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March 1, 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

by
D ELDEN BECK

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by

D Elden Beck

Department of Zoology and Entomology

INTRODUCTION

Preliminary investigations were started on this project in the spring of 1948. The Division of Research Grants and Fellowships of the National Institutes of Health, Department of Health, Education, and Welfare, U. S. Public Health Service, established a research grant for this study at the Brigham Young University September 1, 1950. The author, a member of the faculty of the Department of Zoology and Entomology at the grantee institution, was named the principal investigator. The project was designed for a three year period of study. Most of the work originally planned has now been completed and is being reported upon in this paper.

Objectives of the study were as follows:

1. To locate and identify the species of known vectors of plague and Rocky Mountain spotted fever in Utah.
2. To specifically identify hosts with which the known vectors would be associated and show their geographic distribution.
3. To determine and locate in Utah the known reservoir hosts for plague and Rocky Mountain spotted fever.
4. To make observations on vector-host relationships.
5. To record, insofar as possible, information on vector populations in order to determine seasonal variations if any.
6. To conduct investigations both in the field and by laboratory studies which would help solve some problems related to life histories of various species involved as vectors of Rocky Mountain spotted fever and plague.

General survey procedure:

Those areas of the State where the greatest concentration of people was located were surveyed first. Following this, the more outlying towns and cities were studied. Vast stock grazing domains, wilderness areas and mining locations in both desert and mountainous situations were surveyed. Since the hinterland areas in the southeastern section of Utah are being invaded by many hundreds of uranium prospectors, it was felt that significant surveys in this extensive area would be of value from a public health point of view. Surveys were also made in some of the national parks and monuments within the State of Utah, visited annually by many thousands of tourists. Finally, spot checking was done along the principal arterial state and federal highways in Utah.

Field surveys were conducted on a year-round basis, insofar as host animals were available and access to areas was possible. Hosts were captured both alive and dead, by whatever means best suited the conditions of collecting. Several types of live traps were utilized. Some types of live traps were more effective in trapping certain animals than others, and certain traps were more effective than others in different kinds of habitats and at different seasons. Dead hosts were usually captured by snap traps or by shooting with the appropriate calibre or gauge of gun.

If an animal were captured alive, it was then taken to the field station or laboratory where it was chloroformed and the body carefully examined for parasites. Dead animals were placed directly from the trap into paper bags and then taken to the field station or laboratory where the body was subjected to the chloroform treatment which drove the parasites from the host or made it possible for the parasites to be brushed or otherwise removed from the body of the host. Once the parasites were collected, they were placed in containers with identifying lables. A field number on this lable referred to the field records which were made up in detail. These data included the name of the host, sex, number of parasites, date of collection, place, collector, and a general description of ecological conditions where the collection was made.

A great number of nest collections were made. The nests were placed in "Berlese" funnels for the removal of consortes. All collections, whether taken from the host body or from the nest, were preserved in 70% ethyl alcohol. Various sizes of glass vials were used. For the most part, procaine drug vials were the best containers for specimens. Hemopathic glass vials were used to contain engorged ticks.

Once the specimens were collected, they were brought to the laboratory and prepared for identification. For the fleas, it meant taking the steps necessary to clear and mount the specimens on microscope slides. Fortunately, the ticks needed no special treatment in order to be properly identified. With identification complete, the data for that specimen were recorded on a master file sheet from which information could be obtained.

Host collections:

1. Fifty-nine species and subspecies of mammals, representing 29 genera and approximately 5,500 individual animals were collected. All animals were carefully examined for medically important ectoparasites, as well as other consortes.
2. Eight species of reptiles, representing 8 genera and 86 individual animals were collected.
3. Twenty-six species of birds, representing 21 genera and 78 individual birds were collected.
4. Nests of mammals were collected because nesting sites harbor immature and mature stages of the vectors; 277 nests, representing 7 genera and 9 species and subspecies of mammals were taken.

Consortes collections:

It was decided early in the project that careful removal and preservation should be done for all arthropod consortes although particular attention was given to those forms for which this project was established. Listed below are the closely approximated numbers of all consortes removed from the hosts as well as those collected by Berlese funnel extraction of consortes from host nests:

1. There were approximately 19,000 specimens of *Siphonaptera* collected. The total siphonapteron collection represents 82 species and subspecies of 38 genera.
2. There were about 25,000 specimens of ticks of the families *Ixodidae* and *Argasidae* collected. This collection includes 14 species of 6 genera.
3. Approximately 280,000 specimens of mites have been taken during the period of this study, representing an unknown number of species.
4. Some 3,000 specimens of *Mallophaga* (biting lice) have been collected representing an unknown number of species.
5. Close to 12,000 specimens of *Anoplura* (sucking lice) have been collected also representing an unknown number of species.
6. About 20,000 specimens of various other arthropods have been collected. These represent immature and mature stages of organisms belonging to the true bugs (*Hemiptera*), beetles (*Coleoptera*), flies (*Diptera*), pseudoscorpions, spiders, and others.

PROBLEMS OF SURVEY RELATED TO UTAH GEOGRAPHY

Utah is divided along a north-south axis by mountain ranges and high plateaus (Fig. 4). The principal mountain range areas in the north-central region consists of the Wasatch Range, having a north-south axis, and the Uinta Mountains which extend east and west near the northeast border (Figs. 1 and 4). South of the Uintah Mountains and South of the Wasatch Mountains (the latter terminating at about the place where the town of Nephi is located) is the "plateau" country of the State. This mountain range and plateau combination divides the State more or less into eastern and western divisions. The western unit is, in the main, a part of the Great Basin region (Figs 1, 2, 3, and 4) and has its separate drainage pattern. This is likewise the case with the eastern portion of the State which is a part of the Colorado River Basin.

The eastern half is bordered on the north by the unusual east-west range, the Uinta Mountains (Fig. 1) With the exception of the Bear, Weber, and Provo Rivers, which flow into the Great Salt Lake, the drainage from this mountain range is to the Colorado River Basin. The southern portion of the Colorado River Basin within the confines of Utah is very graphically described in U. S. Department of Interior National Park Service publication, "A Survey of the Recreational Resources of the Colorado River Basin," (1950).

"It is a wild and fantastically eroded

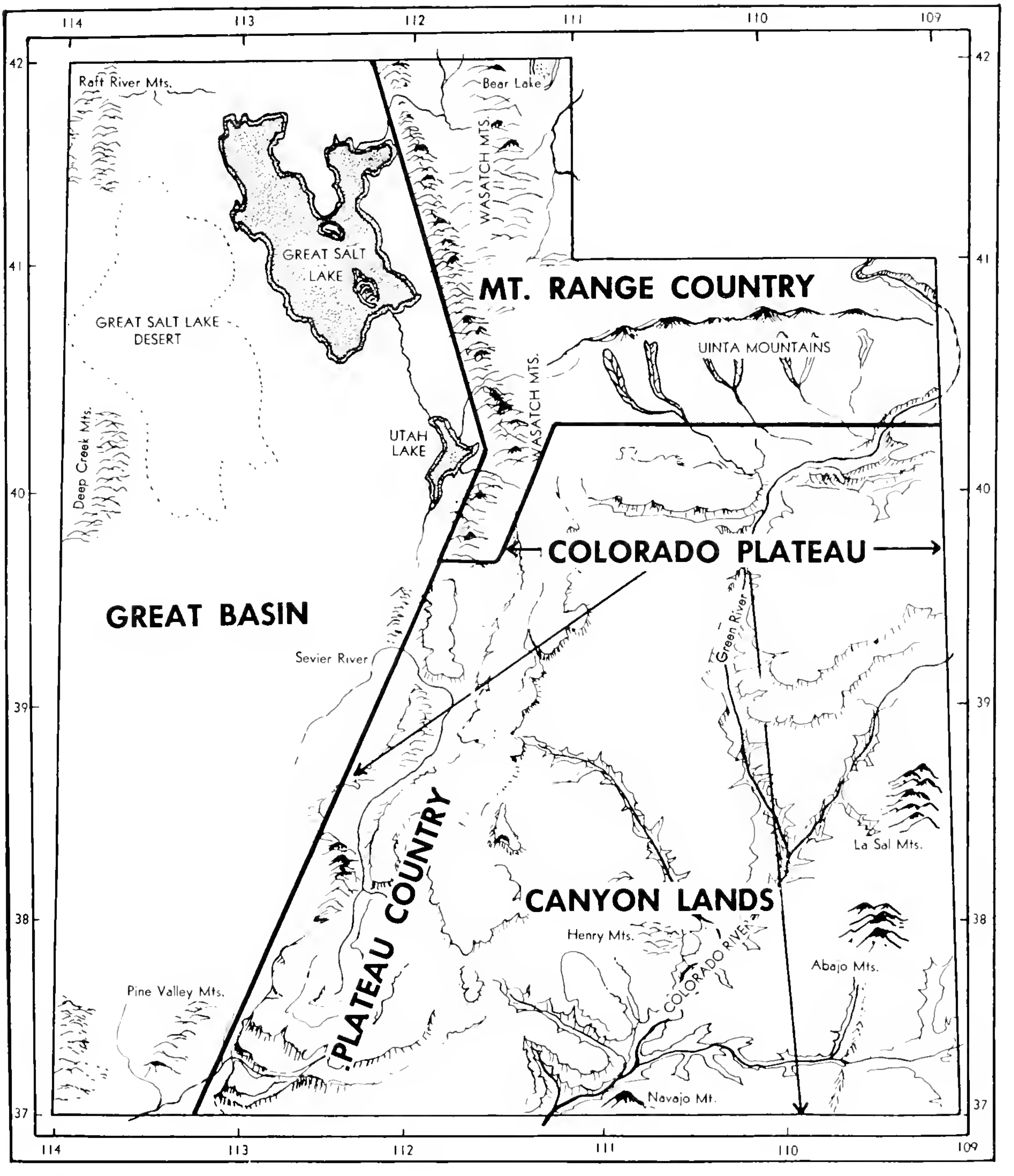

Figure 1. The principal physiographic areas of Utah.

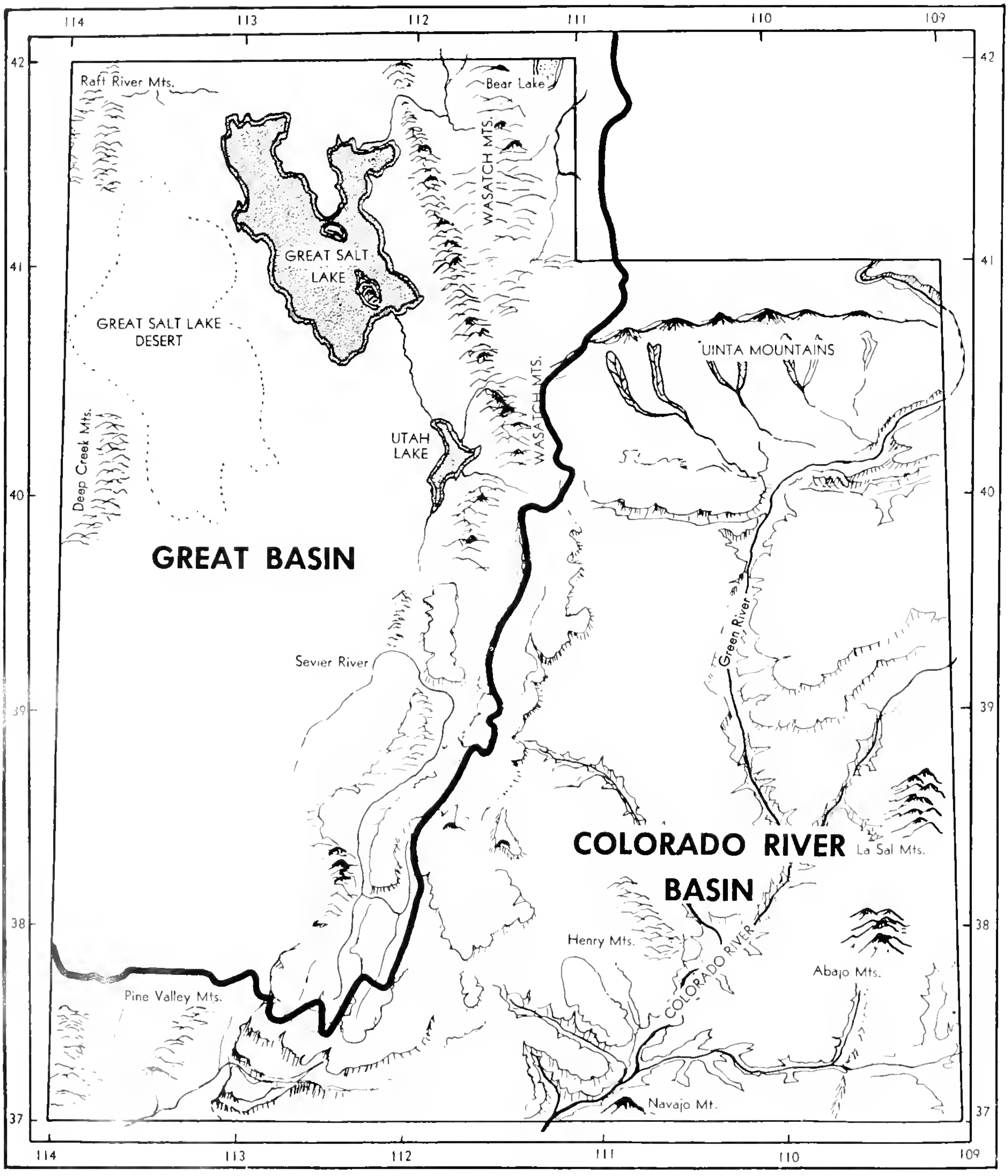

Figure 2. The Great Basin and Colorado River Basin regions in Utah.

