Brigham Young University Science Bulletin, Biological Series

Volume 4 | Number 1 Article 1

10-1963

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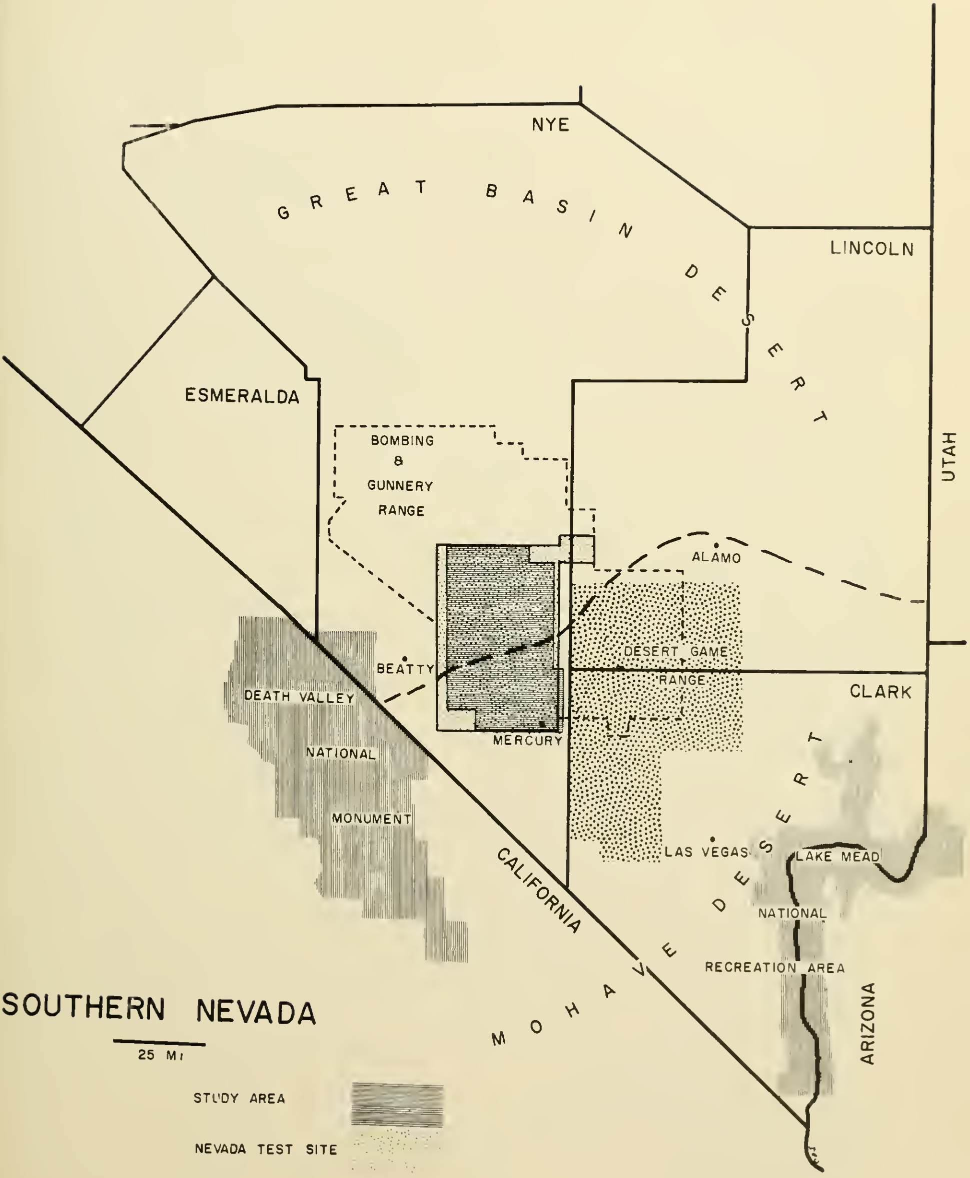

Fig. 1 Map of Southern Nevada

TICKS OF THE NEVADA TEST SITE

INTRODUCTION

This report on the tick fauna of the Nevada Test Site is one of the series of publications resulting from ecological studies conducted by the Brigham Young University Department of Zoology and Entomology in cooperation with the United States Atomic Energy Commission.[1] The principal objectives of the over-all project were maintained in this study, namely, to determine kinds, population, seasonal occurrence, and geographical and ecological distribution of ticks in areas where nuclear detonations have taken place compared with undisturbed areas. (For a detailed account of the over-all project and description of the general ecology of the area, see "Biotic Communities of the Nevada Test Site" by Allred, Beck and Jorgensen, 1963a.)

Published accounts of ticks collected in Nevada are for the most part instances of isolated collections, such as reported by Cooley and Kohls (1944), Philip, Bell and Larson (1953), Parsons (1947), and Allen (1960). As far as is known, our report is the first which deals with a periodic collection of ticks in a specific area of that state.

METHODS AND PROCEDURES

Although the tick collections were a by-product of studies of the mammalian fauna, especially the rodents and leporids, they were not incidental. A planned set of procedures and methods involving examination of each host for all kinds of ectoparasites, including ticks, was followed.

Rodent hosts were obtained by two trapping methods, and all specimens thus taken were placed in separate paper sacks which were sealed and returned to the laboratory. Specimens trapped in live-catch traps were killed in the field and sacked or taken to the laboratory where they were killed and sacked. Those captured in break-back traps were sacked in the field. Rabbits and larger vertebrates collected by use of jaw traps, shot guns, or rifles were also placed in paper bags when possible.

The specific site where a host was collected was related to a particular plant community and reference area which enabled an identification code to be attached to each parasite collection (see "Nevada Test Site Study Areas and Specimen Depositories" by Allred, Beck and Jorgensen, 1963b).

