography of the range was the first step toward arranging a set-up to study the extant forms of this tick under natural conditions at the laboratory. To study the activity and oviposition of the replete female exposed to the same conditions as those in nature, the outdoor enclosure was arranged. Other schemes of study were developed in a similar fashion.

In order to study the normal activity of the engorged female, replete females that detached of their own accord were obtained by placing a sheep infested with engorging ticks in the engorgement stanchion. Replete females were removed from the box of the engorgement stanchion and dropped into an outdoor enclosure for observation.
In order to prevent unnecessary disturbance of the natural cover in making observations on oviposition and incubation in the outdoor enclosures, several schemes were used. In cases where oviposition occurred in an open place, observations could be made without any derangement of the vegetation. When this was not the case, the time required for preoviposition and incubation combined was ascertained by determining the beginning of host-seeking activity of the newly emerged larvae. By this method, the conditions under which the engorged females adjusted themselves were not disturbed. For more detailed study of females ovipositing under cover, the activities of females, exposed to view in tender dishes, were used to gauge the observations of those in the outdoor enclosures.

To determine the beginning of host-seeking activity of larvae, the hand was placed among the vegetation. Active larvae coming in contact with the hand cling readily to its surface.

The native hosts of the immature stages of the Gulf coast tick were determined by collecting and examining vertebrate animals that showed ground inhabiting-tendencies.

Collections and examinations of possible hosts were made in the following manner: As soon as an animal was taken it was placed in a paper bag of suitable size which was folded and creased from the top until the space within was filled with the specimen; then, a rubber band was placed around the
bag to hold the folds in place until the specimen was examined at the laboratory. Notes pertaining to the collection were written on the paper bag.

In collecting the meadowlark, the feathers were picked from the head and neck as soon as the bird was taken. If the specimen was found infested, the head was segregated from the body at the base of the neck. Each part was placed immediately in a separate bag and reserved for further examination. After it was found that the head and neck of birds bore the entire infestation, the examination of the body was discontinued and only the portion known to carry the infestation was reserved for examination. A quarter-pound size paper bag was used for this purpose.

A systematic examination of each specimen was made at the laboratory by tearing the paper bag until the entire inside surface was exposed. Then, the inside surface of the paper bag and the enclosed specimen were thoroughly searched. All ecto-parasites were placed in an open dish of 70% alcohol for determination and counting. The species of tick, number in each stage of development, state of engorgement, the host, the date and locality of collection were recorded. In the case of the meadowlark, the flock or specific locality from which the particular specimen was taken was recorded.
Field studies of individual infestation, habits and abundance of each native host were made in order to determine the relative importance of each species as a host.

The seasonal activity and abundance of larvae were determined by collecting and examining meadowlarks at irregular times during biweekly intervals.

The study of the host-seeking activity of the free parasitic larva was made in outdoor enclosures, stender dishes, and open vegetation at the laboratory. Their reaction in the presence of a host was observed in closed and open environments. The dispersion of the larvae from an egg mass was studied in open vegetation.

In the dispersion study, a mass of hatching eggs was placed on the soil beneath a normal growth of native vegetation and the distance of migration was noted at various intervals. The determination of the extent of migration was made by locating larvae at various distances away from the point where hatching occurred.

Longevity studies were made in outdoor enclosures, bottomless fruit jars and glass tubing. The larvae were observed at weekly intervals from the time the eggs began hatching until the study terminated with the disappearance of the last survivors.

Birds were infested in the laboratory by placing larvae on the feathers of the crown of the head. As soon as the
larvae disappeared among the feathers, the bird was returned to its cage. The number of larvae with which meadowlarks were infested ranged from relatively few to numbers ranging between three and four thousand per bird.

Engorged larvae were collected from the water below the host twice daily and placed in the sand humidor in groups of 100 for development.

The free parasitic nymph was studied in the same manner as that given for the larva with a few exceptions. The maximum number of nymphs placed on the meadowlark ranged from 100 to 125. Engorged nymphs in aggregations of 25 to 40, depending on the size of the animal chamber, were placed in the sand humidor for development.

The host-seeking activity of the free parasitic adult in the field was determined by weekly and biweekly examinations of sheep ranging in a pasture known to be infested. The weekly examinations were made when the activity was at its height. Activity in vegetation was observed in outdoor enclosures at the laboratory. Longevity studies were made in the outdoor enclosure and the sand humidor.

The habits governing the localized attachment of the adult were studied during the infesting process. To infest a free animal, it was placed in the infesting stanchion. Ticks were placed in the animal's ear with a camel's hair brush or by allowing them to crawl directly from the animal chamber of
the sand humidor onto the ear.

To cause the ticks to forgo the tendency to crawl about freely, the ear of the animal was swung vigorously to and fro in a fashion simulating the natural response of the animal. The disengaging force set up by this procedure caused the tick to cease crawling and cling to the hair of the animal. Repetition of this procedure developed a tendency in the tick to move in among the hair. From this position the tick proceeded to attach of its own accord. Attachment could be promoted, however, by gently prodding the tick until it had penetrated to the skin of the animal. The animal was left in the infesting stanchion from two to three hours to allow the ticks to become firmly attached. The resistance of the animal to newly acquired infestations was usually ineffective if the ticks were allowed to become firmly attached.

Infested animals were further infested by simply placing the free ticks among those already attached.

The parasitic phase of the adult stage which includes sexual relationship and engorgement, was studied by daily observations of infested sheep kept in a small pasture at the experimental farm.

Sheep were infested with females alone to determine whether or not the presence of the male was essential to engorgement.
The period required for the male to reach sexual maturity was determined by removing males from the host after they had been attached among females for definite intervals of time. Copulation and engorgement of the female were the criteria on which evidence of sexual maturity was based. To determine the number of days required to reach sexual maturity, males which were allowed to attach among females were removed after two days. If the females failed to engorge the animal was infested with a new set of six or more males which were allowed to remain attached three days. This procedure was repeated and the time extended to four days, then to five days and to six and seven days. Copulation was provoked by allowing free females to crawl over the bodies of the attached males. This method was used in determining the earliest period that males will copulate after attachment to the host.

The engorgement period of the female was determined by daily observations made from the time of attachment to the detachment of the engorged female. The sexual status of the males in this study was known. This study was made on sheep ranging in a small pasture.

The study of engorgement was approached from three angles. Sheep free of ticks were infested with both males and females simultaneously. In this case, copulation was based on the position of the male. Sheep infested with mature males were
infested with females. Copulation, in this case, was observed at the time of infestation. Sheep infested with infertile females were infested with sexually mature males by transferring them from other animals. Mature males were induced to detach by allowing free females to crawl over them. The transfer was made with a camel's hair brush.
LIFE HISTORY AND HABITS

The study of the life history and habits of the Gulf coast tick in southern Georgia began the latter part of September, 1935. At that time the larval stage was at the height of its prevalence, the prevalence of the nymph was moderate and the incidence of adult on sheep was comparatively high although its normal host-seeking activity had almost ceased. This study was carried from this point in the life cycle to its status in December, 1936.

Preoviposition, Oviposition and Incubation. The engorged female, during the preoviposition period, seems to be mechanically controlled in locating a place suitable for oviposition. Its movements are apparently governed by negative phototropic behavior. It ordinarily seeks a secluded position under vegetation. If the vegetation is sparse, however, the female crawls about extensively and locates under bark or other objects offering seclusion. The engorged female may burrow slight excavations in the surface of the soil occasionally.

The length of the preoviposition period varies from four to six days, almost without exception, under conditions prevailing during the time when the incidence of the adult on hosts in nature is sufficient for engorgement to occur to an
appreciable extent. The length of this period, however, may be extended to anywhere from 7 to 58 days depending on the temperature. The number of females engorging late enough in the year to come under these conditions, however, is very few.

Only one case has been observed in which oviposition began as early as the third day following detachment.

Engorged females invariably deposit their eggs on the surface of the soil under vegetation, tree bark or other objects. Sometimes the eggs are deposited in shallow excavations.

The number of eggs deposited under optimum conditions depends on the size of the replete individual. An unusually large female measuring 18 x 15 x 10 mm. deposited 18,497 eggs. Hooker, Bishop and Wood (5) record 8,000 as the average number of eggs deposited by this species. The fertility of the eggs is almost invariably 100 percent.