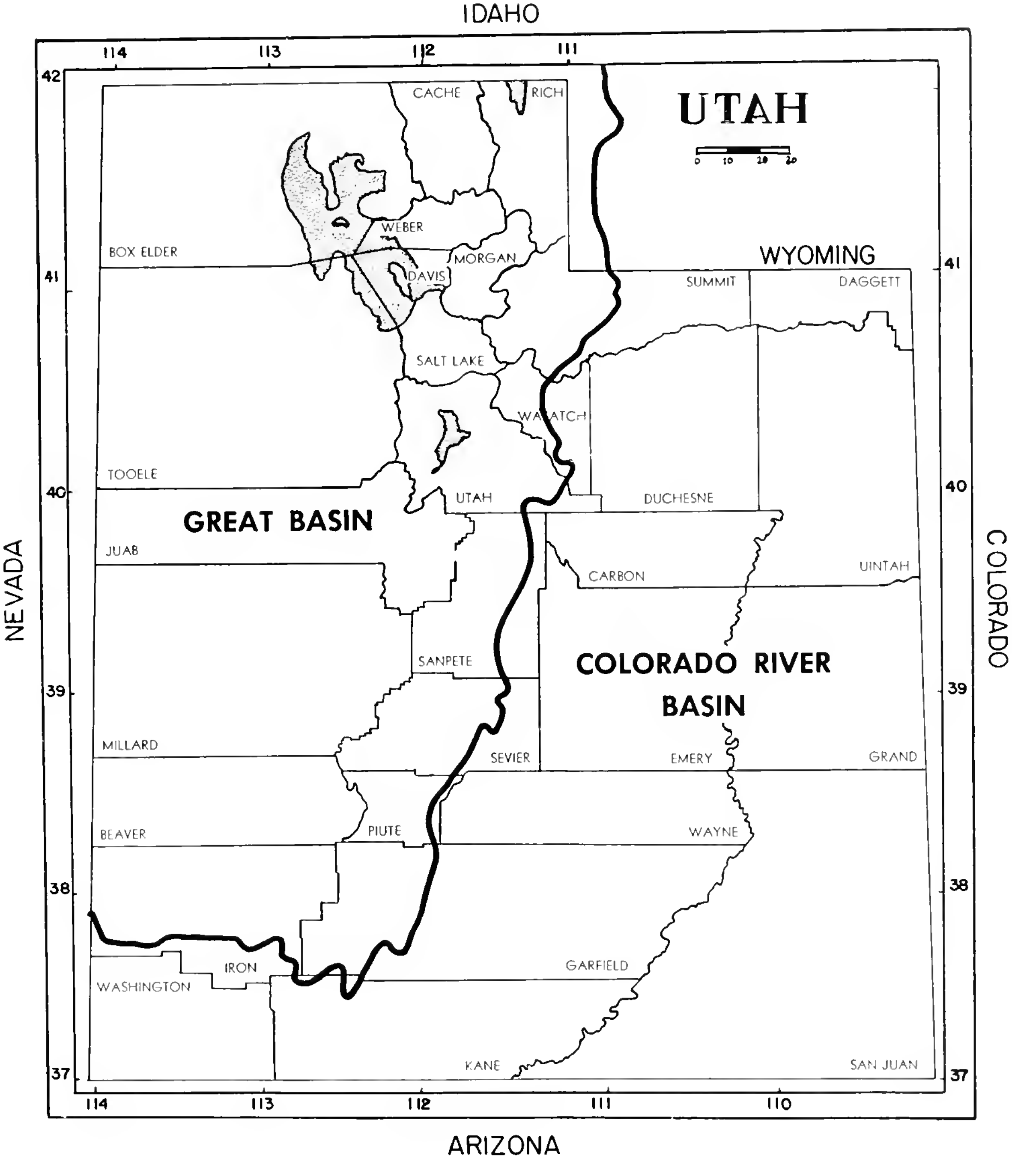

Figure 3. The Great Basin and Colorado River Basin regions in Utah with reference to the political subdivisions.

Figure 4. A physiographic map of Utah on which are identified the principal biotic communities, the primary physiographic regions as well as drainage basins.

land of winding gorges and sandstone mesas whose vast expanses are punctuated at irregular intervals by the isolated, steeply upthrust masses of the Henry, Abajo, and Navajo Mountains. With the exception of the mountain summits, which are cool and moist, the greater portion of the area receives but little snowfall in winter and is characterized by a long, warm summer season. Average temperatures are higher than those of valleys to the north, in conformity with the decrease in latitude, but lower than those of deserts to the south. The annual precipitation ranges from about 6 to 14 inches, with the greatest amount coming from thunderstorms during July and August."

"This desolate but spectacular scenic sandstone area is referred to in this report as Canyon Lands of southeastern Utah."

The Canyon Land topography continues on eastward into the state of Colorado. (Figs. 2 and 4). The western portion of the Colorado River Basin in Utah is elevated into a high plateau type of typography. The western faces of these plateaus are deeply cut into countless canyons which drain westward into the Great Basin. The eastern escarpments are likewise cut into canyons which for the most part drain into the Colorado River Basin.

From the standpoint of accessibility, there is relatively little hindrance in travel throughout the Great Basin area except perhaps in the Great Salt Lake Desert region and the tops of the few high mountains. The central mountain ranges (block fault mountains), the Uinta Mountain range and the western-most part of the Colorado River Basin to a great extent also have been opened to travel.

The Canyon Land country, however, presents next to impossible obstacles in road building even though uranium explorers are now fingering trails into some of this most formidable and remote country in the United States. There are no east-west roads in the southern part of the State of Utah as are found in the northern half, owing to the impassability of the rugged terrain. To go from the southwestern corner to the southeastern corner of the State the present time necessitates a circumventous route northward to the central part of the state and then southward and eastward outside of Utah into Colorado, New Mexico, and thence northward into the Four-Corners area. On the other hand, one could take a southern route which would carry him into the State of Arizona, over desolate desert trails and then northward to the Four-Corners, the only place in the United States where four states of the Union border each other.

There are extraordinary "desert island mountains" located in both the Great Basin and Colorado River Basin areas. Such mountains are the Henry Mountains, the La Sal Mountains (Fig. 5), and the Abajo Mountains in the plateau region of the Canyon Lands. In the plateau country south of the Wasatch Range are found high mountain peaks rising to over 11,000 feet in elevation. In the Great Basin are such high mountains as the Deep Creek Mountains with elevations above 12,000 feet.

This highly variable topography of the State of Utah makes a natural history survey very difficult, and a major portion of the funds allocated for this study has had to be expended for travel.

BIOTIC COMMUNITIES OF THE STATE OF UTAH

There is no intent on the part of the author to discuss in detail the biotic areas of Utah. However, it will materially help the reader to orient himself ecologically if he could at least get a generalized concept of the biotic communities in which these surveys were conducted.

Utah's diversified topography provides for a comparable diversification in biotic communities. There are altitudinal ranges from 2,760 feet above sea level at St. George in Washington County, to King's Peak of the Uinta Mountain range in Daggett County, with an elevation of 13,498 feet. Wide variations in soil composition, fertility, structure, and alkalininty likewise causes marked differences. Consequently, the flora and fauna varies markedly.

There are three major biotic habitats in Utah, when considered in the broadest sense. There are deserts, foothills, and mountains. Each of these major habitats may be still further subdivided into natural biotic communities. For this study the above-mentioned habitats have been considered as follows:

The desert region:

The desert is conveniently separated into the northern and southern deseret shrub biomes as described by Fautin (1946).

The southern desert shrub biome in Utah is geographically located in the southwestern corner of the state (Fig. 4). It is identified locally as the Virgin Valley and is a part of the Colorado River Drainage system. A very mild climate exists during the winter; however, maximum summer temperatures are common

Figure 5. Scattered throughout the High Plateau country are singular "desert island mountains" created by intrusive upthrusts. Such a mountain region are the La Sal mountains in Grand and San Juan Counties.

Figure 6. Southern Desert Shrub Community: The dark colored plants are Cresote bushes, *Covillea tridentatum* Vail. The lighter colored ones are *Kramcria glandulosa* Rose and Painter. The foreground is part of the Virgin Valley area. In the background are the Pine Valley mountains which rise to more than 10,000 feet above sea level.

Figure 7. In the east central portion of Utah are extensive plateaus and table lands possessing shallow drainage basins, salt flats, mesas and desert canyons. This picture was taken near the town of Green River, Emery County. It shows a shallow desert drainage basin of a rugged canyon country as indicated by the rocky formation in the distance. This rocky wall-like formation marks the eastern flank of the San Rapheal Swell.

above 100° F. It is a land of arid sand and barren rock. Creosote, mesquites, and cholla cactus are distinctive floristic indicators. This hot desert situation is also distinguished under the life zone concept of Merriam (1898) as the Lower Sonoran Zone (Fig. 6). It occupies a very small geographic area in comparison to the rest of the state. Nevertheless, it does present a unique ecological type.

The northern desert shrub biome constitutes the greater surface area of Utah (Figs. 4, 7, 8, and 9). Under the life zone concept this community would be designated the Upper Sonoran Zone. It is contained in the Great Basin area except the higher mountains. In the Great Basin region of Utah, the topography is one of extensive flatlands interrupted at intervals by low-lying block fault mountain ranges extending along a north-south axis. All of the Colorado River Basin within the state, except the high mountain ranges and plateaus, is characterized by this northern desert shrub community. There are lowlands, valleys, plains, the desert canyons, low-lying mesas, shallow drainage basins, and salt flats (Fig. 7). Found in both the Great Basin and Colorado River Drainage area of the northern desert shrub community are such plants as tri-dent sage, greasewood, saltbush, rabbit brush, alkali plants of various species, hackberry, white sage, blackbrush, pinyon pine and juniper. Each of these may be and is greatly restricted by such factors as soil type, water supply and degree of alkalinity.

The upper limits of the northern desert shrub community in Utah are reached at the foothills of the mountains and plateaus. The "pigmy forest" or Pinyon-Juniper woodland (Fig. 10) is the most common plant community found at these elevations.