Hosts returned to the laboratory were refrigerated for several hours and then examined in a large, white enamel pan exposed to good illumination. The ticks were obtained by brushing the fur of the host as well as close examination of its body to locate those which remained attached in places such as the ears and axillae. Some ticks readily detached from the host after the heat of illumination stimulated them. Others had to be removed with forceps. Even with care the latter method of removal resulted in broken mouth-parts of some ticks. This was especially true of species of *Ixodes.*

Ticks were preserved in glass vials containing 70 percent ethyl alcohol. Those collected from each host were kept separate and labeled with necessary coded information.

When ticks were prepared for specific indentification each collection was supplied with a reference number. This same number referred to a line of data on a collection record form (CR form) and was also entered on an identification sheet in column style after which the identifier wrote the name of the organism. Data on the CR form also included the collection code and a serial number for each collection. From the identification sheet the species name was entered opposite the same reference number on the CR form. The coded collection data were then transcribed from this sheet to IBM punch cards preparatory to computer tabulation and analysis. Computer analysis provided statistical information on host-parasite relationships, seasonal incidence and ecological distribution with reference to a previously identified plant community at the Nevada Test Site.

DELIMITATIONS

As already mentioned, the tick collections in this study were principally from rodents and leporids. Such sources naturally would not reveal all the kinds of ticks which may occur at the test site. For example, only a few nests of

[1]AEC Research Grant AT(11-1)786

the desert wood rat, *Neotoma lepida*, were examined. Although no ticks were found, the original discovery of an atypical (Davis and Mavros, 1956) soft-bodied tick of *Ornithodoros hermsi* Wheeler, Herms, and Meyer in Utah was reported from wood rat nests by Beck (1955). These specimens were first taken from wood rat nests by Allred in 1950. Since that time many collections have been made in Utah, although specimens were not found in every nest. Undoubtedly a thorough study of many wood rat nests at the Nevada Test Site would supply this and perhaps *O. talaje* or other related species.

Inasmuch as Jellison (1940) found *O. parkeri* on the burrowing owl, *Speotyto cunicularia*, and in its nests and burrows in Washington, it is possible that this tick may be present at the test site. Cooley and Kohls (1944) also reported this tick from burrows of *Sylvilagus* sp., *Citellus* sp., *Dipodomys* sp. and other rodents in Nevada. Some of these collections reported were made in southern Nevada.

Certainly when the bat fauna and their retreats at the Nevada Test Site are studied more carefully, additional records of soft-bodied ticks may be discovered.

For the most part our initial surveys were confined to the valleys and lower elevations of the surrounding mesas and mountain ranges. Surveys of vertebrates at higher elevations at the test site naturally would provide a more accurate picture of the tick distribution. For example, *Dermacentor hunteri* has been taken on the mule deer and desert bighorn sheep a few miles east of the Nevada Test Site.

Undoubtedly when a complete survey has been made of the avifauna and their parasites at the test site additional tick species will be found. This would most likely be true for the ground- and cliff-nesting species of birds.

The species of ticks and their known hosts at the Nevada Test Site are shown in Table 1.

PUBLIC HEALTH IMPLICATIONS

This study was not intended to investigate the ticks as natural reservoirs for infectious diseases or as vectors. Nevertheless, it is interesting to note that there are species of hosts and ticks present which have been so implicated. *Dermacentor parumapertus* is one of the most abundant hard-bodied ticks at the test site. Philip and Hughes (1953) reported natural infections in this tick of tularemia, Rocky Mountain spotted fever-like rickettsia, and the virus of Colorado tick fever, all of which are diseases affecting man. Workers in the University of Utah Ecological and Epizoological Research Unit at Dugway effectively demonstrated by laboratory experiments the capability of *Otobius lagophilus* as an agent of transfer and reservoir for tularemia organisms (Vest, 1957). They reported that one female retained the organisms for 611 days and nymphs for more than nine months. Stoenner, Holdenreid, Lackman, and Orsborn (1959) reported Q-fever in Utah as occurring naturally in the black-tailed jack rabbit, *Lepus californicus*, and its almost omnipresent parasite the rabbit tick, *Dermacentor parumapertus*. Both of these animals are abundant at the Nevada Test Site. The tick *Hemaphysalis leporis-palustris* was also found at the test site. Parker (1923) and Philip (1942) have shown this species of tick to be a natural carrier of Rocky Mountain spotted fever.

The above indicates a potential public health problem at the Nevada Test Site. As far as the authors know there has been no attempt to recover any disease agent from either hosts or ticks at the test site. Such a study would certainly be noteworthy.

ACKNOWLEDGMENTS

Identifications and verifications of the mammalian hosts were made by C. Lynn Hayward of the Department of Zoology and Entomology, Brigham Young University. Most of the immature ticks of the genus *Ixodes* were classified by Carlton M. Clifford and Glen M. Kohls at the Rocky Mountain Laboratory, Hamilton, Montana. The remaining determinations of immature as well as adult stages were made by the authors of this paper. Questionable adults were submitted to Clifford and Kohls for corroboration or correction.

Ticks from mule deer and bighorn sheep were kindly supplied us by Dr. Charles Hansen, Biologist at the Bighorn Game Refuge, Nevada.

In a study of this dimension and especially in view of the fact that it was associated with the larger study of the biotic communities at the test site, there were many persons directly and indirectly involved. As research associates, technicians or clerks they have been an integral part of the study, and even though the long list of names is not given here, they are gratefully recognized for the valuable part they have played.