The length of the incubation period is conspicuously influenced by temperature. Even variations in vegetative cover within a small space may alter the temperature sufficiently to cause a marked difference in the incubation period.

The incubation period normally ranges from 19 to between 50 or 60 days or it may extend through the winter to the following spring. During the season of normal parasitic activity of the adult, however, the eggs ordinarily hatch in from 19 to 28 days. It is only during the latter part of
September and thereafter that eggs require a longer time for development.

The time required for engorged females to complete oviposition varies according to the temperature. Eggs hatch in the order in which they are deposited. The time required for one mass of eggs to hatch is also dependent on the temperature. The shortest period observed was six days. During periods of low temperature range, hatching of a mass of eggs may extend over a period of a month or more.

Field data give an interesting study relative to the time required from engorgement of the female to the beginning of larval activity. The presence of both the male and female on the host was used as a criterion to engorgement which, under field conditions, closely follows female attachment. The appearance of larvae on the meadowlark is used as the criterion of larval activity. The corresponding increase in incidence of both phases is illustrated in figure 2. The data on which this figure is based are given in Tables I and II. Table I was prepared from data on the tick incidence on thirty head of sheep each of which was examined on the dates shown in the table.

The percentage of animals infested with both males and females began to show a definite increase the fourth week in June. The incidence rose from 25 percent to 37 percent to 73 percent during the period from June 9 to July 7. The
Fig. 2. Percentage of sheep infested with both sexes of the Gulf coast tick and percentage of meadowlarks infested with larvae.
### TABLE I. MALE AND FEMALE INCIDENCE OF THE GULF COAST TICK ON 30 REGULARLY EXAMINED SHEEP.

<table>
<thead>
<tr>
<th>Date examined</th>
<th>Number of ticks:</th>
<th>Percentage of animals:</th>
<th>Infested females with males:</th>
<th>Percentage</th>
<th>Number of females:</th>
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<tbody>
<tr>
<td>April 28</td>
<td>6</td>
<td>1</td>
<td>20</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>May 12</td>
<td>26</td>
<td>8</td>
<td>60</td>
<td>23</td>
<td>1</td>
</tr>
<tr>
<td>May 27</td>
<td>26</td>
<td>5</td>
<td>67</td>
<td>17</td>
<td>1</td>
</tr>
<tr>
<td>June 9</td>
<td>42</td>
<td>16</td>
<td>90</td>
<td>23</td>
<td>3</td>
</tr>
<tr>
<td>June 23</td>
<td>42</td>
<td>16</td>
<td>97</td>
<td>37</td>
<td>4</td>
</tr>
<tr>
<td>July 7</td>
<td>53</td>
<td>74</td>
<td>97</td>
<td>73</td>
<td>46</td>
</tr>
<tr>
<td>July 20*</td>
<td>115</td>
<td>165</td>
<td>100</td>
<td>73</td>
<td>105</td>
</tr>
</tbody>
</table>

*This is a summation of data taken July 13 and 20.*
TABLE II. INCREASE IN THE INCIDENCE OF THE LARVA OF THE GULF COAST TICK ON MEADOWLARKS IN JULY, 1936.

<table>
<thead>
<tr>
<th>Date examined</th>
<th>No. birds</th>
<th>Percentage</th>
<th>Ave. no.</th>
<th>Calculated no.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>collected</td>
<td>birds in-</td>
<td>fested</td>
<td>fested</td>
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<td>July 5-12</td>
<td></td>
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</tr>
<tr>
<td>July 13-20</td>
<td></td>
<td>10</td>
<td>20</td>
<td>2.5</td>
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<td>July 21-28</td>
<td></td>
<td>9</td>
<td>78</td>
<td>10.7</td>
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<td>July 29-Aug. 5</td>
<td></td>
<td>8</td>
<td>88</td>
<td>18.2</td>
</tr>
</tbody>
</table>

corresponding period in July shows a like increase in the percentage of meadowlarks infested with larvae. These data are evidence that about one month, under field conditions, is required from engorgement of the female to the beginning of larval activity.

Some typical examples of studies made under various conditions at the laboratory give evidence of the ordinary and extremes in these first phases of the life cycle.

Two females that engorged July 30, 1936, were placed in an outdoor enclosure. Larvae from these females were active September 3.

An engorged female that detached August 12, 1936, was placed in a stender dish in the laboratory. The eggs from this female began hatching September 3, embracing a period
of 22 days.

Larvae from seven females which were placed in an outdoor enclosure August 28, 1936 began to show activity September 30. Thousands of larvae were active in this enclosure by October 5.

Of three engorged females that detached September 2, 1936, one was placed in a stender dish in the laboratory. This female began oviposition September 6. The eggs began to hatch September 25 and hatching was complete October 1. Another female was placed in a stender dish sunk in the soil in light vegetation. The eggs from this female began hatching around September 28. The last female of this group was placed in a stender dish under dense vegetation. The eggs from this female began hatching October 2.

A female that detached October 1, 1936 was placed in an outdoor enclosure. This female began ovipositing October 8. Oviposition was apparently complete October 17. The eggs began to hatch November 24 and only about one-half of the eggs had hatched by December 22.

Three females that engorged September 27, 1935, were placed in an outdoor enclosure. One had begun to oviposit October 2. The eggs of one female which located in fairly light vegetation, began hatching November 14. The eggs of a second female were deposited in a slight excavation in the soil under fairly light vegetation. This mass of eggs began hatching November 26. The eggs of the third female were deposited under heavy
vegetation. On January 18, these eggs were still in the early stages of development. A few eggs from this mass were placed in a stender dish in the laboratory. They hatched about two weeks later. The other eggs were transplanted in another outdoor enclosure and were destroyed by mold.

The difference in the developmental time in the original enclosure was evidently due to temperature variations. The variation was caused by the relation of each mass of eggs to the direct sunlight, the soil and especially vegetative cover. The egg mass deposited by the first female was protected from the heat of sunlight only by light vegetation; that deposited by the second female was protected by light vegetation and the soil; that by the third was protected from the heat of the sunlight by dense vegetation and the cooling effect of the soil was not counteracted.

An engorged female which detached September 29, 1935, was placed in a sparsely vegetated enclosure. Oviposition began under a piece of bark October 5. The eggs began to hatch November 10.

A female that detached November 4, 1935, began ovipositing November 7. The eggs began to hatch December 9. This female was kept in the laboratory on moist sand in a small ointment jar.

Three females were placed in an outdoor enclosure between November 4 and 11, 1935. One of these began oviposition on
November 8, and two others November 11. The respective pre-oviposition periods were 4, 5, and 6 days. The eggs did not begin hatching until the first week in April, 1936.


Other observations made on female ticks in various containers such as fruit jars, pill boxes and outdoor enclosures were in common agreement with the data given above.

Larva. Newly hatched larvae congregate on the surface of some object near the remains of the egg mass and remain immobile for a period of one to two days. Thereafter they exhibit a tendency to crawl about at irregular intervals. This is especially true during periods of relatively high temperatures.

Larvae from one mass of eggs may migrate a radial distance of about three feet in the first ten days following hatching. An area with a radius of approximately six feet may be occupied within a month. This spread is due to intermittent activity which is accelerated by the presence of a host.

During periods of inactivity the larvae are found assembled in flat clusters on the lower surface of grass blades or leaves of other vegetation. These clusters are usually located on parts of plants extending into open spaces.
among low vegetation, at elevations varying from two to six inches from the ground.

Animal odor is the stimulus which excite ungorgerd larvae to activity. Larvae are usually found clustered on the underside of some object. When they sense the approach of a host the forelegs are soon extended out around the edge of the object giving it a pubescent appearance. Host-seeking activity does not cease as long as the animal odor is present. Many larvae continue to crawl actively about and others wait in small clusters, with the forelegs extended, at terminal points on the vegetation. The larvae gradually return to inactivity when the odor is dispelled. Larvae in closed glass containers show no activity on the approach of a host unless the container is opened.

Larvae cling tenaciously to any object with which the extended forelegs come in contact. One larva of a waiting cluster, on contacting a moving object, may swing a chain of a variable number of larvae onto the object. They cling to each other in the waiting stance.