Foothill communities:

As the name implies, these foothill areas are located at the meeting place where the mountains, mountain-high plateaus, and mesas merge into the valleys. Here are found very distinctive and interesting biotic communities. Ecologically they represent an ecotonal situation. They are the meeting places of northern (Boreal) biota, common to the mountain ranges, and the southern (Sonoran) biota found in the desert valleys. Under the life zone concept, they would be classified as the Transition Zone. In north and north-central Utah, best demonstrated at the foothills region of the Wasatch Mountains, are the chaparral shrubs of oak-brush of several species, serviceberry, elderberry and maple (Fig. 11). In the southern part of the state, the ponderosa pine forests denote a change from a strictly mountain foothill brushland to one of a montane forest type.

Mountain communities:

The entire complex of montane communities is frequently referred to as Boreal which may be broken down into Alpine, Hudsonian, and Canadian life zones, listed here from highest to lowest in altitude, respectively. From the standpoint of the various boitic communities the Alpine area is treeless and tundra-like. Grasses, sedges, Parry's Primrose, lichens, and certain species of buttercups are common plant indicators. The Hudsonian zone comprises part of the very distinctive montane forest community. Here are found the Engleman and blue spruce, alpine fir, lodge pole, foxtail, and limber pine. Extensive grassy parklands and meadows may also be found in the montane forest areas, but it is primarily a conifer community. The so-called Canadian zone is also a part of the Montane forest, but altitudinally it is found at the lower limits of this community. The quaking aspen, red cedar (juniper), mountain sumac, bracken fern, and blue spruce are some common examples of plants found here. Douglas fir and White fir, however, are the best plant indicators for this community (Fig. 12).

HISTORICAL RESUME

Plague and Rocky Mountain spotted fever are to be discussed in separate sections of this paper. Significant historical information will be given at the appropriate place in the separate sections designated for each subject.

ACKNOWLEDGMENTS

The following institutions and organizations have provided the material means to make this project possible and to bring it to completion: The National Institutes of Health, Division of Research Grants and Fellowships provided the major source of funds for the project. The Brigham Young University, through the Department of Zoology and Entomology, made space and equipment available and also contributed supplemental funds from their research budgets. The Research Department at the Brigham Young University, under the direction of Dr. Harvey Fletcher, generously contributed funds for printing this report. The regional office of the National Park Service was most

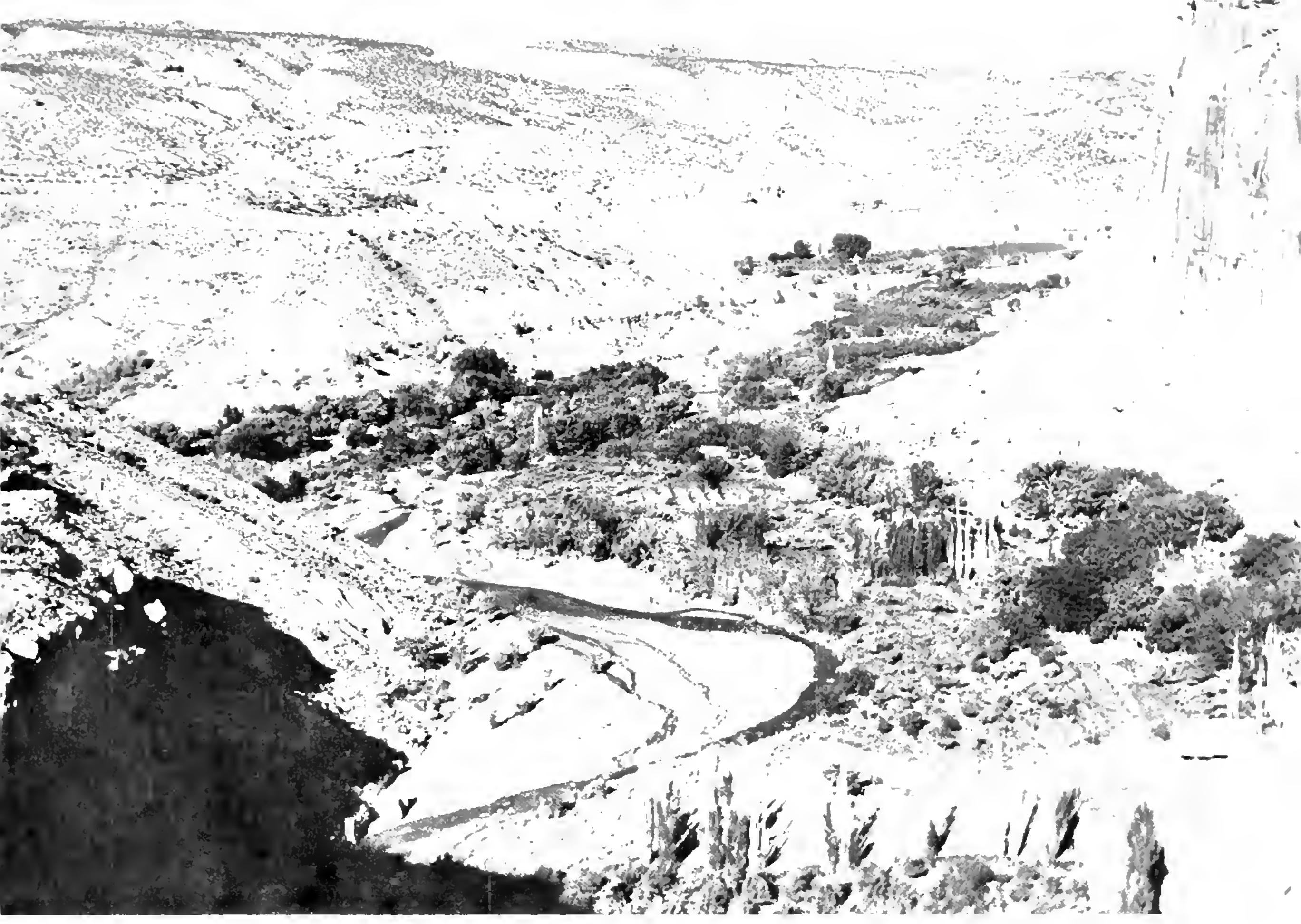

Figure 8. The farming village of Fruita in Capital Reef National Monument, Wayne County. This is a typical desert canyon kind of topography in the plateau country of the Colorado Drainage system.

Figure 9. Great Basin desert flatland as seen at the Desert Range Experiment Station in western Millard County. The light colored shrub is White Sage *Eurotia lanata* (Pursh). The darker colored plants are predominantly Bud Sage *Artemesia spinescens* Eaton, and the shadscale *Atriplex confertifolia* (Torr. & Frem.).

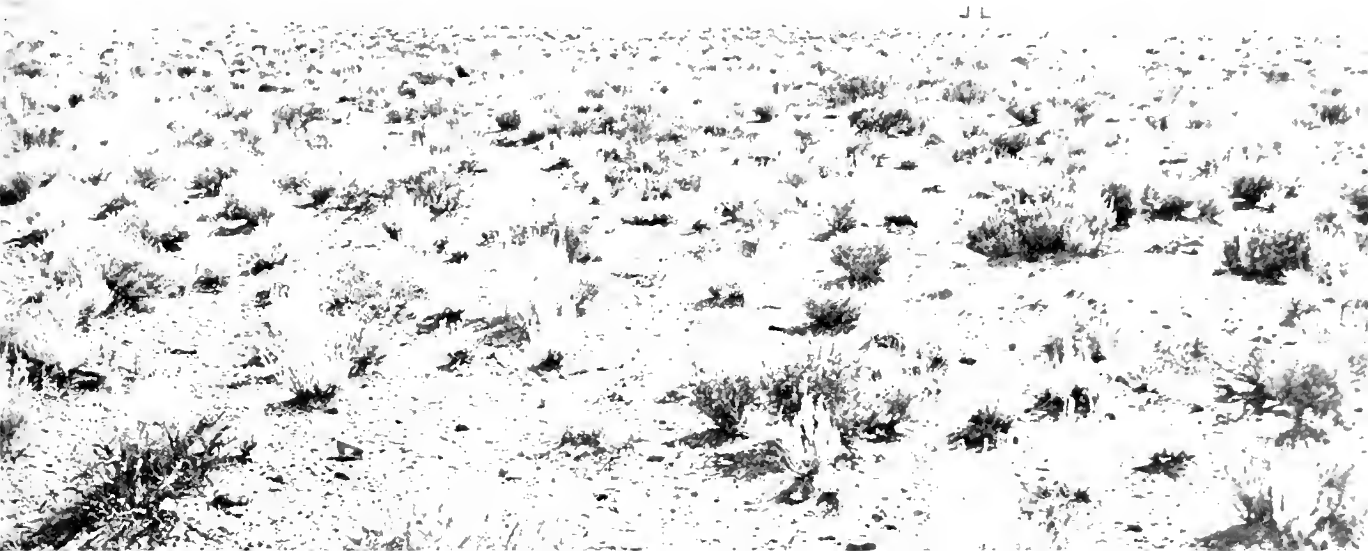

Figure 10. Juniper woodland about 3 miles north of Jericho, Juab County, Utah, on U.S. highway 6.

Figure 11. In the middle distance of the central part of the picture are the chaparral shrubs typical of the Transition Zone as found on the Wasatch Range in Provo Canyon of Utah County. On the tops of the mountains are sparse stands of conifers.

Figure 12. A boreal type of environment is exhibited by this mountain scene. It is near timberline in the La Sal mountain area of Grand and San Juan Counties, Utah.

cooperative in making permits available in order that collections of rodents and lagomorphs in selected areas of several parks and monuments could be made. Personnel of the Department of Entomology and Parasitology, Army Medical Service Graduate School, Washington, D.C., contributed taxonomic assistance. This was likewise the case with the Rocky Mountain Laboratory, Hamilton, Montana; the San Francisco Communicable Disease Center station of the U. S. Department of Health, Education, and Welfare. The Utah State Department of Health gave wholehearted cooperation in furnishing needed statistical information. The Brigham Young University library helped in processing inter-library loans and obtaining many needed reference books required for this study. Doctors George Knowlton and J. S. Stanford were very helpful in making available their collection of vectors at the Utah State Agricultural College at Logan.

Many persons have worked with me for several years in gathering, compiling, and analyzing data relative to the project. Some of these people are responsible for major facets of information, while others have been instrumental only in bringing specimens to the laboratory. For these greater or lesser acts of kindness I am very grateful. All of the thoughtful contributions have been important factors in contributing to the quality and completeness of this study. There are some names, however, which should receive special mention.

For a major part of the duration of the project, I was fortunate in having three outstanding graduate students working with me. Their labors have contributed greatly to the success of the study. Without their help, the project would not have been possible of completion. These men are Dorald M. Allred, Marvin D. Coffey, and Merlin L. Killpack. Specialists for various taxonomic groups gave unstintingly of their time to corroborate determinations made by our staff, or made accurate determinations of "unknowns" sent to them. Colonel Robert Traub and Captain Vernon J. Tipton of the Department of Entomology and Parasitology, Army Medical Service Graduate School, helped with some siphonapteran determinations. To Dr. William L. Jellison, of the Rocky Mountain Laboratory, Hamilton, Montana, who helped with siphonapteran determinations, and Mr. Glen M. Kohls, who helped with tick taxonomy, I owe a special debt of gratitude. All during the investigation they gave much encouragement and help to all members of the survey staff. Mr. Harold Stark, of the U. S. Department of Health, Education, and Welfare, San Francisco, California, field station, has carefully examined flea specimens of the genus *Thrassis*. Mr. Frank Prince, of the same office, has checked many specimens of fleas of the genus *Malaraeus*.

Mr. Stark, while at the University of Utah as a graduate student produced a Master of Science thesis titled, "A Preliminary Study of Utah Fleas" which has not been published to date. It has an abundance of information which was helpful in many respects in this project. Added importance is also attached to Mr. Stark's unpublished manuscript in that Mr. Frank Prince contributed some data to Mr. Stark regarding western fleas. The thesis has been made available to me through the courtesy of the University of Utah Library. Mr. Stark contemplates a more complete publication in the near future dealing with Utah fleas and hence has withheld publishing his M.S. thesis.