Table 1. Host-tick associations indicated by stage of tick development[1]

Host	Tick										
	Argas persicus	*Otobius lagophilus*	*Dermacentor albipictus*	*Dermacentor parumapertus*	*Haemaphysalis l.-palustris*	*Ixodes angustus*	*Ixodes kingi*	*Ixodes ochotonae*	*Ixodes pacificus*	*Ixodes sculptus*	*Ixodes spinipalpis*
BIRDS											
Anas cyanoptera Cinnamon Teal	A										
Melospiza lincolnii Lincoln's Sparrow					N						
MAMMALS											
Antrozous pallidus Pallid Bat		L									
Ammospermophilus leucurus Antelope Squirrel				LN		NA	N	L		LNA	
Bassariscus astutus Ringtail				L			N				
Canis latrans Coyote							A				
Dama hemionus Mule Deer			A								
Dipodomys merriami Merriam's Kangaroo Rat				LN	U		LN			N	N
Dipodomys microps Chisel-toothed Kangaroo Rat	A			LNA	L	A	LNA				
Dipodomys ordii Ord's Kangaroo Rat				LN							
Eutamias dorsalis Cliff Chipmunk						N		L			
Lepus californicus Jack Rabbit		N		LNA							
Microdipodops megacephalus Kangaroo Mouse							LN				
Neotoma lepida Wood Rat				L			LN				
Onychomys torridus Grasshopper Mouse		L		LN			LN				
Perognathus formosus Long-tailed Pocket Mouse				L					LN		N
Perognathus longimembris Little Pocket Mouse				LN							N
Perognathus parvus Great Basin Pocket Mouse				LN			LN		L		
Peromyscus crinitus Canyon Mouse		L									
Peromyscus maniculatus Deer Mouse				L		N	LN				
Peromyscus truei Piñon Mouse						N					
Sylvilagus audubonii Desert Cottontail				LN	LN		L				
Sylvilagus nuttallii Nuttall's Cottontail					N						
Thomomys umbrinus Pocket Gopher					N						

[1] L = larva, N = nymph, A = adult, U = stage unknown.

SPECIES DISCUSSION

Argas persicus (Oken)

Hosts. Only two females were found — one from a Cinnamon Teal and the other from a kangaroo rat.

Seasonal incidence. The tick from the duck was taken in April, and the one from the rat in June.

Comments. This species is usually listed as the "fowl tick" although it has been frequently found on native wild birds distributed worldwide in warm, dry situations. The infrequency of collection is not necessarily indicative of its occurrence at the test site. Roosting sites, nests, and the tunnels of burrow-inhabiting birds have not been systematically examined. Cooley and Kohls (1944) reported specimens collected from "nesting holes" of the Inyo Screech owl, *Otus asio inyoensis*. Its occurrence on a kangaroo rat as found in our studies is unusual. Nevertheless, other soft-bodied ticks such as *Ornithodoros turicata* and *O. parkeri* have been taken in rodent burrows elsewhere, so a thorough survey of such habitats at the test site may reveal its presence.

Otobius lagophilus Cooley and Kohls

Hosts. Twenty-eight larvae were taken from two pallid bats, two from a grasshopper mouse, 22 from a canyon mouse, one from the desert wood rat, one from the chisel-toothed kangaroo rat, 32 from the black-tailed jack rabbit, and two from the House Finch. A total of 89 nymphs was collected from the black-tailed jack rabbit.

Seasonal incidence. The earliest date for larval collections was May 18 and the latest was January 30. Some nymphs were taken in January from the jack rabbit but most were taken in April, May, June, July, August, and September with the majority between May and August.

Comments. In the original description for the species (Cooley and Kohls, 1940), a long list of collections from western United States shows about the same pattern of seasonal appearance except 10 nymphs listed from a "rabbit" in October. We have not taken specimens during this month although they may be present.

All of the ticks taken at the test site in the nymphal stage came from the black-tailed jack rabbit, *Lepus californicus*. All of the host records listed by Cooley and Kohls (1940) in the original description of the species were nymphs collected from various kinds of leporids. Typical of some species of ticks, in the larval stage *O. lagophilus* is found on a variety of hosts. Woodbury (1954) reports an unsuccessful attempt to get newly hatched, laboratory reared larvae of this species to attach to kangaroo rats. On the other hand, we have found them on the chisel-toothed kangaroo rat, *Dipodomys microps*. Of special interest are nymphs taken in June, July, and August which were shipped alive in glass, cotton-stoppered vials to the Brigham Young University laboratory for life history studies. Within five days after collection, the greatly engorged nymphs had transformed to the adult stage during transit from the test site.

Plant community relationships. As would be expected, the geographic distribution for the ticks would be determined by host distribution. The black-tailed jack rabbit is generally distributed over the test site with greatest abundance in the Grayia-Lycium community and is next most abundant in the Mixed community. Inasmuch as larvae were collected from bats, birds and several species of rodents it is obvious that much more extensive collecting must be done at the test site in order to correlate larval stage with plant communities.

Dermacentor albipictus (Packard)

Hosts. One male and three females were found on two mule deer.

Seasonal incidence. The adult ticks were collected in October.

Plant community relationships. At the test site the mule deer are found mainly in the Pinyon-Juniper community of the high mesas. They are known to migrate through the valleys, going from one mountain range to another. No doubt this tick species is relegated to the habitat of the mule deer.

Comments. This species is common on deer and elk in the western United States and occasionally infests horses and cattle. It is a one-host tick. The engorged females drop to the ground where they lay eggs in the autumn. The larvae await contact with the preferred host (the mule deer) or may over-winter. When a likely host comes along in the spring, they attach to it. Larvae once attached remain on the host, engorge and undergo developmental changes through the nymphal to the adult stage. In the adult stage, a final engorgement takes place and the cycle is repeated.