The incidence of the larva on meadowlarks is shown graphically in figure 3 and also in the summarized data presented in Table III. The greatest incidence of this form occurred from the latter part of July to the middle of November in 1936. In 1935 the incidence decreased in the latter part of November and remained comparatively low throughout the
Fig. 3. Biweekly average of daily maximum temperature and calculated number of Gulf coast tick larvae and nymphs per hundred meadowlarks based on collections made in 1935-'36.
### TABLE III. INCIDENCE OF THE LARVA AND NYMPH OF THE GULF COAST TICK ON MEADOWLARKS.

<table>
<thead>
<tr>
<th>Inclusive dates</th>
<th>No. of birds</th>
<th>Larva</th>
<th>Nymph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct. 14-27</td>
<td>3</td>
<td>100</td>
<td>32.0</td>
</tr>
<tr>
<td>Oct. 28-Nov. 10</td>
<td>10</td>
<td>70</td>
<td>45.5</td>
</tr>
<tr>
<td>Nov. 11-24</td>
<td>16</td>
<td>81</td>
<td>38.4</td>
</tr>
<tr>
<td>Nov. 25-Dec. 8</td>
<td>26</td>
<td>35</td>
<td>8.7</td>
</tr>
<tr>
<td>Dec. 9-22</td>
<td>10</td>
<td>20</td>
<td>1.5</td>
</tr>
<tr>
<td>Dec. 23-Jan. 5</td>
<td>20</td>
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<td>0.0</td>
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<td>Jan. 6-19</td>
<td>21</td>
<td>5</td>
<td>1.0</td>
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<tr>
<td>Jan. 20-Feb. 2</td>
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<td>6.4</td>
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<td>Feb. 3-16</td>
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<td>Feb. 17-Mar. 1</td>
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<td>Mar. 16-29</td>
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<td>11</td>
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<td>0.0</td>
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<tr>
<td>Apr. 27-May 10</td>
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<td>0</td>
<td>0.0</td>
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<td>May 11-24</td>
<td>17</td>
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<td>0.0</td>
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<td>May 25-June 7</td>
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<td>0.0</td>
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<td>June 8-21</td>
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<td>0.0</td>
</tr>
<tr>
<td>June 22-July 5</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>July 6-19</td>
<td>14</td>
<td>14</td>
<td>2.5</td>
</tr>
<tr>
<td>July 20-Aug. 2</td>
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<td>11</td>
<td>64</td>
<td>13.9</td>
</tr>
<tr>
<td>Aug. 17-30</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Aug. 31-Sept. 13</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sept. 14-27</td>
<td>8</td>
<td>75</td>
<td>45.8</td>
</tr>
<tr>
<td>Sept. 28-Oct. 11</td>
<td>12</td>
<td>42</td>
<td>31.8</td>
</tr>
<tr>
<td>Oct. 12-25</td>
<td>7</td>
<td>71</td>
<td>28.2</td>
</tr>
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<td>Oct. 26-Nov. 8</td>
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<td>90</td>
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<td>Nov. 9-22</td>
<td>17</td>
<td>65</td>
<td>12.9</td>
</tr>
<tr>
<td>Nov. 25-30</td>
<td>7</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
remaining existence of that generation. Low temperature and decrease in abundance are the factors diminishing the incidence in the later periods. The meadowlark is seldom infested in the field when the daily maximum temperature remains below 65°F.

The abundance of larvae in the field was indicated as comparatively low in the latter part of January, 1936. There was no indication of its presence in the middle of March and its abundance was too low to show an incidence on meadowlarks at the end of the month.

These data are supported by the disappearance of larvae in an outdoor enclosure in the latter part of March, 1936. The eggs from which these larvae developed were deposited by two females that engorged the last week in September, 1935 when the host-seeking activity in the field had practically ceased. These eggs began hatching the second week in November.

Through the correlation of these data it is deducted that parasitic larvae reached the end of their natural existence in March, 1936, thus indicating that about four months was the length of life of this form in the field during the winter of 1935-36.

Because of the decreased host-seeking activity at low temperatures and its limited longevity, the parasitic larva is of comparatively little importance to the propagation of this species after the biweekly maximum temperature average falls below 65°F. This combination of circumstances is probably
a factor in restricting the distribution of the Gulf coast tick to the south.

Observations of larvae at the laboratory resulted in data that supplied some definite information on the longevity.

Two to three hundred larvae from eggs that began hatching September 3, 1936, had decreased in numbers the second week in November. Only one larva was present the first week in December and it had disappeared by the second week of that month. This study was made in an outdoor enclosure.

Larvae, from the eggs of seven females that began to hatch the last week in September, 1936, had decreased in number to a marked extent by the third week in December. This study was made in an outdoor enclosure.

Larvae from eggs that passed the winter and began hatching the first week in April, 1936, were present in large numbers at the end of the third week of that month. The number had decreased to relatively few by the first week in May. Two larvae were present the last week in May. These had disappeared by the first week in June. No larvae were found on meadowlarks collected during this period.

Larvae retained in closed jars and tubing, located outdoors, endured longer than those exposed directly to the environmental changes in the outdoor enclosure. Representatives in the jars and tubing persisted longer than five months. Although these larvae had gradually decreased during the preceding
period, the termination of this study was caused by the top soil drying out in the containers during the third week of April, 1936.

Larvae from one mass of eggs that began hatching the first week in November, 1935, were placed in a cloth covered bottomless fruit jar November 20. The surviving representatives of these larvae had perished by the fourth week in April, 1936.

One mass of hatching eggs were placed in a tube October 31, 1935. Larvae from these eggs persisted until the third week in April, 1936.

Larvae attach primarily about the occipital region of the head and in and around the ears of bird hosts. Attachment may occur, however, on any part of the head and neck. Larvae attach on the head and neck of mammals. In rodents, attachment is most common around the eyes. Larvae attach on the face near the muzzle of young ruminants.

The process of engorgement is gradual until the larva is about half engorged after which it becomes replete in a comparatively short time. The time required for engorgement varies from 3.5 to 7 days. Records of the engorgement period on the meadowlark are given in Table IV. Engorgement occurs within the same range on the roof rat, cotton rat, bobwhite, and the English house sparrow.

Detachment of the engorged larva occurs most frequently in the early part of the morning and the latter part of the after-
### TABLE IV. ENGORGEMENT PERIOD OF THE LARVA OF THE GULF
COAST TICK ON MEADOWLARKS.

<table>
<thead>
<tr>
<th>Date infested</th>
<th>Number of engorged larvae detaching</th>
<th>Number of days following infestation</th>
<th>Number detaching</th>
</tr>
</thead>
</table>
noon under cage conditions. Field studies also indicate that detachment occurs most frequently in the morning and afternoon while the host is feeding.

The majority of nymph infestations on meadowlarks are single or exhibit different stages of engorgement; thus, indicating that engorged larvae are well distributed. Some nymphal infestations, with several nymphs in the same state of engorgement, indicate that larval detachment occurs while the host is stationary in many cases. Of 95 meadowlarks infested with the nymph, 48 were infested with only one, 16 with two, nine with three, nine with four, four with five, three with six, one with eight, one with nine, one with ten, one with eleven, one with fourteen and one with nineteen.

As soon as engorged larvae drop from the host, they begin crawling among the lower stratum of vegetation in search of a place to locate for development. Small secluded crevices such as spaces between the sheath and stem of grasses, curled grass blades and other small spaces formed near the ground by adjacent vegetative growths are locations in which the quiescent larvae are most commonly found.

The engorged larva is glued to the surface on which it becomes quiescent by a body secretion. This prevents the quiescent larva from being dislodged by wind and rain.
Under temperatures ranging between 75 and 80° F., the engorged larva usually becomes quiescent within two days. At 90° F., it becomes quiescent within a day following detachment. The quiescent larva will complete development in an environment in which the newly emerged nymph will perish in less than a week. The skin which becomes rigid and covered with a wax-like substance seems to act as a protective coat, preventing excessive evaporation even in relatively dry environments.