Dr. Clarence Cottam, dean of the College of Biological and Agricultural Sciences, Brigham Young University, read the manuscript and offered valuable suggestions on its composition. It was mainly through his interest and effort that publication was made possible. Dr. C. Lynn Hayward, of the Department of Zoology and Entomology at Brigham Young University, has been most helpful in corroborating taxonomic determination of host mammals. His advice on matters of ecological significance has also been appreciated and he likewise has carefully edited this manuscript. Mr. Merlin L. Killpack, mammalogist, has collected many hundreds of parasites in the northeastern part of Utah and has submitted them to this project. He, also, has spent several summers in field surveys on this project. Richard M. Hansen, U. S. Public Health Service Fellow, Microbiological Institute, University of Utah, supplemented the collections of this survey by his own collections of fleas and ticks collected during his studies with the squirrels of the genus *Citellus* and others in Utah.

Mr. John Wright, of the Utah State Department of Health, furnished the statistical data on incidence of Rocky Mountain spotted fever in Utah.

Other people, who have made general contribution to the project, are Mr. Fred C. Harmston, Roy J. Myklebust, Robert Liddiard, and J. Franklin Howell. All, with the exception of Mr. Harmston, were former students. Mr. Harmston is, at present, with the U. S. Depart-

ment of Health, Education, and Welfare.

I am personally indebted to Dr. Vasco M. Tanner, Chairman of the Department of Zoology and Entomology at the Brigham Young University. It was primarily through his efforts that space and equipment needed were made available for this study.

Finally, I would be most ungrateful if I did not acknowledge the tireless, cooperative assistance given me by my wife, Florence. She has helped with field surveys and technical preparation of specimens. The careful record making and filing of data has without doubt been a major undertaking, accurately and neatly done. I cannot thank her too much.

PART I

PLAGUE VECTOR INVESTIGATIONS

INTRODUCTION

This report, "should be considered as an attempt to facilitate the better understanding of the present status of the problem of vectors and reservoirs of plague with a view to improving our knowledge of the subject, particularly considering that sylvatic plague is a disease of increasing importance, the control of which is still one of the main unsolved problems of tropical medicine." Macchiavello, 1954.

Anyone acquainted with world history is aware of the devastating plague pandemics of the past, where millions of people died from its effects. In most cases these pandemics caused a high rate of mortality, ranging from 60% to 90%. The possibility of using natural vectors in modern biological warfare to disseminate disease to a war-stricken population is frightening to say the least. The very fact that plague in both parasite and host has been identified in Utah, has justified gathering as much data as possible on vectors and vector-host relationships. Each year new data are found, extending the range of the disease from its originally discovered focus in the U. S. at San Francisco in 1900. Concommitant with the geographic expansion of the disease is the rapidly expanding population in Utah and the other western states. This present study dealing with the distribution of plague vectors, reservoir hosts and vector-host relationships for the State of Utah should, therefore, prove valuable to the science of preventive medicine.

THE DISEASE PLAGUE

Etiological aspect

The infectious disease, plague, has as its causative organism the bacilliform bacterium *Pasturella pestis* Yersin. According to Craig, Faust and Miller (1951) the etiological agent of plague is a:

> "Gram-negative, pleomorphic, bipolar staining bacillus, which is non-motile, does not form spores, but at times produces a capsule. It was discovered by Yersin, in 1894, at the beginning of the extensive pandemic of the disease which developed in Hongkong (China) in that year."

Host relationship

Plague is considered a disease of rodents even though since antiquity devastating outbreaks have occurred in mankind. From the standpoint of host-parasite relationships as well as the location of the bacterium in the body of the host, the disease is known under various names. The most commonly used classification is murine, sylvatic and human or bubonic plague.

Non-native rodents as the gray or sewer rat, *Rattus norvegicus* (Erxleben), the house or ship rat, *R. rattus rattus* (Linn.), and the black Alexandrine rat, *Rattus rattus alexandrinus* (Geoffroy) belong to the family of rodents known as the *Muridae* and to the order *Rodentia*. The house mouse *Mus musculus* L. also belongs to this family. When these rodents are infected with *Pasturella pestis*, the disease condition is known as murine plague.

A great number of animals belonging to several other families of the order *Rodentia* have been found to act as reservoirs of plague. Such an infection in wild native rodents is known as sylvatic plague.

Bubonic plague is the result of the infection by *Pasturella pestis* in the human organism.

Another classification of the disease is based on the location of the disease in a host's body. This classification is used whether the disease is in the definitive host, a rodent, or the alternate host, man.

The common name reference to the disease by most people is that of bubonic plague. In this type of plague the usual portal of entrance is the skin. Injection is accomplished by some arthropod vector, usually a species of flea. Shortly after the entrance of the bacillus in a host's body, a characteristic swelling occurs at the nearest lymph node. This swelling of one or more nodes produces what is known as a bubo, from which the term "bubonic" plague is derived. The enlargement of the nodes is due to the increased numbers of *P. pestis* being formed at that locus, plus increased leucocyte activity.

In due process of time, an infected node may become hemorrhagic and the bacilli will find their way to the blood stream and are distributed throughout the body to produce spleenic, hepatic, and other local infections. Such systemic distribution is identified as septicemic plague.

In septicemic plague a local infection in any organ may be identified as hepatic plague, spleenic plague, etc. One body part which is seriously affected is the lung area. Such an infection may have originated from a bubonic type or contracted directly from another organism by way of the respiratory tract. This type of infection is termed pneumonic plague.

According to Kelly and Hite (1949),

> "Bubos are present in about three-fourths of the human cases. Septicemia with hemorrhages into the skin and tissues is commonly present. The pneumonic variety is characterized by pneumonia and the presence of organisms (*P. pestis*) in the sputum."

In the clinical diagnosis of the above three kinds of disease, classified on the basis of location in the body, several procedures are followed. In the bubonic form, a bubo is aspirated and a smear is prepared and examined microscopically for the bacilli. In addition to this, the specimen is cultured in the laboratory, or some of the aspirated fluid is inoculated into a laboratory animal for further identification. Blood cultures are obtained and produced from specimen samples where septicemic plague is suspected. In the pneumonic type the sputum is examined microscopically for the plague bacilli.

It must be re-emphasized that plague is primarily a disease of rodents and secondarily of man. In either case, however, the effects are symptomatically alike. That is, the disease will produce buboes in either case, be septicemic, etc. As a disease it is just as infectious and fatal to rodents and other animals as it is to man. Epidemiologically, to one acquainted with rodent surveys, it is clearly demonstrated from time to time that plague epizootics have completely destroyed large colonies of animals.

HISTORICAL RESUME

Early historical records

Regarding the many references to plague in ancient history, religious, political or otherwise, where pandemics and epidemics decimated great populations of people, the exact etiological agent or agents are not known. It is generally considered, however, by most writers on the subject today, that the earliest records of plague were perhaps a combination of disease epidemics due to several etiological agents. This was most likely the case of the great pandemics in Europe, Asia, and Africa during the sixth and fourteenth centuries which resulted in such disastrous loss of life.

Cosmopolitan occurrence of plague

Historically speaking the most dramatic plague was that known as the "Black Death" which occurred during the 14th Century (1348-49). The plague septicemia caused dark spots to appear subcutaneously, hence the term "Black Death." Various figures have been given, but a conservative estimate of 25,000,000 persons are supposed to have died of this disease at that time. In Oxford, England, it is said that two-thirds of those connected with educational institutions perished. The "Black Death" plague of that period was supposed to have been Asiatic in origin, first invading North Africa and then Europe.

Another plague pandemic spread across Europe and Africa during the sixteen hundreds. Egypt lost approximately 1,000,000 of her inhabitants in 1603. The Great Plague of London, 1664-1665, caused a total of deaths for the year 1665 of 68, 596 in population estimated at 460,000.

Meyer (1950) reports:

> "In the Pacific Basin recent local epidemics warn that, although the plague problem is solvable, it is not yet solved. In the post-war period extensive outbreaks have been reported from Java and China. According to incomplete information, during the first 42 weeks of 1948 there were 3,422 cases in Java and 3,365 persons died; in China in 1947 there were at least 30,000 cases. The old focus in Burma is still active, and in recent years there have been a few cases of plague on the island of Hawaii and in New Caledonia."

The outstanding epidemic of the twentieth century although not as great as the "Black Death" was that which took place in Manchuria during the years 1910-1911. More than sixty thousand persons lost their lives, the case fatality being almost 100% and was primarily of the pneumonic type.

Burrows (1949) states:

"During recent years, plague has caused terrible loss of life in British India; official statistics show that in the period from 1896 to 1918 more than 10,000,000 deaths were due to this disease."

The following quotation is taken from Hoekenga's (1947) article, "Plague in the Americas:"

"During the period 1899-1939, approximately 57,000 cases of human plague were reported from North and South America together. Some 2,500 more have been reported since then . . . Peru has the unhappy distinction of having had more plague (21,037 cases) than any other country."

According to Simmons and Hays (1948):

"Plague now exists in India, Ceylon, Burma, Indochina, Java, China, Manchuria, parts of Asiatic Russia, Hawaii, Ecuador, Peru, Bolivia, Argentina, Brazil, 14 western states of the U. S., Canada, Germany, the Azores, Madagascar, and many parts of Africa."

PLAGUE IN THE WESTERN STATES OF THE UNITED STATES

C. R. Eskey and V. H. Haas (1940) of the United States Public Health Service published a joint paper titled "Plague in the Western Part of the United States." Several quotations have been taken from their publication and are given below. These references will show plague incidence in the western United States up to the year 1940, as well as provide data on the geographic distribution of the disease to that date. Their observations include both sylvatic and bubonic records:

"In March, 1900, Dr. W. H. Kellog of San Francisco, recognized the first human case of plague reported in the United States. From 1900 to 1904 there were 121 cases with 113 deaths reported at San Francisco, and during the second outbreak in 1904-08, there were 160 cases with 78 deaths. Twelve cases were reported in Oakland, located across the bay from San Francisco. In October, 1907, three cases of human plague were discovered at the port of Seattle."

"Due to the discovery of plague in Montana in that year (1935)[2] three more units (U.S. P.H.S. mobile field survey units) were sent into the field in 1936."

"Since the spring of 1935 field investigations have been conducted in the 11 Pacific Coast Rocky Mountain States and foci of wild rodent plague have been discovered in all of them except Colorado."

2 Plague of sylvatic nature was discovered by a U.S.P.H.S. unit in 1935 in the state of Montana.

The sylvatic plague studies by Ecke and Johnson (1950) in Colorado showed extensive distribution of the disease among prarie dogs and ground squirrels.

"Plague in Park County, Colorado, was first discovered in the summer of 1945, and spread across the country through the prairie dog population in two years. In less than four years, it had killed practically all of the dogs on about 627,000 acres."

V. B. Link, reporting in the September 30, 1950 "Journal of the American Medical Association," had the following to say about plague distribution in the Western United States:

"Human plague attributable to contact with infected wild rodents was limited to Califforina until 1934, when a human case was reported in Lake County, Ore. Infected rodents were found in Oregon in 1935 and successively in the following states: Montana, 1935; Idaho, 1936; Nevada, 1936; Utah, 1936; Wyoming, 1936; Washington, 1937; Arizona, 1938; New Mexico, 1938; Colorado, 1941; North Dakota, 1941; Oklahoma, 1944; Kansas, 1945; and Texas, 1946. Surveys have been conducted in over 600 counties of the 17 westernmost states, and plague has been found nearly 4,000 times in the rodents of 132 counties of 15 of these states, South Dakota and Nebraska being the exceptions."

With regard to North America, Hubbard (1947) has this to say:

"From its inception into man in North America in 1900, plague has been found in 506 persons, 321 of whom died of the infection. Eight states have reported human cases."