Ticks taken in our collections were from hosts which were shot during a deer hunt. No year-round survey for these ticks has been made of the larger vertebrates at the test site, especially those at higher elevations.

Dermacentor parumapertus Neumann

Hosts. Totals of 869 larvae, 243 nymphs, and 199 adults were collected from 10 species of rodents, 44 rabbits of two species, and one species of carnivore. Larvae were most commonly encountered on kangaroo rats, pocket mice, and the black-tailed jack rabbit. Nymphs were common on kangaroo rats and were less abundant on other rodents. They were completely absent on carnivores. Almost without exception the adults were taken from black-tailed jack rabbits. Exceptions were two females collected from the chisel-toothed kangaroo rat and three males from the Golden Eagle, *Aquila chrysaetos.*

Seasonal incidence. Larvae were collected every month of the year except July (Fig. 2). The highest incidence was in February and the greatest number of hosts with larvae was in April, with kangaroo rats and the antelope squirrels predominating.

Nymphs were collected every month of the year except July and September, with the highest population in May. Average numbers of nymphs found were constant for each month, increasing slightly in April, abruptly in May, declining slightly in June and abruptly in July.

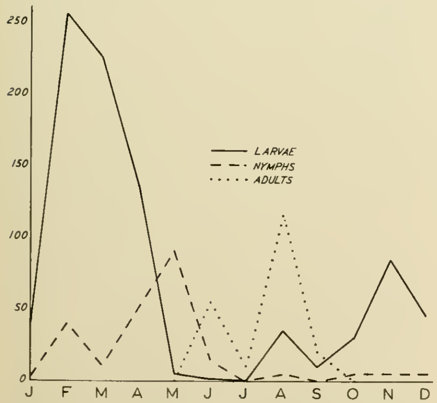

Fig. 2. Seasonal incidence of *Dermacentor parumapertus.*

Their host predominance and preference were similar to the larvae.

Adults were collected from June through September, with the highest population occurring in August. There were no systematic collections of the jack rabbit over a 12 month period at the test site. Consequently the seasonal picture of adult ticks is incomplete. This is not the case with the immature forms.

Plant community relationships. Larvae were not found in the Pinyon-Juniper and Atriplex-Kochia communities. They were most frequently encountered in Coleogyne. Nymphs were absent from Salsola and Atriplex-Kochia, but were most frequent in Grayia-Lycium. The adults were likewise most abundant in Grayia-Lycium. No adults were taken in the Pinyon-Juniper and Salsola communities.

Comments. Although the type specimens from which Neumann (1901) described the species were "taken on a man and in a chicken house" in California, practically all adult specimens collected since that time have been found on the black-tailed jack rabbit.

All stages of development are known to occur in the temperate deserts of the western United States where rodents of several species serve as hosts for the immature stages, kangaroo rats being the principal hosts. The host-parasite association at the test site follows somewhat the same pattern as found in other parts of the desert areas of western United States.

From the data at hand it appears that there is only one generation a year, with eggs laid from July through September and hatching beginning as early as August. In studying the life history of this species, Allred and Roscoe (1956) found that the females oviposited within 20 days after detachment from a host. Incubation period of the eggs varied from 28 to 37 days, and the newly hatched larvae attached to hosts within nine days. Larval engorgement varied from 4 to 13 days and the larvae molted within 16 days. Nymphal engorgement and molting required up to 16 and 28 days, respectively. Our seasonal observations of these ticks at the test site are in agreement with Allred's and Roscoe's findings.

The pattern of distribution by stage and season agrees for the most part with the findings of Beck (1955), Gastfriend (1955) and Fremling and Gastfriend (1955) for similar studies conducted in Utah. Beck found the main seasonal peak for larvae to be in April and May, June for nymphs, and July for adults. Fremling and

Gastfriend observed brief larval peaks from September to October, in December, February, and March to May. Nymphs were highest in their study during May, June, and September and adults highest in July.

Fremling's and Gastfriend's observations were based on small samples from rabbits taken for only a one-year period. Inasmuch as rabbits are not the principal hosts for the immature stages of *D. parumapertus*, limited validity can be attributed to their study except for the adult stage of this tick. Beck's study was conducted for several years and involved rodent as well as rabbit hosts. Consequently, his study is assumed to be more representative of the cycle of *D. parumapertus* in Utah.

The major points of difference between the Nevada and Utah results were the spring peak in larval population which occurred earlier in Nevada than in Utah, the earlier nymphal population in Nevada, as well as the bimodal June and August peaks for adults which at the test site were earlier and later than the Utah studies.

Our observations agree in part with Beck, Fremling, and Gastfriend except for the slight differences in season as mentioned above. The February-March larval population likely was responsible for the May nymphs, which in turn were responsible for the August adults. These adults probably gave rise to the February-March larvae. However, other population peaks in Nevada possibly indicate a separate population of ticks which demonstrate different seasonal activity (Fig. 2). In this case the August larval population likely gave rise to the February nymphs, which in turn were responsible for the June adults, and so on to the August larvae.

There is little doubt that these ticks are influenced in their ecological distribution by the nature of the physical environment when off their hosts. The ticks at the test site were found most frequently where the plant cover and humus were more abundant than elsewhere and likely furnished a better chance of survival for the ticks by providing protection from high temperatures and low humidities. In the Salsola and Atriplex-Kochia communities where plant cover and humus are minimal, few ticks are apt to survive exposure to the elements when off their hosts. Consequently, few ticks of this species were found in these communities even though the common hosts of their immature stages occurred there in abundance. Such small numbers as were found in the Pinyon-Juniper community probably were due to the lower temperature extremes. Similar situations are known to occur farther north in the Great Basin where *D. parumapertus* occupies only the lower elevations of the valleys and foothills.