Engorged larvae develop to the nymphal stage and emerge in six days following engorgement at a constant temperature of 98° F. Under ordinary conditions, it requires from 9 to 12 days. Low temperatures decrease the speed of development of engorged larvae. Following are some representative studies on the development at different periods. Quiescent larvae were observed from time to time in these studies and even after nymphs became active in some cases.

One hundred and forty engorged larvae were placed in a bottomless fruit jar December 6, 1935. Four nymphs were active February 10, 1936.

Fifty engorged nymphs were placed in an outdoor enclosure October 21, 1935. One nymph was active January 15, 1936.

Eighty engorged larvae were placed in an outdoor enclosure March 11, 1936. One nymph was active April 9.
Two hundred engorged larvae were placed in an outdoor enclosure in the last half of November, 1935. One nymph was observed the second week in February, 1936. Several nymphs were active the first week in March and a fairly large proportion were active by the second week.

**Nymph.** The nymph is present and active during almost the entire year as shown in the data represented in figure 3 and Table III. The abundance wanes in the early summer but is built up again by the new generation in late summer and fall. The parasitic nymph is probably the predominating form during the winter months. Its host-seeking activity is decreased at that time, however, by low temperatures.

During periods conducive to normal host-seeking activity, newly emerged nymphs exhibit a short variable non-parasitic period. This period usually lasts about two days under ordinary conditions.

Nymphs emerging in periods of relatively low temperatures remain inactive throughout the duration of such periods. One hundred newly emerged nymphs that were placed in an outdoor enclosure October 26, 1936, had shown no host-seeking activity up to December 16. They showed activity, however, when the plat of vegetation in which they were located was exposed to the heat of an electric light.

The longevity of the nymph varies with the season of the year. Five and a half months is the longest record obtained
with this stage. The representatives in this study went through a period of inactivity. About four months is the normal length of life during the season of host-seeking activity. The longevity studies were terminated by adverse weather conditions in the late spring. Those retained in closed containers survived longer than those in outdoor enclosures. Observations on the longevity are given in the following data.

Sixty nymphs that emerged from engorged larvae the last week in November were placed in an outdoor enclosure. The last survivors of this group had perished by the last week in April, 1936.

Twenty-five nymphs that emerged from engorged larvae the last week in November, 1935, were placed in a bottomless fruit jar. Eight still persisted at the end of the second week in May, 1936. These had perished by the end of the third week.

Representatives from 15 nymphs that emerged the last week in November, 1935, persisted in a 25 mm. tube until the end of April, 1936. The soil had become dry during the first week in May and the survivors of this group perished during that time.

Representatives of 20 nymphs that emerged the first week in February, 1936, survived in a 16 mm. tube until the second week in June.

Representatives of 20 nymphs that emerged the first week in March, 1936, persisted in a 16 mm. tube until the first week in July. The last week in May all the nymphs were alive;
the third week in June ten were alive; at the end of the fourth week in June only five were alive. Soil in this tube did not dry out until the middle of June and it became very dry in the latter part of that month.

One hundred nymphs that emerged the third week of March, 1936, were placed in an outdoor enclosure. The number had decreased considerably by the first week in May. Five persisted until the first week in June, but they had perished by the end of the following week. The death of the forms involved in this study was caused by the top soil drying out on account of lack of sufficient rain.

Nymphs that emerged the third week in August, 1936, were placed in a sand humidor and kept in the laboratory. Members of this group had begun to die the third week in October. Of the original fifty only three survived until December.

Nymphs attach on the head and neck of their normal hosts. The occipital and parietal regions of the head are the most common places of attachment on birds. On mammals attachment is apt to occur at any point on the head and neck.

Engorgement is a gradual process until the nymph has developed to about half the replete dimension, after which repletion is accomplished in a comparatively short time. The nymph ordinarily completes engorgement, under cage conditions, during the night while the host is inactive. Detachment occurs to the greatest extent in the morning after the host becomes
active. Regardless of the time of day the host is infested, the engorged forms begin detaching the morning of the fifth day following as shown in Table V.

Nymphs in small infestations, comparable to those found in nature, require from 4.5 to 7 days to complete engorgement. In unnaturally large infestations the range may extend to 9 days. Records on the engorgement period of nymphs on meadowlarks are given in Table V. Infestations on birds in poor condition may also extend the time required for engorgement. Body fluids from the host may glue the engorged form to the feathers and delay detachment for unusually long periods.

After dropping, engorged nymphs crawl about in the lower stratum of vegetation and locate in natural crevices formed by vegetative growth, where they become quiescent and develop to adults. The quiescent form of this stage is most commonly found wedged between the sheath and stem of grasses and other places in or near the crown.

The engorged nymph becomes quiescent within two days at \(98^\circ F\). This period is prolonged by lower temperatures. In the quiescent state the engorged nymph is very resistant to adverse conditions. Development in the quiescent state is not hindered under conditions of low humidity which cause other forms of this species to perish prematurely.
TABLE V. ENGORGEMENT PERIOD OF THE NYMPH OF THE GULF COAST TICK ON MEADOWLARKS.

<table>
<thead>
<tr>
<th>Date infested</th>
<th>Number of engorged larvae detaching - days following infestation</th>
<th>Number detaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 27 - M.</td>
<td>1 : 8 : 12 : 4 : 2 : 13 : 15</td>
<td></td>
</tr>
<tr>
<td>January 8 - P.M.</td>
<td>9 : 2 : 19 : 28 : 2</td>
<td></td>
</tr>
<tr>
<td>February 20 - P.M.</td>
<td>50 : 5 : 32 : 3 : 1 : 0 : 85 : 8</td>
<td></td>
</tr>
<tr>
<td>February 28 - P.M.</td>
<td>10 : 3 : 8 : 3 : 1 : 19 : 7</td>
<td></td>
</tr>
<tr>
<td>November 17 - A.M.</td>
<td>9 : 0 : 65 : 0 : 8 : 0 : 1 : 83 : 0</td>
<td></td>
</tr>
</tbody>
</table>

*These data are a summation from 9 birds.*
The engorged nymph requires 13 days to complete development and molt at 98° F. In temperatures ranging between 75° and 80° F, development requires around 20 days.

Nymphs engorging in the fall and winter do not emerge as adults until the following spring. There is no distinct difference in the time required for the male and female to develop from the engorged nymph. Variations in the developmental time overlap in both sexes. The sex ratio is about equal. Of 869 engorged nymphs, 409 males and 460 females emerged. Observations on the developmental time of the engorged nymph are given in the following data.

Six engorged nymphs were placed in a 25 mm. tube December 12, 1935. A male and a female had emerged March 31, 1936. Another male was present April 9.

Twenty engorged nymphs were placed in an outdoor enclosure in November, 1935. One fully developed adult was found still in its exuvia March 6, 1936. The earliest adult activity was noted in this enclosure April 30.

Forty nymphs were placed in a sand humidor February 11, 1936. Molting began March 3 and was complete the following day.

Two hundred and forty-five nymphs that emerged February 25, 1936, were placed in a sand humidor for development. Adults began to emerge March 17. Emergence was practically complete March 19. From one to three in each of the five
chambers had not emerged on the latter date.

Eighty engorged nymphs were placed in an outdoor enclosure in the period from April 24 to 27. Adults were emerging May 16.

Three nymphs that engorged August 25, 1936, were placed in a sand humidor under heavy vegetation. Adults had emerged by September 12.

Adult. Adults begin emerging from engorged nymphs the latter part of March and continue on into June. The majority, however, emerge in April and May. Nymphs engorging in July and August emerge as adults in August and September, thus establishing the beginning of a second generation. Evidence of a second generation was indicated in the incidence study given in Table VI.

Adults that emerge in April and May do not become active immediately after emergence. They remain immobile at the base of vegetation for varying periods of time. They are usually found clinging to the stems of herbaceous plants near the soil.

Host-seeking activity of the adult stage is governed to a great extent by temperature. The incidence of the adult on sheep began to increase and reached its peak in the latter part of June and early July, 1936, and was suppressed in early October when the maximum temperature average went below 90°F.
The earliest record of the adult as a parasite on the host was taken April 17, 1936. An old emaciated ram was infested with three males. The male precedes the female in host-seeking activity. Data showing this precedence is tabulated in Tables VI and VII.