PLAGUE IN UTAH

In Allred's (1952) study of the distribution of some fleas known to be capable and potential vectors of plague in Utah, he noted that plague had been recorded from the following eleven of the twenty-nine counties of the state of Utah since the first discovery in Beaver County in 1936:

Beaver County, July 1936 (Bubonic and Sylvatic)
Sevier County, July 1936
Garfield County, August, 1936
Morgan County, August, 1937
Salt Lake County, September, 1948
Millard County, November, 1939
Kane County, May, 1938
Rich County, July, 1938
Wasatch County, August, 1937; June, 1938

Weber County (No date given)
Iron County (No date given)

PLAGUE AND ENDEMICITY

There are two schools of thought regarding plague distribution. Meyer (1943),[3] Meyer and Holdenried (1949) for example maintain that plague may be endemic from a distributional point of veiw; i.e., it exists and has existed in the various areas where it has been discovered and has not necessarily been introduced from elsewhere. In the latter work, Meyer and Holdenried studied a plague epidemic in California involving squirrels and non-native rats. From the summary of their publication the following quotations are given:

> "*Xenopsylla cheopis* was not found on the rats, but the relatively poor vector the mouse flea (*Leptosylla segnis*), and a few *Nosopsylla fasciatus* were present. Rat fleas were not found on the squirrels. Thus it is not unlikely that the squirrel fleas not only introduced, but also maintained the infection in the rat population."
>
> "These observations conclusively prove for the first time that plague may be spread from wild to domestic rodents."

During the several years that the author has conducted plague vector surveys throughout Utah, there have been occasions when there was observed what appeared to be epizootics of old and recent occurrence among rodent colonies. In some of these examples the native rodent colonies were far removed from contact with domestic rodents and their flea parasites. An example of plague existing in localities far removed from domestic rat contamination is described by Eskey & Haas (1940, op. cit., p 16).

> "Trapping conducted on a routine basis yielded plague-infected fleas from a wood rat in Kane County, Utah. In 16 nests of these rodents which were demolished, 13 carcasses were found, indicating an epizootic; no one in the vicinity had been aware of anything unusual in regard to the wood rats."

These authors in the same publication (page 19) have this to say regarding plague distribution in the western U. S.:

> "It has been pointed out under the discussion of rodent epizootics that the spread of plague into inland regions of the continent has been a gradual and logical progression through a period of nearly 40 years during which time the infection has become established among wild rodents from the Pacific Mountains."
>
> "These characteristic epizootics, followed by subsidence of the disease into the enzootic state, when considered in the light of the logical inland progression of the infection among the wild rodents, support the impression that plague is a disease with which they (the rodents) are in the process of acquiring the type of communal resistance which results from longer contact with an infectious disease of this type."
>
> "The establishment of plague among our wild rodents is now so widespread, and has endured under so many different conditions of climate and rodent ecology, that it must be regarded as permanent."

If the concept as given above in extract from the study by Eskey and Haas (1940) is correct there may in part be some explanation why there are such conditions of pandemic proportion in human infection, with occasional recurrence, resulting eventually in epidemic outbreaks and finally sporadic occurrences of single cases. From the standpoint of biogeography the distribution of plague has both endemic and non-endemic aspects.

Even though rodents of the genera *Citellus*, *Neotoma* and *Cynomys* are considered the most general reservoirs of infection, several other genera of rodents can maintain an infection reservoir. Such animals are the chipmunk *Eutamias* sp., tree squirrel *Tamiasciurus* sp., and marmot *Marmota* sp.

The condition of having plague infected murine rodents come in contact with endemic rodents makes possible the establishment of a reservoir of sylvatic plague. The principal reason of importance can be appreciated when one realizes the close association between *Rattus rattus alexandrinus*, *Rattus rattus rattus*, and *R. norvegicus*, man, and the flea vectors which live with the rats and which readily bite man.

Meyer and Holdenried (op. cit., 1949) concluded that a murine infection may be derived from on endemic infection. If such is the case, there is then created a serious situation. It is possible, to have a plague enzootic in native rodents which will provide a reservoir of infection for murine hosts, or have an enzootic in murine hosts which may act as a source of infection for sylvatic rodents. In either case, however, an epizootic of major or minor proportions, may break out. The greater the epizootic among rodents the greater the chance for human infection either by direct contact

3 C. F. Craig and E. C. Faust in their text, "Clinical Parasitology," page 816, 1951, refer to Meyer (1943) as follows "supports the theory that wild rodent plague was present before the development of urban rodent plague in California."

with an infected animal or by vector transmission, usually by a species of flea. In Utah, especially in those areas where population density is greatest, there are found conditions of distribution allowing for direct contact between ground squirrels and the Norway rats. Capable vectors for plague are found on both hosts and interchange has certainly taken place. (Table 1).

PLAGUE AND PLAGUE VECTORS

Many species of fleas have been shown to be vectors of plague. Lice and ticks are also known to demonstrate plague experimentally but are of no importance as far as our field surveys have revealed.

The most usual process of plague transmission by the flea is in the main the result of what is known as a "blocked" condition. A blood meal from an infected host is taken up by a flea and passed along the esophagus to the proventriculus. This structure is an enlarged bulbous part of the alimentary canal just anterior to the stomach. The peculiarity in structure of the proventriculus allows the plague bacillus in the blood to multiply and increase in numbers sufficient to "block" off the passage of the blood to the stomach. In many cases the blocking may occur in the stomach region. The flea, unable to get sustenance from its blood meal feeds again, perhaps from an infected host or another host free from plague. In the process of feeding, due to an already filled esophagus and proventriculus or stomach, it may regurgitate its previous meal plus plague bacilli and a reinfection or new infection results.

It is well known that some species of fleas are more efficient vectors of plague than others. For example, Eskey and Haas (1940, op. cit. p. 42) in their laboratory tests found that *Oropsylla idahoensis* (Baker) and *Malareus telchinum* (Roth) were poor vectors and stated that in the case of *M. telchinum*, "these fleas could not be natural vectors of the infection." On the other hand, the rat fleas *Xenopsyla cheopis* (Roth) and *Nosopsyllus fasciatus* (Bosc d'Antic) were demonstrated experimentally to be equally effective as vectors of plague. The general conclusion reached by Eskey and Haas in laboratory tests was: "That some of the wild rodent fleas are as capable vectors as either of the rat fleas."

In the examples given above, reference has been directed to laboratory experiments on disease transmission. When attention is directed to natural transmission, it is likewise discovered that some species of fleas are more efficient vectors than others. This efficiency seems to be associated with the rate of incubation of the infective agent in the body of the flea which Eskey and Haas terms the "extrinsic incubation of the infection" and which Simmons and Hays (1948, op. cit., p. 1679) say, "has been observed to range from 5 to 130 days. This range exists among different species and even between different individuals of at least two species, *N. faciatus* and *Opisocrostis labis*."

Xenopsylla cheopis is the most common and efficient vector of plague where plague of bubonic nature is considered as endemic, such as in India (flea sometimes termed "Indian rat flea" as well as the "Oriental rat flea") parts of Africa, South America, North America, and the U. S. It readily bites man and can be expected to be found wherever domestic rats have become distributed although this is not a hard and fast rule. For example, *X. cheopis* has been but rarely found in Utah as far as present collection records show, even though domestic rats are widely distributed in the north-central part of the state.

Simmons and Hays (1948, op. cit., p. 1680) say:

> "It seems probable that human (bubonic) plague may be perpetuated by *Pulex irritans* Linnaeus, without intervention of rats. Such a mode of spread may have been active in the Black Death and the great plague of London."

Craig et. al., (1951, op. cit., p. 816) in referring to studies made by Eskey say:

> "On epidemiological grounds, Eskey (1930) believes that *Pulex irritans* is probably responsible for most of the human cases of plague in the high mountain districts of Ecuador, where *X. cheopis* does not occur, although in Guayaquil the latter is the only flea apparently responsible for epidemic outbreaks in human population (Eskey 1938)."

Quoting further from Simmons and Hays (1948, op. cit., p. 1678):

> "*Diamanus montanus* and *Hoplopsyllus anomalus* (are considered important as actual and potential vectors of plague) in the western part of the United States; *Nosopsyllus silantievi* and *N. tesquorum* in Mongolia; *Rhopalopsyllus cavicola* in Argentina and Ecuador; *X. erides*, *Dinapsyllus lypusus* and *Chiastopsyllus rossi* in South Africa; *X. brasiliensis* in Uganda, Kenya and Nigeria (Africa); and *Pulex irritans* in many parts of the world."

HOST SPECIES	CAPABLE VECTORS																			
	Atyphloceras multidentatus	Ctenocephalides felis felis	Diamanus montanus	Echidnophaga gallinacea	Hoplopsyllus anomalus	Histrichopsylla gigas dippiei	Malaraeus telchinum	Megabothris abantis	Monopsyllus eumolpi eumolpi	Nosopsyllus fasciatus	Opisocrostis hirsutus	Opisocrostis labis	Opisocrostis t. tuberculatus	Oropsylla idahoensis	Pulex irritans	Thrassis a. arizonensis	Thrassis francisi	Thrassis howelli howelli	Thrassis pandorae	Xenopsylla cheopis
Canis familiaris		X																		
Canis latrans															X					
Citellus armatus			X		X	X		X	X	X	X	X	X	X		X	X		X	
Citellus lateralis ssp.			X		X	X			X		X			X						
Citellus richardsoni			X									X	X	X					X	
Citellus leucurus ssp.			X	X	X						X	X	X	X			X			
Citellus townsendii ssp.			X		X							X	X	X			X	X	X	
Citellus t. mollis			X		X								X	X			X		X	
Citellus variegatus ssp.			X	X	X				X	X			X	X				X	X	
Citellus v. grammurus			X		X															
Citellus beldingi													X	X						
Clethrionomys sp.						X														
Clethrionomys gap. galei								X												
Cynomys gunnisoni ssp.			X								X									
Cynomys leucurus			X		X						X	X	X		X				X	
Cynomys parvidens			X		X						X		X	X						
Dipodomys merriami ssp.				X																
Dipodomys ordii ssp.			X				X				X									
Eutamias minimus ssp.					X			X	X				X							
Eutamias quadrivittatus ssp.			X					X	X					X						
Eutamias dorsalis								X	X											
Felis domestica		X																		
Glaucomys sabrinus									X											
Lepus californicus ssp.			X		X						X		X							
Lynx rufus ssp.															X					
Marmota flaviventer ssp.			X		X	X			X				X	X				X	X	
Microtus montanus ssp.					X	X	X	X	X	X										
Microtus longicaudus mordax								X												
Microtus pennsylvanicus ssp.					X					X										
Mus musculus ssp.					X	X				X										
Mustela frenata ssp.			X		X					X				X						
Mustela sp.											X			X						
Neotoma lepida ssp.			X	X	X	X														

Table 1. Vector-host relationship in Utah collections for vectors of plague listed as capable vectors.

HOST SPECIES / CAPABLE VECTORS	Atyphloceras multidentatus	Ctenocephalides felis felis	Diamanus montanus	Echidnophaga gallinacea	Hoplopsyllus anomalus	Histrichopsylla gigas dippiei	Malaraeus telchinum	Megabothris abantis	Monopsyllus eumolpi eumolpi	Nosopsyllus fasciatus	Opisocrostis hirsutus	Opisocrostis labis	Opisocrostis t. tuberculatus	Oropsylla idahoensis	Pulex irritans	Thrassis a. arizonensis	Thrassis francisi	Thrassis howelli howelli	Thrassis pandorae	Xenopsylla cheopis
Neotoma l. lepida			X																	
Neotoma cinerea ssp.	X		X			X					X							X		
Neotoma c. acraia																				
Ochotona princeps ssp.								X												
Onychomys leucogaster ssp.					X															
Perognathus parvus ssp.									X											
Perognathus sp.																				
Peromyscus maniculatus ssp.	X		X		X	X	X	X	X	X				X				X	X	
Peromyscus boylii ssp.	X					X	X		X											
Peromyscus crinitus ssp.																				
Peromyscus truei					X	X	X													
Peromyscus eremicus			X	X			X													
Phenacomys intermedius ssp.						X		X		X										
Rattus norvegicus ssp.			X					X		X										X
Rattus rattus alexandrinus																				X
Rattus rattus rattus										X										
Reithrodontomys megalotis ssp.									X											
Sorex sp.																				
Sorex vagrans								X												
Spilogale gracilis ssp.			X		X															
Spilogale g. saxatalis			X		X															
Sylvilagus auduboni ssp.				X	X															
Sylvilagus a. warreni																				
Sylvilagus idahoensis			X																	
Sylvilagus nuttallii ssp.																				
Sylvilagus sp.			X	X	X									X						
Sciurus aberti ssp.																				
Tamiasciurus hudsonicus ssp.						X			X					X						
Thomomys bottae ssp.			X																	
Thomomys talpoides ssp.																				
Vulpes macrotis ssp.					X										X					
Zapus princeps						X		X												

Table 1. (Continued) Vector-host relationship in Utah collections for vectors of plague listed as capable vectors.