More intensive studies on all stages of development of this tick must be done before the entire life cycle can be considered as well known. This is especially true for the adults and their hosts. More data are needed with reference to the emergence of the various developmental stages as they are affected by environmental factors such as temperature and humidity.

Haemaphysalis leporis-palustris (Packard)

Hosts. Only four larvae were collected. They were taken from a chisel-toothed kangaroo rat and the desert cottontail. Ninety-five nymphs were taken from a southern pocket gopher, six Lincoln's sparrows, and desert cottontails. No adults were found.

Seasonal incidence. The larva on the rabbit was found in November, whereas those on the kangaroo rat were taken in February. The nymph on the bird was taken in May; all other nymphs were found in November.

Plant community relationships. The larvae were taken from the Grayia-Lycium and Mixed plant communities. The nymphs were found predominantly in Mixed, with small numbers found in Grayia-Lycium and Pinyon-Juniper.

Comments. This tick commonly occurs on rabbits and less frequently on rodents and birds. It is surprising that adults of this tick have not been found on black-tailed jack rabbits for many rabbits were examined. It is also unusual that only a few specimens of the immature stages have been collected from the hundreds of small rodents that were examined in this study.

There likely are two reasons for the scarcity in numbers of specimens of all stages of development having been taken at the test site. The collections of cottontail rabbits have been few in number. In addition, these cottontails are somewhat limited in their distribution at the site. They were encountered principally where some water was available as springs or seeps. A year-round study of cottontails at the few springs and seeps would no doubt provide a much different record than at present. On December 21, 1950, Beck collected 60 nymphs and 121 adults from a cottontail at Beaver Dam Wash, Utah, in an ecological situation somewhat similar to that at the Nevada Test Site.

Although it has been the rule rather than the exception for cottontail rabbits to be the main hosts for this species of tick, a thorough survey of the ectoparasites of birds likely would produce additional specimens of this species.

Ixodes angustus Neumann

Hosts. No larvae of this species were taken. Thirty-six nymphs were found on eight rodents of four species. Three adults were taken from an antelope squirrel and two chisel-toothed kangaroo rats.

Seasonal incidence. Nymphs were found from April through June and in September and November. Adults were found from November through January.

Plant community relationships. Nymphs were found most commonly in the Mixed community but were also taken in Atriplex-Kochia and Pinyon-Juniper.

Comments. Cooley and Kohls (1945) listed 16 genera of animals which serve as hosts for *I. angustus* in northwestern United States. Gregson (1956) listed 13 genera as hosts from his studies in Canada. Allred, *et al.* (1960) listed six species from four genera of hosts for this tick in Utah, with larvae being taken only from *Peromyscus maniculatus*. The tick has an extensive geographic range in North America, extending from Alaska to southern California and to the eastern part of the United States.

The information from the literature indicates that this species is more abundant and has a wider range of distribution in nondesert situations. All the collections in Utah have been taken at high elevations in mountainous areas or in the northern part of the state. Gregson mentions the species extending across Canada, from Alaska to California, and "east to New York State." An examination of the host listing by Cooley and Kohls also shows host animals whose ecological distribution is either at higher altitudes in mountain ranges, foothills, the Pacific coastal region, or in the northern part of the United States. It appears that a principal factor directly affecting distribution is humidity.

On the above basis, the Mojave area would not be considered a region which would be productive of hosts on which this tick is normally found, and hence one would expect the tick to be limited in numbers collected as well as range of distribution at the test site. Such was the case!

The seasonal occurrence of this species at the test site is in agreement with findings of other workers.

Ixodes kingi Bishopp

Hosts. This tick was taken from 48 animals including two carnivores, a rabbit, and eight species of rodents. A total of 82 larvae was collected from the rabbit and from 45 rodents of seven species. The greatest number was taken from wood rats, with none found on carnivores or antelope squirrels. Thirty-two nymphs were taken from all the host species on which larvae were found except the coyote and the leporids. They were most abundant on the wood rat and chisel-toothed kangaroo rat. Only two adults were taken: a male from a coyote and a female from the chisel-toothed kangaroo rat.

Seasonal incidence. Larvae were found from March through December except in August and September. They were taken most frequently in April, although greatest numbers were found in October. From October through December they were found on a rabbit and wood rats, whereas from March through July they occurred on rodents of other species. Nymphs were found in December and January and from April through September except in July. They were taken most frequently from April through June. During the winter months they were taken principally from wood rats, whereas in summer they were found on other rodents. The male from a coyote was taken in November, and the female from a kangaroo rat in June.

Plant community relationships. Larvae were taken most frequently in the Grayia-Lycium and Coleogyne communities. Nymphs were found most frequently in Grayia-Lycium and Mixed. The adults were found in Grayia-Lycium and Atriplex-Kochia.

Comments. Cooley and Kohls (1945) and Allred *et al.* (1960) listed many species of hosts for this tick. Although the deer mouse and kangaroo rat are preferred hosts in Utah (Allred *et al.*, 1960), wood rats apparently are a common host at the test site. Except for their occurrence on wood rats in October, they were seldom found on a host in numbers of more than one or two. This is in agreement with Allred *et al.* who stated that few animals are heavily infested with this tick and most had only one or two.

Their seasonal occurrence is similar to that found by Cooley, Kohls, Allred *et al.* Figure 3 shows the population fluctuations of *I. kingi* larvae and nymphs. Adults were taken in insufficient numbers for inclusion. These data are indicative of possibly two generations a year. This assumption is based on the relative populations of larvae and nymphs for each season. It is unlikely that a given larval population could give rise to a larger nymphal population. Consequently the larval peak in April likely gave rise to the nymphs in June and the larvae in October to the nymphs in December. Adults, which were not collected in any number at the test site, likely attain highest numbers on their hosts (unknown to us) about August and February.