The incidence of the adult on sheep rose gradually from mid-April until the latter part of June, at which time it made an abrupt increase as shown in figure 4. It was also found difficult to induce laboratory reared specimens to attach in May and early June. In July and thereafter adult specimens attached readily. These data indicate a non-parasitic tendency when the temperature average is below 90° F.

The adult awaits the host in various positions among vegetation. It is usually found immobile, clinging to grass blades among the normal growth. From this position adults become very active on the approach of a host, and crawl rapidly about in the upper stratum of vegetation directing the movements toward the host. Adults stationed near the top of unusually tall grass blades may remain immobile with the forelegs extended dorsally and the second pair extended ventrally in an effort to contact a host.

The longevity studies of this stage, under outdoor conditions, were interrupted by adverse weather conditions. The longest record made in the outdoor enclosure was established by a lone male that emerged the last week in March, 1936. This
Rainfall, daily maximum temperature, and incidence of the adult Gulf coast tick on sheep in Berrien County, Georgia, 1936.
### TABLE VI. INCIDENCE OF THE ADULT GULF COAST TICK ON SHEEP RANGING A 250 ACRE ROUGH PASTURE, 1936.

<table>
<thead>
<tr>
<th>Date of examination</th>
<th>No. animals examined</th>
<th>No. of ticks per animal per day</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 17</td>
<td>25</td>
<td>0.008</td>
<td>3</td>
<td>0</td>
</tr>
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<td>April 28</td>
<td>25</td>
<td>0.036</td>
<td>8</td>
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<td>May 12</td>
<td>25</td>
<td>0.069</td>
<td>17</td>
<td>7</td>
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<td>May 27</td>
<td>25</td>
<td>0.107</td>
<td>31</td>
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<td>June 9</td>
<td>31</td>
<td>0.134</td>
<td>39</td>
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<td>June 23</td>
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<td>0.112</td>
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<td>July 7</td>
<td>30</td>
<td>0.326</td>
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<td>75</td>
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<td>July 13</td>
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<td>0.872</td>
<td>72</td>
<td>99</td>
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<td>July 27</td>
<td>28</td>
<td>0.403</td>
<td>39</td>
<td>40</td>
</tr>
<tr>
<td>August 3</td>
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<td>August 26</td>
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<td>5</td>
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<td>September 9</td>
<td>26</td>
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<td>1</td>
<td>1</td>
</tr>
<tr>
<td>September 18</td>
<td>25</td>
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<td>0</td>
<td>4</td>
</tr>
<tr>
<td>September 28</td>
<td>23</td>
<td>0.03</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

*Ave. number of ticks accumulated per animal per day during the interval between each examination.*
### TABLE VII. INCIDENCE OF THE ADULT COAST TICK ON SHEEP RANGING A 320 ACRE WINTER-BURNED PASTURE, 1936.

<table>
<thead>
<tr>
<th>Date of examination</th>
<th>No. animals</th>
<th>Ticks per:</th>
<th>Number of ticks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>examined</td>
<td>per day*</td>
<td>male</td>
</tr>
<tr>
<td>April 28</td>
<td>38</td>
<td>.014</td>
<td>4</td>
</tr>
<tr>
<td>May 12</td>
<td>42</td>
<td>.019</td>
<td>6</td>
</tr>
<tr>
<td>May 27</td>
<td>33</td>
<td>.102</td>
<td>27</td>
</tr>
<tr>
<td>June 9</td>
<td>53</td>
<td>.252</td>
<td>133</td>
</tr>
<tr>
<td>June 23</td>
<td>33</td>
<td>.227</td>
<td>64</td>
</tr>
<tr>
<td>July 7</td>
<td>45</td>
<td>.316</td>
<td>118</td>
</tr>
<tr>
<td>July 13</td>
<td>35</td>
<td>.419</td>
<td>39</td>
</tr>
<tr>
<td>July 20</td>
<td>48</td>
<td>.500</td>
<td>88</td>
</tr>
<tr>
<td>July 27</td>
<td>39</td>
<td>.256</td>
<td>24</td>
</tr>
<tr>
<td>August 3</td>
<td>43</td>
<td>.216</td>
<td>19</td>
</tr>
<tr>
<td>August 17</td>
<td>37</td>
<td>.054</td>
<td>6</td>
</tr>
<tr>
<td>August 26</td>
<td>41</td>
<td>.062</td>
<td>8</td>
</tr>
<tr>
<td>September 9</td>
<td>33</td>
<td>.048</td>
<td>8</td>
</tr>
<tr>
<td>September 18</td>
<td>39</td>
<td>.022</td>
<td>2</td>
</tr>
</tbody>
</table>

*Ave. number of ticks accumulated per animal per day during the interval between each examination.*
male persisted until October 2, 1936, a period of six months. Records on the longevity of the adult are given in the following data.

A male and female that emerged the third week in December, 1935, were retained in a sand humidor. The male died the third week in October and the female still persisted the third week in December, 1936.

Fifty males and fifty females that emerged the last week in March, 1936, were placed in an outdoor enclosure. Only a relatively few endured until the first week in August. Only one male was present August 20, and it persisted until the first week in October, 1936.

Adults emerging in March, 1936, and retained in sand humidors showed very little mortality previous to October. A very small percentage persisted until December, thus indicating that about seven or eight months is the normal length of life of the adult.

The unattached adult shows a positive geotropic tendency both in vegetation and on the host. Its tendency to repel physical forces is apparently the most important factor governing its activity during the free parasitic period.

Adults of this species attach almost invariably inside the pinna of the ear. However, it is not uncommon to find it attached on the outside of the pinna, on the neck, and to a
lesser extent at the base of the horn and occasionally at other points on the animal.

The natural tendency of the animal to flip its ear when a tick crawls on the sensitive hair inside the pinna is the factor causing the tick to attach there. The impulse set up by the tick crawling on the sensitive hair causes the animal to swing the ear to and fro in an effort to dislodge the pest. The centrifugal force set up by this activity causes the tick to cease crawling and to cling to the hair in order not to be flung off the animal. The ear reflex of the animal is repeated each time the tick makes a move; consequently, the tick becomes quiet and moves in among the hair and attaches. Although this host behavior is the dominant influence promoting attachment, it may be encouraged by other factors.

Attachment is most likely to occur adjacent to other ticks, abnormal growths or folds formed by the tissue of the ear. Because of this habit this tick usually attaches in groups.

The male of this species must remain attached to the host from six to seven days before it becomes sexually mature. Sexual maturity is probably reached in the majority of cases in the early part of the seventh day. Few males can be induced to copulate in the latter part of the sixth day, but the majority can be induced to copulate by the latter part of the seventh day. Sexually mature males are stimulated to sexual
activity by other ticks crawling among them.

The male remains attached in one place throughout the pre-copulation period. If undisturbed its position may remain unchanged for several weeks. Mature males may change positions spontaneously, however. On detaching, mature males seek attached or free, fertile or infertile females and take the copulating position. If disturbed before taking the copulating position, the male immediately reattaches to the host.

In copulating the male clasps the body of the female, venter to venter, and inserts the hypostome into the genital aperture. This position is held for a period varying from ten to fifteen minutes. A spermatophore is left protruding from the genital aperture of the female. It has been observed, however, that males may go through the copulating procedure without leaving evidence of the spermatophore.

Immediately following copulation the male reattaches to the host. In most cases the male reattaches to the host with the same position in respect to the female as that held during copulation. This position in many cases is held until the female becomes replete and detaches. Some males, however, move away from the female to attach after copulation.

Copulation is the factor regulating normal engorgement of the female. Normal engorgement has been observed following copulation, but the resulting eggs were infertile. The males in this case were removed from the animal following copulation.
From this observation it seems likely that engorgement is induced by some substance that is injected into the female during copulation.

The number of females that one male is able to fertilize appears not to be limited. One male was known to have induced the engorgement of six females within a period of five days.

Males remain attached to the host for long periods. There are records for as long as 89 days. A male on one sheep and three on another that were attached September 24, 1936, were still attached December 22.