Seasonal variations in vector populations

An understanding of plague vector relationships involves the matter of seasonal variations, with special reference to populations. That there is seasonal variation of this type, in rodent infestation by fleas, is well known for certain species. Both Eskey and Haas (1940), and Holdenried, Evans and Longanecker (1951) showed this to be true with *Diamanus montanus* (Baker) and *Hoplopsyllus anomalus* (Baker). These two species of fleas are capable vectors of plague. Holdenried, et al, showed *H. anomalus* to be abundant from October through March, while *Diamanus montanus* was most abundant in other months with a low density of population in the springtime. These authors worked with *Citellus beechyi douglasii* (Richardson), the common California ground squirrel. This squirrel is one of the common host reservoirs of the plague organism in California. In some aspectional field studies with *Anomiopsyllus amphibolus* Wagner, a consors of *Neotoma lepida* Thomas, conducted as a part of these investigations, there were found distinct population changes during a 12-month period.

RESERVOIR HOSTS AND PLAGUE VECTORS

The following taxonomic orders of mammals are listed in order of importance as reservoir hosts for plague: *Rodentia, Lagomorpha,* and *Carnivora.* The genera and species of ani mal reservoirs found in these orders differ when analyzed on a world-wide basis. For example, the squirrel genus *Citellus* represented by several species, is the most important sylvatic genus which acts as a reservoir host for plague in the western United States. In South Africa, Davis (1948) reports that the primary rodent reservoir of a sylvatic nature are the gerbils of the genus *Tatera,* represented by several species.

The order *Rodentia* includes both "Murine" and "Sylvatic" plague host reservoir animals. The murine reservoir includes those species and genera of hosts belonging to the family *Muridae* and represented prominently by domestic rats, house or ship rats *Rattus r. rattus,* Norway or sewer rats *Rattus norvegicus,* Alexandrine rat *Rattus r. alexandrinus* and the house mouse *Mus musculus.*

The order *Lagomorpha* includes rabbits and hares represented by such genera as *Sylvilagus* and *Lepus.* Their several species act as reservoir hosts for plague.

The Carnivora apparently rarely serve as host reservoirs for plague.

Taxidea taxus neglecta (Mearns), the badger of the western U. S., is a carnivore which, however, has been shown to act as a reservoir for the plague organism.

Reservoir hosts of plague in Utah

This particular subject will be discussed under two headings:

1. Those species of animals in Utah which have been found infected with the plague organism *P. pestis.*
2. Those species of animals in Utah which have been found to be plague positive in other states but although distributed in Utah, have not as yet been found to harbor plague the organism.

The first discovery of plague in Utah was made in July, 1936, (Public Health Reports, Vol. 51, p. 1138). Since that time, through surveys by the U. S. Public Health Service, thirteen of the twenty-nine counties in Utah have had some plague incidence indicated. Undoubtedly an intensified state-wide bacteriological survey would greatly extend the incidence. Dr. D. M. Allred, (1952) a former associate in these investigations, has listed information on plague discoveries in Utah from 1936 to and including 1949, as follows:

Beaver County: *Citellus variegatus,* July and August, 1936; *Marmota flaviventer,* July 1936.

Sevier County: *Citellus variegatus,* July, 1936; *C. armatus,* May, 1949.

Garfield County: *Cynomys parvidens,* August, 1936.

Morgan County: *Citellus variegatus,* August, 1937.

Kane County: *Neotoma lepida,* May, 1938.

Rich County: *Citellus armatus,* July, 1938.

Wasatch County: *C. armatus,* August, 1937 and June, 1938.

Salt Lake County: *C. variegatus,* Sept., 1948 and March, 1949; *Peromyscus maniculatus,* Sept., 1948.

Millard County: In late November or early December of 1939, a man supposedly contacted plague from skinning a coyote. (From conversation with residents who remember the case, the writer has strong reason to believe that the man had some other disease contracted from some other source.)

Weber and Iron Counties: The Communicable Disease Center Bulletin (1948) lists plague as having occurred in these counties, but gives no specific date, host, or locality.

Grand and San Juan Counties: During 1949, a hyper-epizootic occurred among prairie dog colonies in these counties. However, no evidence was found to indicate sylvatic plague as the cause of the decrease in population.

At one time in southern and western Utah County there where great numbers of *Citellus townsendi mollis*, the Townsend ground squirrel. This was likewise true of other areas in the Great Basin of Utah. Now there are only scattered colonies with very little continuity of distribution. Colonies in Utah County are practically non-existent. As observed by the writer, from 1921-28, the ground squirrel *Citellus armatus* was continuous in distribution throughout the Marsh Valley, and the Portneuf River areas between McCammon and Lava Hot Springs in Bannock County, Idaho. According to the testimony of residents who have lived in those areas all their lives, from 1940 to 1946 ground squirrels became practically extinct. Of late years they are beginning to increase but are still not common. On inquiry in August 1954 in Bannock County, I was informed that now and again a ground squirrel (*Citellus armatus*)is seen. This information was given from specific localities where, as a youth (1920-25) the writer was involved in poisoning programs where thousands of specimens were killed.

Almost complete decimation of whole rodent populations during a single season has been commonly met with during the present survey. In fact the disappearance of once abundant rodent populations had been too consistent to be a happenstance. These extreme fluctuations in rodent populations may be due in part to man's interference with environmental conditions, or perhaps it is a reflection of the inherent populations rhythm noted in some animals.

It is also possible that the almost; and, in some cases, complete disappearance is due to a disease agent and the vectors involved. Ecke and Johnson (1950) found that the disease plague, contributed to a practical elimination of all prairie dogs over an area of 627,000 acres in Park County, Colorado.

An examination of the literature from many sources, especially the Public Health Reports, reveal that there are sixty-eight species and subspecies of plague implicated mammals occurring in the western United States in which the plague organism has been found. They are shown below:

Citellus armatus (Kennicott)
C. beecheyi beecheyi (Richardson)
C. beecheyi douglasii (Richardson)
C. beecheyi fisheri (Merriam)
C. beecheyi nudipes Huey
C. beldingi oregonus (Merriam)
C. columbinus columbianus (Ord)
C. columbianus ruficaudus Howell
C. idahoensis Merriam
C. lateralis chrysodeirus (Merriam)
C. mexicanus parvidens (Mearns)
C. richardsonii elegans (Kennicott)
C. richardsonii nevadensis Howell
C. richardsonii richardsoni (Sabine)
C. spilosoma major (Merriam)
C. townsendii mollis (Kennicott)
C. tridecemlineatus ssp.
C. variegatus grammurus (Say)
C. variegatus utah Merriam
C. washingtoni loringi Howell
C. washingtoni washingtoni Howell
Cynomys gunnisoni gunnisoni (Baird)
C. gunnisoni zuniensis Hollister
C. leucurus (Merriam)
C. ludovicianus arizonensis Mearns
C. parvidens Allen
Dipodomys ordii ordii Woodhouse
Eutamias quadrivittatus frater (Allen)
E. minimus ssp.
Glaucomys sabrinus lascivus (Bangs)
Lagurus curtatus ssp.
Lepus californicus ssp.
Marmota flaviventer avara (Bangs)
M. flaviventer engelhardti (Allen)
M. flaviventer flaviventer (Audubon & Backman)
M. flaviventer nosophora Howell
Microtus californicus ssp.
M. nanus ssp.
M. montanus ssp.
M. townsendii (Bachman)
Mus musculus ssp.
Mustela sp.
Neotoma albigula ssp.
N. cinerea occidentalis (Baird)
N. fuscipes mohavensis Elliot
N. lepida intermedia (?)
N. lepida lepida Thomas
N. micropus ssp.
Onychomys leucogaster ssp.
O. torridus ssp.
Oryzomys sp.
Perognathus sp.
Peromyscus boylii ssp.
P. leucopus ssp.
P. maniculatus ssp.

P. truei gilberti Allen
P. truei truei (Schufeldt)
Rattus norvegicus (Erxleben)
R. rattus alexandrinus (Geoffroy)
R. rattus rattus (Linnaeus)
Reithrodontomys megalotis ssp.
Sigmodon hispidus ssp.
Sylvilagus auduboni ssp.
S. bachmani ssp.
S. nuttallii nuttallii (Bachman)
Tamiasciurus douglasii albolimbatus (Allen)
Taxidea taxus neglecta (Mearns)
Thomomys talpoides ssp.

Of the above listed species and subspecies there are forty-one species and subspecies of these plague implicated mammals represented in Utah. This list is given below:

Citellus armatus (Kennicott)
C. beldingi ssp.
C. lateralis ssp.
C. richardsonii elegans (Kennicott)
C. spilosoma major (Merriam)
C. townsendii mollis (Kennicott)
C. tridecemlineatus ssp.
C. variegatus grammurus (Say)
C. variegatus utah Merriam
Cynomys gunnisoni zuniensis Hollister
C. leucurus Merriam
C. parvidens Allen
Dipodomys ordii ordii Woodhouse
Eutamias quadrivittatus ssp.
E. minimus ssp.
Glaucomys sabrinus ssp.
Lagurus curtatus ssp.
Lepus californicus ssp.
Marmota flaviventer engelhardti (Allen)
M. flaviventer flaviventer (Audubon & Bachman)[5]
Microtus montanus ssp.
Mus musculus ssp.
Mustela sp.
Neotoma albigula ssp.
N. cinerea ssp.
N. lepida lepida Thomas
Onychomys leucogaster ssp.
O. torridus ssp.
Perognathus sp.
Peromyscus boylii ssp.
P. maniculatus ssp.
P. truei ssp.
P. truei truei (Schufeldt)
Rattus norvegicus (Erxleben)
R. rattus rattus (Linnaeus)
Reithrodontomys megalotis ssp.
Sylvilagus auduboni ssp.
S. nuttallii nuttallii (Bachman)
Taxidea taxus ssp.
Thomomys talpoides ssp.
R. rattus alexandrinus (Geoffroy)

See Table 5 for a listing of plague vector implications with reference to distribution.

Fleas as plague vectors in Utah

According to Simmons and Hays (1948, op. cit., p. 1678), "Thirty-nine American fleas have been shown infectable with plague in the laboratory, and twenty-eight are capable vectors." This agrees closely with the figure of Allred (1952, op. cit., p. 67), in which he mentions, "Various workers have implicated more than sixty species and subspecies of fleas with human and sylvatic plague throughout the world. Of this number, over forty-five species and subspecies are known to occur in the U. S."

During the last three years while the plague-vector-host distribution studies have been in progress in Utah, a total of 78 species and subspecies of fleas have been collected. Of this number there are represented in Utah 32 species and subspecies which are known to be plague implicated. This plague implication is of two types, potential[6] or capable[7] with regard to vector relationship.

Fleas and murine plague in Utah

Fleas show a certain specificity in host preference even though there is a definite interchange of parasites at times. The degree of interchange is greatly affected by the factor of proximity of association the different species of fleas have geographically, the population density of each species of flea involved, the geographical distribution of the host animal, as well as seasonal and climatic factors affecting both host and vector.

Xenopsylla cheopis is usually considered to be associated with domestic rats. However, in Utah this species has been taken but rarely and then only from *Rattus rattus alexandrinus* in Salt Lake City. On the other hand, the rat flea *Nosopsyllus fasciatus* (Bosc.) has been taken in most instances where the Norway rat *Rattus r. norvegicus* has been collected in Utah.

The limiting factors in the distribution of the Norway rat, *R. rattus norvegicus* in Utah are not known. The general area of location at

5 This species is most likely *M. f. nosophora* Howell, as *M. f. flaviventer* is restricted to Sierra Nevada in the vicinity of Lake Tahoe. *M. f. nosophora* is widely distributed in mountainous areas of the northern half of Utah.