It is interesting to note that although the nymphs were frequently found in the Mixed community, larvae were not so frequently found there. The relative frequency of occurrence of larvae and nymphs in other communities where they were found was about equal.

Ixodes ochotonae Gregson

Hosts. Seven larvae were taken from five antelope squirrels and a cliff chipmunk.

Seasonal incidence. Larvae were taken from January through June except in March.

Plant community relationships. Collections were made in Grayia-Lycium, Larrea-Franseria, Coleogyne, and Pinyon-Juniper communities. They were taken most frequently in Grayia-Lycium.

Comments. Cooley and Kohls (1945), Gregson (1956), and Allred *et al.* (1960) listed nine species of six genera of mammals which serve as hosts for this tick. Our data from the test site for collections from antelope squirrels and the cliff chipmunk apparently are new host records.

The seasonal occurrence of the larvae at the test site is earlier than found by Cooley and Kohls, Allred *et al.* This is expected inasmuch as collections reported by them were made at higher elevations at more northerly latitudes.

Most published records of this tick are from hosts taken in forested mountain areas. Inasmuch as Allred *et al.* stated that in Utah it was found about equally in coniferous forest and desert shrub areas, its occurrence at the test site is not unusual.

Gregson (1956) cited this tick as the "pika tick," but most of the records for collections in Utah as reported by Allred *et al.*, and those taken at the test site indicate this species to have a wide selection of hosts.

Ixodes pacificus Cooley and Kohls

Hosts. Twelve larvae and a nymph were taken from four pocket mice.

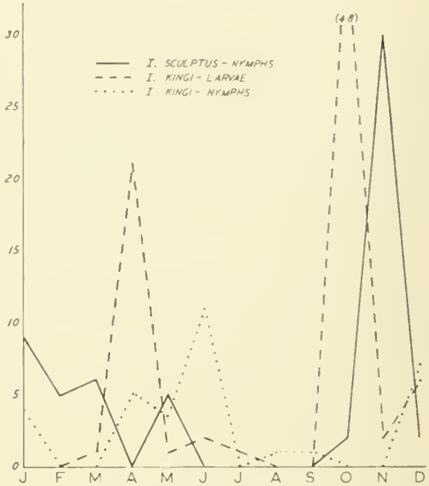

Fig. 3. Seasonal incidence of *Ixodes sculptus* and *I. kingi*.

Seasonal incidence. The larvae were taken in April and the nymph in October.

Plant community relationships. All the larvae were found in the Coleogyne community, whereas the nymph was taken in a Mixed community.

Comments. Cooley and Kohls (1945), Gregson (1956), and Allred *et al.* (1960) listed a variety of hosts for this tick including lizards, domestic animals, and man. Records include pocket mice from California, but our records for other species of pocket mice at the test site apparently are new.

The seasonal incidence agrees with that stated by Cooley and Kohls.

Ixodes sculptus Neumann

Hosts. Two larvae, 58 nymphs, and two females were taken from 22 antelope squirrels. One nymph was taken from a Merriam's kangaroo rat. The antelope squirrel apparently is the preferred host of the nymphs.

Seasonal incidence. The larvae were found during the winter, nymphs in winter and spring, and the adults in the spring. No ticks of any stage of development were collected during the summer months.

Plant community relationships. The larvae were found only in the Coleogyne community.

The nymphs were found principally in the Coleogyne and Grayia-Lycium but also in the Mixed and Larrea-Franseria communities. The adults were taken in Coleogyne.

Comments. Cooley and Kohls (1945), Gregson (1956), and Allred *et al.* (1960) listed squirrels of several species as the preferred hosts of this tick. Collection data for ticks found on the antelope squirrel and kangaroo rat at the test site apparently are new host records.

Our winter records for the larvae are later than those listed by Cooley and Kohls, Allred *et al.*

Although collections of larvae and adults of *I. sculptus* at the test site essentially are lacking, the data on nymphs are suggestive of more than one generation of ticks per year or more than one separate population (Fig. 3).

Ixodes spinipalpis Hadwen and Nuttall

Hosts. One nymph was taken from a kangaroo rat and seven nymphs from three pocket mice of two species.

Seasonal incidence. Nymphs were taken in February, April, June, and November.

Plant community relationships. The two communities represented by our collections were Larrea-Franseria and Mixed. Ticks were taken most frequently from the latter.

Comments. Cooley and Kohls (1945), Gregson (1956), and Allred *et al.* (1960) listed records of this tick from birds, rabbits, and rodents including pocket mice and kangaroo rats. Our records from the chisel-toothed kangaroo rat and little pocket mouse apparently are new. Seasonal findings are in agreement with other workers.

DISCUSSION

Of the 24 species of animals found infested with ticks, 17 were infested with larvae, 19 with nymphs, and only six with adults. Rodents of only two species were found to harbor adults. The paucity of adult ticks of some species taken may be explained on the basis of their known host and ecological relationships.

Antelope squirrels, chisel-toothed and Merriam's kangaroo rats were hosts for ticks of more species than were other animals. *Dermacentor parumapertus* apparently is the most widespread species at the Nevada Test Site. This is true with respect to both host and ecological distribution, although *Ixodes kingi* is almost as widespread. According to recent studies of this latter species by Gregson and Kohls, Gregson (correspondence) states that ticks of *I. kingi* in the Great Basin area are not typical of the *kingi* found east of the Rocky Mountains and may prove to be a different species.