The time required for engorgement of the female of this species shows very little variation under normal sexual relationship. Engorgement is indefinitely prolonged in the absence of the male. This relation was first noted in field observations. Engorgement was noted to be common among females accompanied by males and very seldom among lone females. This indication was proven to be correct by keeping infested sheep free of males. One lone female remained attached from the latter part of October, 1935, until in early January, 1936, a period of approximately 70 days. This indication was also confirmed in engorgement studies as revealed in the data of Table VIII. A gradual process of engorgement may occur without copulation up to varying stages but such forms always present an abnormal appearance.
Females engorge in from four to eight days following copulation. The period required depends on the length of time the females have been attached to the host previous to copulation. Females that have been attached to the host for two days or more require only four to six days to engorge and detach following copulation, while females mating at the time of attachment require from six to eight days to engorge and detach. This study exposed the fact that the female also has to undergo a developmental period of about two days on the animal before engorgement proceeds. Data relative to the engorgement of the female are given in Tables VIII and IX.

Engorgement is gradual in its progression up to the intermediate stage after which the females become replete and detach in less than a day. From the first evidence of engorgement to detachment of the replete female, 3.5 to 5.5 days are required. A very few engorge in 3.5 days. Those engorging in that time usually detach just before the beginning of the fourth day.
TABLE VIII. INDIVIDUAL ENGORGEMENT RECORD OF THE FEMALE GULF COAST TICK, WITH DELAYED COPULATION, ON SHEEP.

<table>
<thead>
<tr>
<th>Date attached:Date of copulation: Date</th>
<th>Detachment: Days</th>
<th>Days following copulation:attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 23 :July 29 :Aug. 2</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>July 23 :July 29 :Aug. 4</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Aug. 1 :Aug. 7 :Aug. 11</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Aug. 1 :Aug. 7 :Aug. 11</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Aug. 1 :Aug. 7 :Aug. 15</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Aug. 11 :Aug. 26 :Aug. 31</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Aug. 23 :Aug. 26 :Aug. 31</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Sept. 1 :Sept. 7 :Sept. 11</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Sept. 3 :Sept. 16 :Sept. 20</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>Sept. 3 :Sept. 16 :Sept. 20</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>Sept. 5 :Sept. 18 :Sept. 23</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>Sept. 5 :Sept. 21 :Sept. 26</td>
<td>5</td>
<td>21</td>
</tr>
<tr>
<td>Sept. 23 :Sept. 29 :Oct. 2</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Sept. 23 :Sept. 29 :Oct. 2</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Sept. 19 :Sept. 25 :Sept. 30</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Sept. 19 :Sept. 25 :Sept. 30</td>
<td>5</td>
<td>11</td>
</tr>
</tbody>
</table>
TABLE IX. INDIVIDUAL ENGORGEMENT RECORD OF THE FEMALE 
OF THE GULF COAST TICK ON SHEEP, INFESTED 
WITH SEXUALLY MATURE MALES.

<table>
<thead>
<tr>
<th>Date of attachment</th>
<th>Date</th>
<th>Days following attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 27</td>
<td>Sept. 3</td>
<td>7</td>
</tr>
<tr>
<td>August 27</td>
<td>Sept. 3</td>
<td>7</td>
</tr>
<tr>
<td>August 27</td>
<td>Sept. 3</td>
<td>7</td>
</tr>
<tr>
<td>August 29</td>
<td>Sept. 4</td>
<td>6</td>
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<tr>
<td>August 29</td>
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<td>8</td>
</tr>
<tr>
<td>September 1</td>
<td>Sept. 7</td>
<td>6</td>
</tr>
<tr>
<td>September 1</td>
<td>Sept. 8</td>
<td>7</td>
</tr>
<tr>
<td>September 3</td>
<td>Sept. 9</td>
<td>6</td>
</tr>
<tr>
<td>September 3</td>
<td>Sept. 10</td>
<td>7</td>
</tr>
<tr>
<td>September 5</td>
<td>Sept. 11</td>
<td>6</td>
</tr>
<tr>
<td>September 5</td>
<td>Sept. 12</td>
<td>7</td>
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<tr>
<td>September 5</td>
<td>Sept. 13</td>
<td>8</td>
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<tr>
<td>September 8</td>
<td>Sept. 14</td>
<td>6</td>
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<tr>
<td>September 8</td>
<td>Sept. 15</td>
<td>7</td>
</tr>
<tr>
<td>September 8</td>
<td>Sept. 16</td>
<td>8</td>
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<tr>
<td>September 8</td>
<td>Sept. 16</td>
<td>8</td>
</tr>
<tr>
<td>September 10</td>
<td>Sept. 18</td>
<td>8</td>
</tr>
<tr>
<td>September 14*</td>
<td>Sept. 21</td>
<td>7</td>
</tr>
<tr>
<td>September 14*</td>
<td>Sept. 22</td>
<td>8</td>
</tr>
<tr>
<td>September 15</td>
<td>Sept. 23</td>
<td>8</td>
</tr>
<tr>
<td>September 25</td>
<td>Oct. 1</td>
<td>8</td>
</tr>
<tr>
<td>September 25</td>
<td>Oct. 3</td>
<td>8</td>
</tr>
</tbody>
</table>

*One animal infested with 12 females, 5 detached September 21 and 7 September 22.
LIFE CYCLE

During the preoviposition period, which varies from four to six days, the engorged female locates in a secluded place under vegetation. The eggs are deposited on the surface of the soil. Eggs hatch in about 26 days following deposition, depending on the temperature.

Larvae usually await a host on parts of plants which extend into small open spaces among low vegetation. They become active in the presence of a host. The longevity of the larva normally varies from three to four months under field conditions. Larvae become parasitically inactive when the maximum temperature remains below 65°F. They attach on the head and neck of the host. Engorgement normally requires from 3.5 to 5 days.

Engorged larvae wedge themselves into small spaces formed by normal vegetative growth above the surface of the soil for development. They molt in about 12 days depending on the temperature. Those engorging in the late fall usually do not molt until late winter and early spring of the following year.

Nymphs become parasitically active within two or three days following emergence. Host-seeking activity is delayed, however, by low temperatures. Nymphs await the host in low vegetation and move actively about in the presence of a host.
The normal longevity of the nymph varies from three to five months depending on the season. Nymphs attach on the head and neck of the host. They engorge in from 4.5 to 7 days. Nymphs usually become replete during the night and detach the following morning.

Engorged nymphs usually wedge themselves into small spaces in the crown of grasses above the soil where they become quiescent and develop to the adult stage. They molt in about 20 days following detachment, depending on the temperature. Those engorging in the late fall and thereafter do not molt, however, until the latter part of March and in April of the following year.

Free parasitic adults remain comparatively inactive during early summer on the base of herbaceous plants. The male actively seeks a host earlier than the female. Host-seeking activity of both sexes increased abruptly in the latter part of June and early July of 1936 when the maximum temperature average went above 90°F. Adults await the host among low vegetation. The normal longevity of adults varies from 6 to 8 months.

Males become sexually mature six days after attaching to the host. Males may remain sexually active on the host for extended periods.

Females do not engorge until after copulation. They remain attached to the host for an extended time if unaccompanied by males. Females engorge in from four to eight days follow-
ing copulation. Females that attach two days or more previous to copulation require only 4 to 6 days to engorge and detach after copulation. Females copulating at the time they attach require six to eight days to engorge and detach.

The life cycle of the Gulf coast tick may be completed under field conditions in less than two and one-half months.
SEASONAL HISTORY

Different stages of the Gulf coast tick overlap to a considerable extent throughout the year. Actually, most forms are in existence to a variable extent throughout the year. Using the extant forms of this tick, the existence of the other forms of this species can be fairly accurately derived.

The egg stage came into existence after the engorgement of the adult which began in the early part of May, 1936; it lingered almost two months after the normal activity of the adult ceased in the latter part of September of both 1935 and 1936. There was evidence of eggs surviving the winter of 1935-'36, but to a very limited extent. The egg stage was prevalent until November in 1935. In 1936, it became prevalent in late June.