6 A potential vector is one which demonstrates the presence of the etiological agent in its body but has not been found to transmit the disease organism either experimentally or naturally.

7 A capable vector shows the presence of the disease in the body of the vector and has demonstrated the ability to transmit the disease either experimentally or naturally.

present is along the base of the Wasatch range of the mountains from Santaquin, Utah north to the Utah-Idaho border. They have been reported from widely scattered areas in Sevier, Juab and Duchesne counties. Their greatest concentrations are in Utah, Salt Lake, Weber, and Cache counties where human population is also most dense.

That *Xenopsylla cheopis* and *Nosopsyllus fasciatus* are efficient vectors of plague is well known. The flea *Diamanus montanus* is usually considered to be a ground squirrel consors, but it has also been taken from domestic rats in Utah thus creating a possible bridge between sylvatic and murine reservoirs. *D. montanus* is an efficient vector of plague in its own right. Other fleas associated with the domestic rats in Utah, and which are plague implicated are, *Monopsyllus wagneri wagneri* (Baker), *Epitedia wenmanni* (Roth), and *Megabothris abantis* (Roth). *Mus musculus*, the house mouse, another murine rodent, is also associated with *Nosopsyllus fasciatus* and *Epitedia wenmanni* in the Utah collections. The house mouse, *Mus musculus*, unlike the Norway rat does not seem to be restricted in its geographic distribution, but is found in or around most places of human habitation. It is generally found by most workers that the house mouse carries very few fleas. This has been our experience during the period this research project has been operating. Many specimens of the house mouse, *M. musculus*, were collected without producing a single flea of any species. The house mouse usually has as its flea consortes, when such are present, those species which are found most commonly on other species of hosts in the immediate environs. The flea *Histrichopsylla gigas dippiei* Rothschild, itself a capable vector of plague, has been found associated with *Mus musculus* in a few of our collections.

From the standpoint of vector relationship *D. montanus*, *M. abantis*, *N. fasciatus*, *X. cheopis* and *Histrichopsylla gigas dippiei* are capable vectors, while *E. wenmanni* and *M. wagneri wagneri* are potential vectors of plague. (See Tables 1, 2, 3 and 4 for host parasite relationship as well as patterns of distribution for each.)

Fleas and Sylvatic plague in Utah

With the exception of *X. cheopis*, all species of fleas listed above and found associated with murine hosts in Utah, are also found on sylvatic hosts which have been implicated with plague.

Of the thirty-one[8] species and subspecies of fleas listed by Allred (1952) as capable and potential vectors of plague in Utah, twenty species would be considered as capable and eleven as potential vectors associated with sylvatic hosts. The names of the species of fleas known as consortes of sylvatic hosts are shown below under the two categories of potential and capable vectors. *Xenopsylla cheopis* is the only exception. (See Tables 1 and 5 for the vector host relationships as well as distribution by county).

POTENTIAL VECTORS

1. *Catallagia decipiens* Rothschild
2. *Epitedia wenmanni* (Rothchild)
3. *Foxella ignota* ssp.
4. *Hoplopsyllus affinis* (Baker)
5. *Megarthroglossus divisus divisus* (Baker)
6. *Monopsyllus wagneri wagneri* (Baker)
7. *Neopsylla inopina* Rothschild
8. *Opiscrostis tuberculatus cynomuris* Jellison
9. *Orchopeas sexdentatus agilis* (Rothschild)
10. *Orchopeas sexdentatus nevadensis* (Jordan)
11. *Thrassis petiolatus* (Baker)

CAPABLE VECTORS

1. *Atyphloceras multidentatus* (C. Fox)
2. *Ctenocephalides felis felis* (Bouche)
3. *Diamanus montanus* (Baker)
4. *Echidnophaga gallinacea* (Westwood)
5. *Hoplopsyllus anomalus* (Baker)
6. *Hystrichopsylla gigas dippiei* Rothchild
7. *Malaraeus telchinum* (Rothchild)
8. *Megabothris abantis* (Rothchild)
9. *Monopsyllus eumolpi eumolpi* (Rothschild)
10. *Nosopsyllus fasciatus* (Bosc)
11. *Opisocrostis hirsutus* (Baker)
12. *Opisocrostis labis* (Jordan and Rothschild)
13. *Opisocrostis tuberculatus tuberculatus* (Baker)
14. *Oropsylla idahoensis* (Baker)
15. *Pulex irritans* Linnaeus
16. *Thrassis arizonensis arizonensis* (Baker)
17. *Thrassis francisi* (C. Fox)
18. *Thrassis howelli howelli* (Jordan)
19. *Thrassis pandorae* Jellison
20. *Xenopsylla cheopis* (Rothschild)

Capable vectors

With reference to the capable vectors, the

8 Allred (1952) listed *Thrassis acamantis* (Rothschild) as one of the Utah fleas. This species is plague implicated but does not occur in Utah, being confused with both *Thrassis stanfordi* and *T. howelli utahensis* in its distribution.

HOST ANIMAL SPECIES	POTENTIAL VECTORS										
	Catallagia decipiens	Epitedia wenmanni	Foxella ignota	Hoplopsyllus affinis	Megarthroglossus d. divisus	Monopsyllus w. wagneri	Neopsylla inopina	Opisocrostis t. cyanomuris	Orchopeas s. agilis	Orchopeas s. nevadensis	Thrassis petiolatus
Canis familiaris											
Canis latrans											
Citellus armatus	X					X	X	X			X
Citellus lateralis ssp.						X			X		
Citellus richardsoni							X				
Citellus leucurus ssp.						X					
Citellus townsendii ssp.						X					
Citellus t. mollis											
Citellus variegatus ssp.	X		X	X		X		X	X		
Citellus v. grammurus											
Citellus beldingi											
Clethrionomys sp.											
Clethrionomys gap. galei			X			X					
Cynomys gunnisoni ssp.											
Cynomys leucurus						X		X			
Cynomys parvidens								X			
Dipodomys merriami ssp.											
Dipodomys ordii ssp.		X	X			X			X		
Eutamias minimus ssp.						X					
Eutamias quadrivittatus ssp.	X					X					
Eutamias dorsalis											
Felis domestica											
Glaucomys sabrinus									X		
Lepus californicus ssp.				X		X					
Lynx rufus ssp.				X							
Marmota flaviventer ssp.						X					
Microtus montanus ssp.	X	X				X					
Microtus longicaudus mordax	X					X					
Microtus pennsylvanicus ssp.		X				X					
Mus musculus ssp.		X				X					
Mustela frenata ssp.			X			X					
Mustela sp.						X					

Table 2. Vector-host relationship for vectors of plague in Utah listed as potential vectors.

HOST ANIMAL SPECIES / POTENTIAL VECTORS	Catallagia decipiens	Epitedia wenmanni	Foxella ignota	Hoplopsyllus affinis	Megarthroglossus d. divisus	Monopsyllus w. wagneri	Neopsylla inopina	Opisocrostis t. cyanomuris	Orchopeas s. agilis	Orchopeas s. nevadensis	Thrassis petiolatus
Neotoma lepida ssp.			X	X	X	X			X	X	
Neotoma l. lepida		X									
Neotoma cinerea ssp.					X	X			X		
Neotoma c. acraia					X						
Ochotona princeps ssp.						X					
Onychomys leucogaster ssp.						X			X		
Perognathus parvus ssp.											
Perognathus sp.											
Peromyscus maniculatus ssp.	X	X	X	X	X	X			X		
Peromyscus boylii ssp.											
Peromyscus crinitus ssp.		X				X			X		
Peromyscus truei		X				X			X		
Peromyscus eremicus						X			X		
Phenacomys intermedius ssp.	X										
Rattus norvegicus ssp.			X			X					
Rattus rattus alexandrinus											
Rattus rattus rattus											
Reithrodontomys megalotis ssp.						X			X		
Sorex sp.	X										
Sorex vagrans											
Spilogale gracilis ssp.			X			X					
Spilogale g. saxatalis											
Sylvilagus auduboni ssp.			X	X		X					
Sylvilagus a. warreni				X							
Sylvilagus idahoensis											
Sylvilagus nuttallii ssp.	X										
Sylvilagus sp.				X		X					
Sciurus aberti ssp.						X					
Tamiasciurus hudsonicus ssp.					X				X		
Thomomys bottae ssp.			X								
Thomomys talpoides ssp.			X								
Vulpes macrotis ssp.											
Zapus princeps	X					X					

Table 2. (Continued) Vector-host relationship for vectors of plague in Utah listed as potential vectors.

COUNTY NAMES	VECTORS	Atyphloceras multidentatus	Ctenocephalides felis felis	Diamanus montanus	Echidnophaga gallinacea	Hoplopsyllus anomalus	Histrichopsylla gigas dippiei	Malaraeus telchinum	Megabothris abantis	Monopsyllus eumolpi eumolpi	Nosopsyllus fasciatus	Opisocrostis hirsutus	Opisocrostis labis	Opisocrostis t. tuberculatus	Oropsylla idahoensis	Pulex irritans	Thrassis arizonensis	Thrassis francisi	Thrassis h. howelli	Thrassis pandorae	Xenopsylla cheopis
Beaver				X		X			X	X			X	X	X			X			
Box Elder							X	X		X				X	X			X		X	
Cache				X		X	X	X	X	X	X			X	X		X		X	X	
Carbon												X				X					
Daggett								X	X	X		X	X		X					X	
Davis				X		X		X		X										X	
Duchesne				X		X	X		X	X		X		X	X	X			X	X	
Emery				X		X				X		X			X	X				X	
Garfield				X		X		X		X		X			X						
Grand				X	X	X															
Iron				X		X	X	X	X	X		X			X				X		
Juab				X		X				X					X						
Kane				X		X				X		X			X						
Millard				X		X	X	X				X	X	X		X		X			
Morgan						X		X		X					X					X	
Piute				X		X						X								X	
Rich						X		X	X	X		X	X	X	X			X		X	
San Juan				X	X	X		X		X		X		X	X						
Sanpete				X		X	X	X		X				X	X			X	X	X	
Sevier				X		X	X	X	X	X		X	X		X			X	X	X	
Salt Lake		X	X	X		X	X	X	X	X	X			X	X			X		X	X
Summit							X						X	X	X	X				X	
Tooele				X		X										X		X	X		
Uintah				X		X	X		X			X			X	X					
Utah		X		X		X	X	X	X	X	X			X	X			X	X	X	
Washington				X	X	X		X								X					
Wayne				X		X			X	X		X									
Wasatch						X	X		X	X				X	X			X		X	
Weber				X		X		X		X	X			X	X	X		X		X	

Table 3. Distributional pattern by counties in Utah for fleas implicated as capable vectors of plague.

COUNTY NAMES	VECTORS	Catallagia decipiens	Epitedia wenmanni	Foxella ignota	Hoplopsyllus affinis	Megarthroglossus d. divisus	Monopsyllus w. wagneri	Neopsylla inopina	Opisocrostis t. cynanomuris	Orchopeas s. agilis	Orchopeas s. nevadensis	Thrassis petiolatus
Beaver		X		X	X		X			X		
Box Elder		X		X		X	X			X		
Cache		X	X	X		X	X	X		X		
Carbon							X					
Daggett		X					X					
Davis		X					X					
Duchesne		X			X		X		X			
Emery			X	X			X					
Garfield					X		X			X		
Grand				X	X		X			X		
Iron		X		X	X	X	X		X	X		
Juab			X	X			X			X		
Kane			X	X	X	X	X			X	X	
Millard		X		X		X	X			X		
Morgan							X					
Piute				X			X			X		
Rich		X	X	X			X	X		X		
San Juan		X		X	X	X	X			X		
Sanpete		X	X	X	X		X			X	X	
Sevier		X	X	X	X	X	X			X		
Salt Lake		X	X	X			X	X	X			
Summit							X	X		X		
Tooele				X		X	X			X		
Uintah		X	X			X	X			X		
Utah		X	X	X		X	X			X		
Washington		X			X		X			X		
Wayne			X	X	X	X	X			X		
Wasatch		X		X		X	X	X				
Weber							X	X	X			

Table No. 4 — Distributional pattern by counties in Utah for fleas implicated as potential vectors of plague.