Adults of *Argas persicus* are principally parasites of birds. The relatively small number of birds examined and the limited seasonal observation for their parasites at the test site would account in part for the low number of collections of this species. The mule deer, if examined on a year-round basis in a systematic manner, likely would produce a great number of *Dermacentor albipictus*. Adults of *Haemaphysalis leporis-palustris* occur most commonly on cottontail rabbits not only at the test site but elsewhere. Only a few of these hosts were taken at the test site mainly because of the limited areas in which they occur and lack of a systematic year-round collection.

With reference to *Ixodes angustus, I. ochotonae, I. pacificus, I. spinipalpis,* and *I. sculptus,* host records reported in the literature indicate that they occur on animals which commonly live in the Desert Woodland, at higher elevations, or in mountain forest areas. Migrations of animals such as domestic stock, deer, and carnivores across the lower valleys of the test site may account for the maintenance and occurrence of the immature stages of these species on rodents at the site. Beck (1955) reports several collections of *I. pacificus* taken from the mule deer in Utah. Most literature reports list the adults from larger animals such as deer, dogs, and man. Adults of some *Ixodes* such as *I. kingi* may infest carnivores. Badgers, bobcats, foxes, and coyotes occur commonly at the test site, but relatively few were examined for ectoparasites. As expected with *Dermacentor parumapertus* and *Otobius lagophilus,* their adults and nymphs, respectively, were commonly taken from jack rabbits which occur in abundance at the test site.

Our results are indicative that the nature of the habitat is influential on survival of the ticks when not on a host. Ticks were collected most frequently in the Grayia-Lycium, Mixed, and

Coleogyne communities (Table 2). The greatest number of species was also found in these communities. Although almost as many species were taken in the Larrea-Franseria community, their frequency of occurrence was only one-third to one-half that of the three communities above. Frequency of collections and fewest species of ticks occurred in the Salsola. These relationships likely are correlated with the amount of plant cover and humus under the plants which may provide microhabitats favorable for survival of ticks when not on their hosts.

Table 2. Frequency of tick collections by plant community.

Plant Community	No. tick species	Percent frequency of total collections*
Atriplex-Kochia	3	4.8
Coleogyne	6	24.4
Grayia-Lycium	7	33.6
Larrea-Franseria	5	10.3
Mixed	7	22.9
Pinyon-Juniper	3	3.0
Salsola	1	1.0

*Slightly skewed because of differences in collecting attempts.

The unusual number of species of ticks which occur in the comparatively small area of the Nevada Test Site may be explained in part on the nature of its geographical and ecological location. Relatively high mountain ranges and intervening valleys extend southward from the Great Basin region and merge into the Mojave region. In such a place of zoogeographic merging one may expect the unusual. For example, six species of *Ixodes* have been taken from the test site whereas less than a dozen are known for the whole state of Utah. A total of eleven kinds of ticks are known from the test site and only 17 are known for all of Utah.

Other species of ticks and new host associations for species already known most likely will be discovered at the test site, especially if emphasis is placed on the examination of birds, carnivores and other less frequently collected animals as well as their nests and burrows. Systematic surveys at higher elevations would likewise produce additional species.

REFERENCES

Allen, R. W. 1962. Parasitism in Bighorn Sheep on the Desert Game Range in Nevada. Desert Bighorn Council Trans., Las Vegas, Nevada.

Allred, D. M. and E. J. Roscoe. 1956. Life history of the tick *Dermacentor parumapertus* in Utah. J. Parasitol. 42:516-522.

Allred, D. M., D E. Beck and L. D. White. 1960. Ticks of the genus *Ixodes* in Utah. Brigham Young Univ. Sci. Bull., Biol. Ser., Vol. 1, No. 4.

Allred, D. M., D E. Beck and C. D. Jorgensen. 1963a. Biotic communities of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser., Vol. 2, No. 2.

Allred, D. M., D E. Beck and C. D. Jorgensen. 1963b. Nevada Test Site study areas and specimen depositories. Brigham Young Univ. Sci. Bull., Biol. Ser., Vol. 2, No. 4.

Beck, D E. 1955. Distributional studies of parasitic arthropods in Utah, determined as actual and potential vectors of Rocky Mountain spotted fever and plague, with notes on vector-host relationships. Brigham Young Univ. Sci. Bull., Biol. Ser., Vol. I, No. 1.

Beck, D E. 1955. Some unusual distribution records of ticks in Utah. J. Parasitol. 41(2):198-201.

Cooley, R. A. and G. M. Kohls. 1940. Two new species of Argasidae (Acarina: Ixodoidea). Public Health Repts. (U.S.) 55:925-933.

Cooley, R. A. and G. M. Kohls. 1944. The Argasidae of North America, Central America and Cuba. Am. Midland Naturalist, Monograph No. 1.

Cooley, R. A. and G. M. Kohls. 1945. The genus *Ixodes* in North America. Natl. Inst. Health Bull. 184:1-246.

Davis, G. E. and A. J. Mavros. 1956. An atypical *Ornithodoros hermsi* from Utah (Ixodoidea, Argasidae). J. Parasitol. 42(3): 293-296.

Fremling, L. and A. Gastfriend. 1955. Seasonal abundance of the tick, *Dermacentor parumapertus*. Ecology 36:162-163.

Gastfriend, A. 1955. New host records for the immature stages of the tick *Dermacentor parumapertus*. J. Parasitol. 41:63-65.

Gregson, J. D. 1956. The Ixodoidea of Canada. Canada Dept. Agric., Ottawa, Ont., Publ. No. 930.

Jellison, W. L. 1940. The burrowing owl as a host to the argasid tick, *Ornithodoros parkeri*. Public Health Repts. (U. S.) 55:206-208.

Neumann, L. G. 1901. Revision de la Ixodides. Extr. des Mem. Soc. Zool. de France, pp. 267-268.