The larva stage succeeds the egg stage, making its appearance about a month later. It went out of existence in March, 1936 and the new generation appeared the second week in July of the same year. There was evidence that it was present to a very limited extent in April and May of 1936. The larval stage was prevalent from the third week in July to the third week in November of 1936. Its prevalence ended at about the same period in 1935. The engorged phase of the larval stage was prevalent until in March, 1936.
The nymph makes its appearance about two weeks following the beginning of the host-seeking activity of the larval stage. This stage gradually increased in abundance from early fall, 1935 to early spring, 1936. It began a decline in abundance in late spring and its abundance became very low in early May, but it remained in existence until the latter part of June. The new generation appeared the third week in July, 1936, and gradually increased in abundance through the fall of that year. The engorged phase of the nymphal stage closely follows the parasitic phase in abundance. It became most abundant in March and April, and its abundance lingered into May, 1936.

The adult stage is in existence throughout the year in the parasitic phase. It was abundant until the latter part of September, 1935. The adult began to increase in prevalence in early April, 1936. It became the predominating form in May. Its abundance, however, was reduced to almost nil in the latter part of July of that year.
HOST RELATIONSHIP

Host specificity is not marked in any stage of the Gulf coast tick. There are, however, physical relationships that cause one host to be more important in the propagation of this species than another. The abundance and interrelationship of hosts in range habits are important considerations in this work.

In southern Georgia normal hosts of the larva include the meadowlark, Sturnella magna; bobwhite, Colinus virginianus; eastern cotton rat, Sigmodon hispidus hispidus; southern fox squirrel, Sciurus niger niger; field sparrow, Spizella pusilla pusilla; kid; lamb; towhee, Pipilo erythrophthalmus; southern gray squirrel, Sciurus carolinensis carolinensis; house wren, Troglodytes aedon; and the brown thrasher, Toxostoma rufum.

Incidental hosts to the larva include the mockingbird, Mimus polyglottos; blue jay, Cyanocitta cristata; loggerhead shrike, Lanius ludovicianus ludovicianus; and the roof rat, Rattus rattus alexandrinus.

The nymph has been collected from the meadowlark, Sturnella magna; bobwhite, Colinus virginianus; eastern cotton rat, Sigmodon hispidus hispidus; southern fox squirrel, Sciurus niger niger; sheep; calf; house wren, Troglodytes aedon; towhee, Pipilo erythrophthalmus; white-throated sparrow, Zonotrichia albicollis; and the robin, Turdus migratorius.
The rank of importance of the hosts of the immature stages is derived from studies and observations as given in Table X. This study is based on individual larval infestations and the estimated abundance of each species of host. The hosts not included in this table are of minor importance. The hosts represented in this table were collected between July 24 and November 20 in both 1935 and 1936, when the larva was known to be prevalent. This period was chosen because meadowlarks were heavily infested during that time of the year.

The abundance and habits of the host are important considerations in determining the importance of each host species to the immature stages. Ground habits of the host are of primary importance. Principal hosts spend considerable time among vegetation in open areas. Incidental hosts usually have arboreal habits and make very infrequent visits to grassland areas.

Birds are more susceptible to infestation than mammals. In the laboratory only a small percentage of the larvae placed on the roof rat and the cotton rat attached and engorged while almost 100 percent of those placed on the meadowlark, bobwhite and the English house sparrow attached and engorged.

In ranking hosts of the immature stages in relative importance on the basis of infestation alone, and without consideration of host abundance, they are listed in the following order: Meadowlark, bobwhite, fox squirrel, cotton rat,
TABLE X. RELATIVE IMPORTANCE OF HOST SPECIES TO THE LARVA OF THE GULF COAST TICK, RATED ON INFESTATION AND ESTIMATED HOST ABUNDANCE.

<table>
<thead>
<tr>
<th>Host</th>
<th>No. specimens</th>
<th>Percent of larvae examined of relative host abundance</th>
<th>Ave. no. of larvae per host</th>
<th>Estimated population of Engorged specimens</th>
<th>Estimated no. of larvae reeled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meadowlark</td>
<td>113</td>
<td>72%</td>
<td>25.7</td>
<td>100</td>
<td>1850</td>
</tr>
<tr>
<td>Bobwhite</td>
<td>17</td>
<td>88%</td>
<td>11.3</td>
<td>60</td>
<td>597</td>
</tr>
<tr>
<td>Cotton rat</td>
<td>2</td>
<td>100%</td>
<td>4.5</td>
<td>25</td>
<td>112</td>
</tr>
<tr>
<td>Fox squirrel</td>
<td>4</td>
<td>75%</td>
<td>11.7</td>
<td>10</td>
<td>88</td>
</tr>
<tr>
<td>Field sparrow</td>
<td>15</td>
<td>20%</td>
<td>5.3</td>
<td>60</td>
<td>63</td>
</tr>
<tr>
<td>Towhee</td>
<td>5</td>
<td>60%</td>
<td>2.7</td>
<td>20</td>
<td>32</td>
</tr>
<tr>
<td>Gray squirrel</td>
<td>14</td>
<td>36%</td>
<td>2.0</td>
<td>50</td>
<td>22</td>
</tr>
<tr>
<td>House wren</td>
<td>2</td>
<td>100%</td>
<td>2.0</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Brown thrasher</td>
<td>2</td>
<td>50%</td>
<td>4.0</td>
<td>5</td>
<td>10</td>
</tr>
</tbody>
</table>
towhee, house wren, brown thrasher, field sparrow, gray squirrel, kid, lamb, calf, white-throated sparrow, robin, mockingbird, blue jay, loggerhead shrike, and the roof rat.

Ranked according to their importance as hosts to the adult stage of the Gulf coast tick in southern Georgia, the following animals have been found infested: Sheep, hog, goat, cow, dog, gray fox and mule. Ranked according to abundance these animals are listed in the following order: Cow, goat, hog, sheep, dog, gray fox and mule.

Several factors are instrumental in the susceptibility of animals to adult infestations. In sheep, non-infested animals ordinarily offer considerable resistance to infestations. This resistance is set up by disengaging the tick with the hoof before it becomes firmly attached. Only a very small percentage of sheep, however, are able to ward off the persistent effort of ticks to establish an infestation during the entire season of adult activity.

Animals with deformed ears, growths, or tick infestations in the ear are more susceptible to attack than animals with normal ears. Animals with these conditions are seldom without an infestation. One sheep examined July 29, 1936, for the first time that season, was infested with a total of 221 Gulf coast ticks.

Heavy infestations with the tick keep sheep in poor condition and build up a condition in the ear which makes the
animal vulnerable to screw worm attack. In two cases out of three, screw worm cases resulted when approximately fifteen adult ticks were placed in the ears of healthy sheep. The two cases that became infested showed a gray exudate among the ticks on which screw worm flies from nature deposited eggs. No exudation occurred among the ticks on the third animal and as a consequence, no screw worm eggs were deposited.

Infestations among the hosts of the larval stage increases in intensity with the degree to which their range overlaps that of the principal hosts of the adult stage. The range habits of normal hosts of the different stages of the Gulf coast tick in southern Georgia show an interrelationship that is ideal for the propagation of this species. Hosts ranging upland and unwooded lowland areas are the most important propagators. Although the concentration of tick population is in the upland regions, the distribution extends into all adjacent areas. Hosts of the Gulf coast tick act as agents which distribute the different stages to the different plant associations within an area. Species that live almost exclusively in dense arboreal or swamp associations, however, seldom act as hosts.

Sheep are the most important hosts to the adult stage. They range in relatively small flocks which congregate at night on a common resting ground. Sheep feed in the morning and afternoon, and rest during the warmer part of the day. During the period of the normal activity of the adult tick,
sheep select lightly vegetated areas for their common range, preferably winter-burned areas or those in which the normal growth of vegetation has been kept back by continual grazing. This choice of range restricts them to a common range. In warm weather they rest in damp shaded lowland areas during mid-day. This animal ranges to the greatest extent in upland areas.

Swine are kept under range conditions in southern Georgia during the major part of the period of normal activity of the adult tick. This animal is not restricted in its range. Although swampy areas are the center of its range, it feeds to a considerable extent in upland areas. Although there is no distinct preference, the hog seems inclined to range more in areas of excessive vegetative growth.

Goats are not restricted in their range by feeding habits. They tend to graze to a greater extent, however, in lightly vegetated areas.

Cattle have wandering habits but their range is also somewhat restricted by their tendency to avoid vegetation of excessive growth.

Canine hosts are not abundant enough to be very important, but they are not restricted in their wanderings and may be important in distributing the tick to distant points.

Equine hosts are of no importance in southern Georgia, since they are seldom kept under range conditions.
The meadowlark, which is the most important host to the immature stages, roosts in large flocks on a common roosting ground. Flocks have been observed that contained between 80 and 100 members. The roosting ground is usually characterized by fairly heavy vegetation in an open area.

The activity of meadowlarks is restricted to a common range. Ordinarily their linear range does not extend beyond a mile, and the lateral range more than a half mile. Their range is characterized by light vegetation in upland areas. They prefer particularly winter-burned areas and heavily grazed grassland areas.

Meadowlarks range in small flocks during the early fore­noon and late afternoon. During the late forenoon and early afternoon they remain inactive in fairly heavy vegetation. On days of high temperatures they rest in damp lowland areas.

Meadowlarks cover an extensive area during each feeding period. They progress, in a scattered group, over the feeding ground by short consecutive flights of individual members of the flock. Most of the time is spent among the grasses in search of food.

The bobwhite is a close second to the meadowlark as a host to the immature stages of the Gulf coast tick. Its activity is more localized, however, than the meadowlark, and it is less abundant. Although the activity of this bird is centered around swampy areas, its range extends well into surrounding upland areas. Its range is not governed by the
vegetative growth.

Bobwhites range in more or less compact groups; consequently, the area covered by a covey is not extensive. The extent of their linear range varies around a half mile. They feed among grasses in open areas.

The cotton rat lives in burrows, under logs or brush or along fence rows where the vegetation is heavy. It has long runs under dense vegetation and feeds among grasses of the adjacent areas particularly during the early morning and late afternoon.

The fox squirrel feeds chiefly on pine seeds and spends its inactive periods in cypress or other trees growing in swampy areas. These separate stations cause the animal to traverse long distances through grassland areas from one environment to another. This animal also spends considerable time on the ground in search of food.

The field sparrow ranges among grasses in search of food. Clumps of bushes located in grassland areas are the center of its activity.

The towhee is a ground-inhabiting bird that is very active in grassland areas interspersed with palmettos and clumps of bushes. It spends most of its time on the ground in underbrush with occasional visits to adjacent grassland areas.

The gray squirrel is almost entirely arboreal in nature. Nevertheless, it visits the ground around the borders of wooded areas occasionally and makes short runs across grassland areas
from one wooded section to another.

The house wren is very active among vegetation near the ground. It ranges around the bases of bushes and trees.

The brown thrasher is a very active bird that spends considerable time on the ground. Its activity is confined largely to thickets and woods with occasional visits to bordering grassland.

The robin spends considerable time on the ground. Its activity, however, is confined to denuded areas or those covered with very short vegetation.

The white-throated sparrow is found on the ground in heavy undergrowth. Its scarcity has limited the study of its activity.

The loggerhead shrike, mockingbird and blue jay make only occasional momentary visits to grassland areas.

The roof rat is an inhabitant of buildings. During its nocturnal activity it probably strays into nearby grassland areas occasionally.

The hosts of both the immature and adult stages, in their feeding activity, completely cover the topographical regions in which the Gulf coast tick occurs. The most ideal host interrelationships for the propagation of this species, however, occur in the heavily grazed or winter-burned upland areas.

Ruminants and meadowlarks are the most important hosts in the upland regions. Swine and the bobwhite correspond in activity to promote the existence of this tick in and
about swampy areas. Other hosts of less importance fill in to make the relationship between the hosts of the adult stage and those of the immature stages even more complete.

The meadowlark is the most important agent in re-establishing infestations in winter-burned areas. Its alternating visits from rough to winter-burned areas account for the reinfestation.
CLIMATIC RELATIONSHIP

Humidity and temperature are the climatic factors directly influencing the activity, development and survival of the Gulf coast tick. Temperature, the pace setter for activity and development, has been treated in the text on the life history and habits. Consequently, it will be considered in this section only in its relation to humidity. Humidity is the factor essential to the continued existence of this tick.

Precipitation occurs quite regularly throughout the year in southern Georgia. The relative humidity at Valdosta, Georgia, remained at 100 percent from 4 to 8 hours almost every night from October, 1935 to December, 1936. In cases where the relative humidity did not reach 100 percent it closely approached it.

The study of climatic conditions and their effects was made in central south Georgia, the most inland part of the range of the Gulf coast tick. In this inland region, the distribution into the multiple environments and the overlapping of the different phases of this tick are important to its continued existence through periods of adversity. It is probably in the lowland areas that this species carries over during the most adverse periods.
In vegetation, the environment in which every form of the Gulf coast tick lives, a relatively high humidity is maintained by the moisture in the top soil. Frequent rains are essential to maintain the moisture in the soil in upland regions particularly during periods of high temperatures. In lowland areas the water level is near the surface and conditions are optimum for the existence of this species at all times.

The free parasitic forms of all three stages of this species can endure moderately adverse conditions for a reasonably long time during the early part of their existence, but a second exposure is fatal and they readily succumb after they have lived under optimum conditions for an extended period.

In studies of engorged females it was found that they were not able to reproduce during dry periods. Larvae failed to develop from two engorged females that were placed in an outdoor enclosure June 12, 1936. Larvae did not develop from another engorged female placed in an outdoor enclosure June 19, 1936. These females were not disturbed after being placed in outdoor enclosures, but the enclosures were observed for larval activity. This failure to reproduce was due to the dry periods that occurred following the placement of the females. These dry periods are represented in figure 4.

The termination of some studies on larval longevity in closed containers, as has been stated previously, came the third week in April, 1936. This is associated with the drying
out of the soil during the rainless period that occurred at
that time.

Larvae that hatched in early April, 1936, did not survive
the dry periods that followed in May. Most of the larvae in
this study perished during the dry period that extended from
April 27 to May 10. This study was made in an outdoor enclosure.

The incidence of the nymph on meadowlarks as shown in
figure 5, illustrates how the incidence of this form dropped
during the latter of two consecutive dry periods. The top soil
in upland regions became very dry during the latter period.
The percentage of meadowlarks infested with the nymph fell
from 72 percent to 17 percent between April 23 and May 12.
Five birds were collected April 17; four were infested with a
total of eight nymphs. Six birds were collected April 25;
four were infested with a total of ten nymphs. Six birds were
collected in the same vicinity May 12; only one bird was in­
fested. It was infested with four nymphs in the same state
of engorgement. No birds were collected in this same vicinity
during the interval between the last two dates. The effect of
such periods on the survival of the nymph was also confirmed
in longevity studies at the laboratory.

The field data of the incidence of the adult on sheep show
the effect of consecutive dry periods on the existence of the
free parasitic adult. These data are represented in figure 4
and tables VI and VII. The dry periods preceding the third
Fig. 5. Rainfall, daily maximum temperature, and percentage of meadowlarks infested with nymphs of the Gulf coast tick in Berrien County, Georgia, 1936.
week in July, 1936, had no apparent effect on the inactive adults. The incidence on sheep made a definite decline, however, during the succeeding dry period that extended from July 23 to 30. Studies in the outdoor enclosures showed a corresponding decrease in abundance.

A study made in the laboratory is interesting in respect to the survival of adults at comparatively low humidity. Two females and two males were kept at room humidity which ranged between 40 and 60 percent. This study started on January 8, 1936. On February 24, two of the ticks were dead. A third had perished by February 27. On March 3, the remaining female was practically dead. The legs were paralyzed in a contracted condition. The tick was able to move the legs only at the coxal joints. In this condition the tick was placed on moist sand. It was active and apparently normal the following day. The sand on which the female was located was allowed to dry out the second week in May and the tick was dead by the 15th of that month.

It is apparent that the free parasitic adult is able to withstand adverse conditions preceding host-seeking activity. After activity has begun the resistance to such periods is remarkably reduced. This assumption was confirmed through both laboratory and field studies.

Through this study it is logical to assume that the humidity in vegetation which is dependent on soil moisture,
is the factor that accounts for the restricted distribution of this species to the region along the seaboard.
LITERATURE CITED