Parker, R. R. 1923. Transmission of Rocky Mountain spotted fever by the rabbit tick *Haemaphysalis leporis-palustris* Packard. Am. J. Trop. Med. Hyg. 3:39-46.

Parsons, L. 1947. Relapsing fever at Lake Tahoe, California, Nevada. Am. J. Clin. Pathol. 17:388-392.

Philip, C. B. 1942. Rocky Mountain spotted fever: known and potential tick vectors in the U. S. Proc. 6th Pacific Sci. Cong. 5:581-584.

Philip, C. B.and L. E. Hughes. 1953. Disease agents found in the rabbit tick *Dermacentor parumapertus* in southwestern U. S. Sixth Congr. Intern. di microbiol. Sezioni VIII-XVI, 2(793):600.

Philip, C. B., J. F. Bell and C. L. Larsen. 1953. Evidences of infectious diseases and parasites in a peak population of black-tailed jack rabbits in Nevada. J. Wildl. Mgmt. 19:225-233.

Stoenner, H. G., R. Holdenried, D. Lackman and J. S. Orsborn, Jr. 1959. The occurrence of *Coxiella burneti*, Brucella and other pathogens among the fauna of the Great Salt Lake Desert in Utah. Am. J. Trop. Med. Hyg. 8:590-596.

Vest, D. E. 1957. Study on the ecology and epizoology of the native fauna of the Great Salt Lake Desert: Annual report of the resident director and staff. Ecol. and Epizool. Ser., No. 41, Ecol. Research, Univ. Utah.

Woodbury, A. M. 1954. Ecology of disease transmission in native animals: Semiannual report, 1 June to 30 November. Ecol. Research, Univ. Utah.

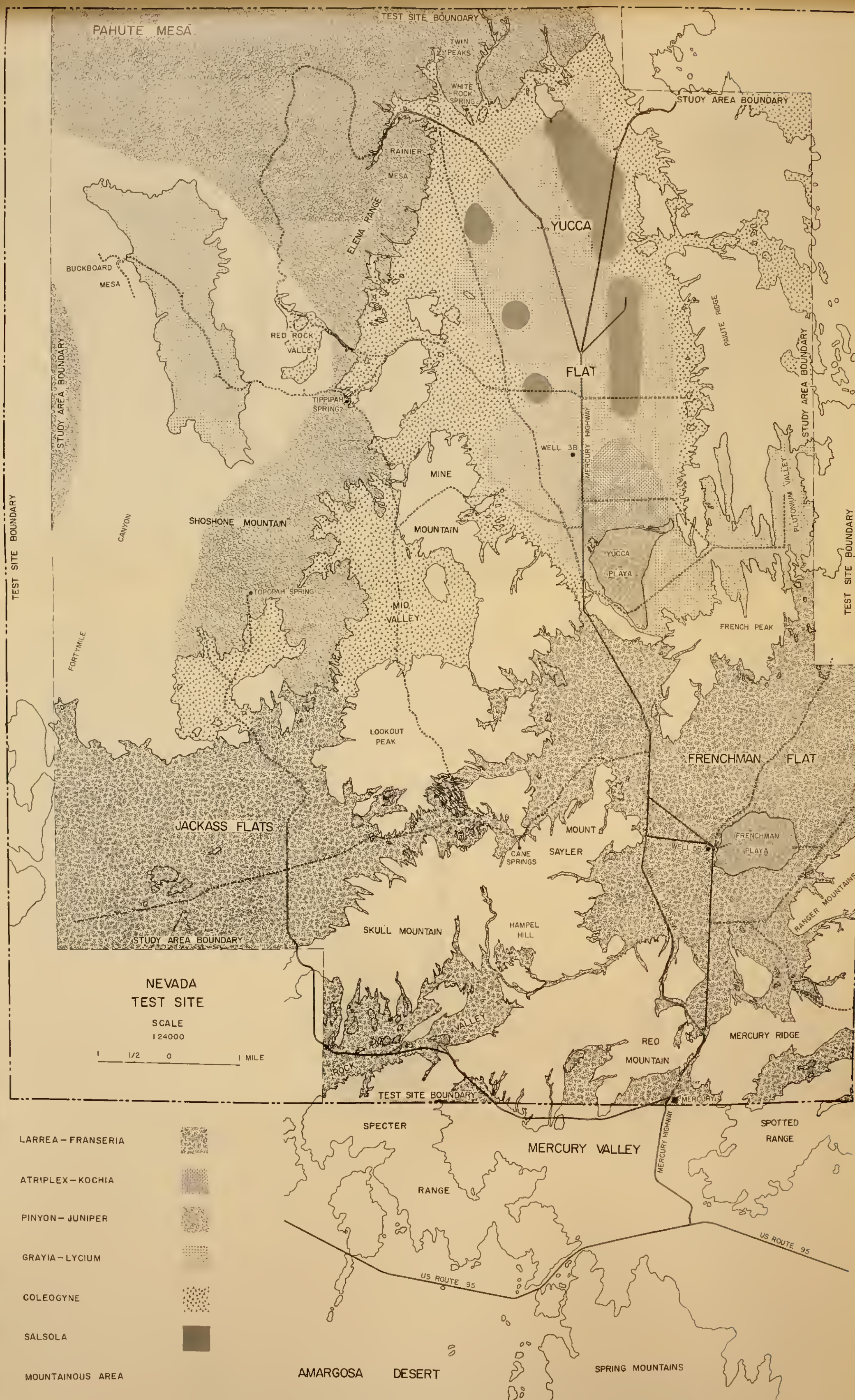

Fig. 4. Extent of the major plant communities — Nevada Test Site.