PLAGUE IMPLICATED HOSTS

C=capable vector
P=potential vector

COUNTY NAMES	Citellus armatus	Citellus beldingi ssp.	Citellus lateralis ssp.	Citellus r. elegans	Citellus s. cryptospilotus	Citellus t. mollis	Citellus tridecemlineatus	Citellus variegatus grammurus	Citellus v. utah	Cynomys g. zuniensis	Cynomys leucurus	Cynomys parvidens	Dipodomys o. ordii	Eutamias quadrivittatus ssp.	Eutamias minimus ssp.	Glaucomys sabrinus ssp.	Lagurus curtatus ssp.	Lepus californicus ssp.	Marmota f. engelhardti	Marmota f. nosophora	Microtus montanus
Beaver			C			C			C				P	C				P			
Box Elder	C	C											PC								
Cache	PC		C						C											PC	P
Carbon			C								C										
Daggett			C	C							C										
Davis	C								PC												
Duchesne	C		C								PC				PC					C	
Emery	C		C						C		C									C	
Garfield			C						C			C						P	P		
Grand								C													
Iron			C			C						PC	C					P	C		
Juab									C				P					C			
Kane								C	C			C	P					P		C	
Millard			C			C			C			C	P								
Morgan	C		C	C					C						C						
Piute									C			C									
Rich	PC			C							C			C	C					C	PC
Sanpete	C		C						C											C	
Salt Lake	C					C			C											C	
San Juan								PC		C					P			P			
Sevier	C		C			C			C			C			C					C	
Summit	PC			PC							C					P					
Tooele									C												
Uintah			C								C			P						C	
Utah	C		C	C		C			C				P							C	P
Wasatch	PC		C											C						C	C
Washington								C	C									PC	C		PC
Wayne			PC					C	PC			C	P		C					C	
Weber	PC								C												

Table 5. Distribution by County of potential and capable plague vectors with reference to hosts which have been shown to be plague implicated.

PLAGUE IMPLICATED HOSTS

C=capable vector
P=potential vector

COUNTY NAMES	Mus musculus ssp.	Mustela sp.	Neotoma albigula ssp.	Neotoma cinerea ssp.	Neotoma lepida lepida	Onychomys leucogaster ssp.	Onychomys torridus ssp.	Perognathus sp.	Peromyscus boylii ssp.	Peromyscus maniculatus ssp.	Peromyscus truei ssp.	Peromyscus t. truei	Rattus norvegicus	Rattus r. rattus	Rattus rattus alexandrinus	Reithrodontomys megalotis ssp.	Sylvilagus auduboni ssp.	Sylvilagus n. nuttallii	Taxidea taxus ssp.	Thomomys talpoides ssp.
Beaver					P					P						P				
Box Elder					P	P		P		P C						P				P
Cache		P C		P						P C			C							P
Carbon										P						P				
Daggett										P	P									
Davis										C										
Duchesne										P C	P					P				
Emery										P										
Garfield				P C	P			P		P							P			
Grand					P					P								P		
Iron		P			P					P C										
Juab					P C					P C	P									
Kane					P	P		C		P							P			
Millard					P C	P				P						P				P
Morgan										P C										
Piute					P					P	P	P				P				P
Rich								P C		P C										P
Sanpete					P					P C										P
Salt Lake				P C						P			C		C					
San Juan						P C				P C	P					P	P	P C		P
Sevier					P					P C	P									P
Summit										P										
Tooele				P	P					P C						P				
Uintah		C								P C						P				
Utah	C	C		P C	P C	P		C	P C	P C	P C		C	C		P				P
Wasatch										P C										P
Washington					P					P C						P	P C			
Wayne										P C							P			P
Weber										P C			C							

Table 5 (Continued) Distribution by County of potential and capable plague vectors with reference to hosts which have been shown to be plague implicated.

most widely distributed species in Utah are *D. montanus*, *Hoplopsyllus anomalus*, *Malaraeus telchinum*, *Oropsylla idahoensis*, *Thrassis pandorae*, and *Monopsyllus eumolpi eumolpi*. There are undoubtedly other factors involved, but this wide distribution is in part due to the extensive distribution of the hosts involved for each species of flea, as well as to the ability of the above-named fleas to adapt to several hosts, although they may be more commonly associated with certain species or genera of hosts. For example, the flea *Diamanus montanus* is found on at least 27 species and subspecies of mammals in Utah representing 12 genera other than *Citellus*. However, it is usually listed in the literature as a squirrel flea, especially for the squirrels *Citellus armatus* and *Citellus variegatus*. This condition of relative host specificity is likewise the case for the fleas *Hoplopsyllus anomalus*, *Oropsylla idahoensis* and *Thrassis pandorae*, although their host ranges are not so extensive as *D. montanus*. The usual hosts of *Malaraeus telchinum* as found in Utah are various species of native mice, although it has been found on field mice and pack rats. *M. eumolpi eumolpi* is regarded as a chipmunk flea. Records from the literature and our field studies show it to be associated with eight other genera and 11 species of rodents in addition to 3 species of chipmunks in the genus *Entamias*. This would constitute a total of fourteen species and subspecies acting as hosts for this particular flea (Table 1).

There are certain capable vectors which are fairly abundant (that is, the numbers found on a given species of host is high) and common (that is, at least a few specimens are usually found on most of the hosts collected) but are restricted geographically. This is true of the flea *Echidnophaga gallinacea*. This flea is apparently restricted to the southern portion of the State in Utah. One of its more common hosts is the squirrel *Citellus variegatus* which as a host animal has a very extended distribution over the State. Another host to this flea, having wide geographic distribution within the State,, is *Citellus leucurus* and its several subspecies. Nevertheless, for some unknown reason the flea parasite *E. gallinacea* does not follow the same distributional pattern as its host. (Table 1 and Fig. 14).

Opisocrastis hirsutus, whose usual hosts are considered to be the several species of prairie dogs widely distributed in Utah, is restricted in the sense that its range is determined somewhat by the extent of prairie dog distribution. Several species other than the 3 species of *Cynomys* have been shown to be hosts for this species of flea in Utah (Table 1).

The list of fleas shown below is arranged in order of relative abundance in Utah as determined in the main from collections made by this survey. For an illustration showing the pattern of distribution in Utah see Fig. 14.

1. *Diamanus montanus*
2. *Hoplopsyllus anomalus*
3. *Thrassis pandorae*
4. *Oropsylla idahoensis*
5. *Opisocrostis hirsutus*
6. *Malaraeus telchinum*
7. *Thrassis howelli howelli*
8. *Echidnophaga gallinacae*
9. *Nosopsyllus fasciatus*
10. *Monopsyllus eumolpi eumolpi*
11. *Opisocrostis labis*
12. *Megabothris abantis*
13. *Atyphloceras multidentatus*
14. *Opisocrostis tuberculatus*
15. *Ctenocephalides felis felis*
16. *Pulex irritans*
17. *Histrichopsylla gigas dippiei*
18. *Thrassis francisi*
19. *Thrassis arizonensis*
20. *Xenopsylla cheopis*

Eskey and Haas (1940, op. cit., p. 41) experimentally demonstrated the possibilities of transmission of plague by several species of fleas. The effectiveness of transmission varied. Comparing his list of species with the plague-implicated capable vectors found in Utah, the following list of Utah fleas are arranged below in order of their apparent effectiveness as transmitters. The pattern of distribution is shown in Fig. 13.

1. *Xenopsylla cheopis*
2. *Nosopsyllus fasciatus*
3. *Hoplopsyllus anomalus*
4. *Diamanus montanus*
5. *Thrassis pandorae*
6. *Opisocrostis tuberculatus*
7. *Opisocrostis labis*

The generalized pattern of distribution by county, for the above-listed fleas in Utah, as well as all other capable vectors, is shown in Table 3.

Potential Vectors

There are several species of fleas involved as potential vectors for plague in Utah. One species, *Monopsyllus wagneri wagneri*, far surpasses all others in its geographic distribution. It is a native mouse flea but has a rather general

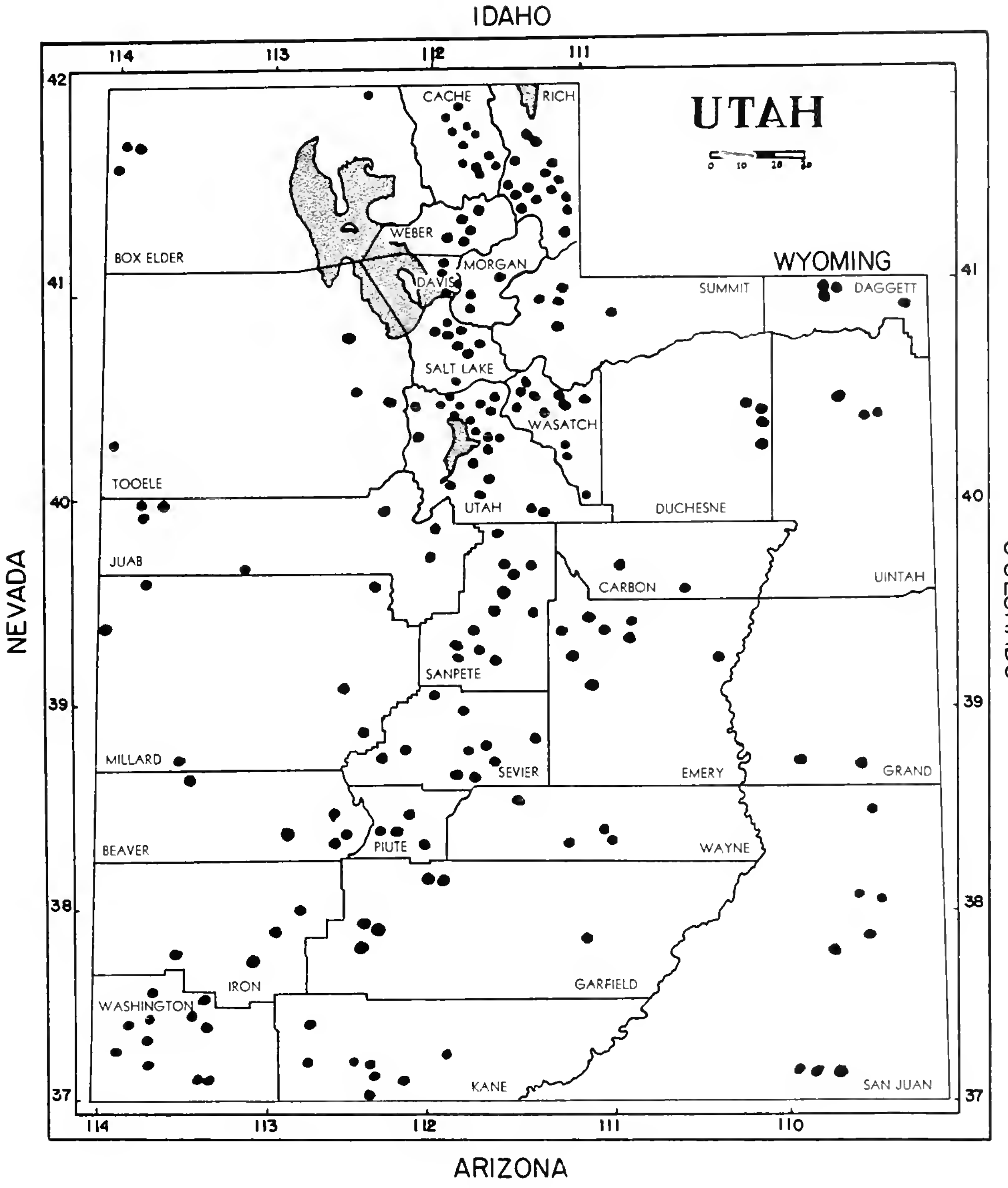

Fig. 13. Distributional pattern for those species of fleas in Utah listed as the most effective capable vectors for plague.

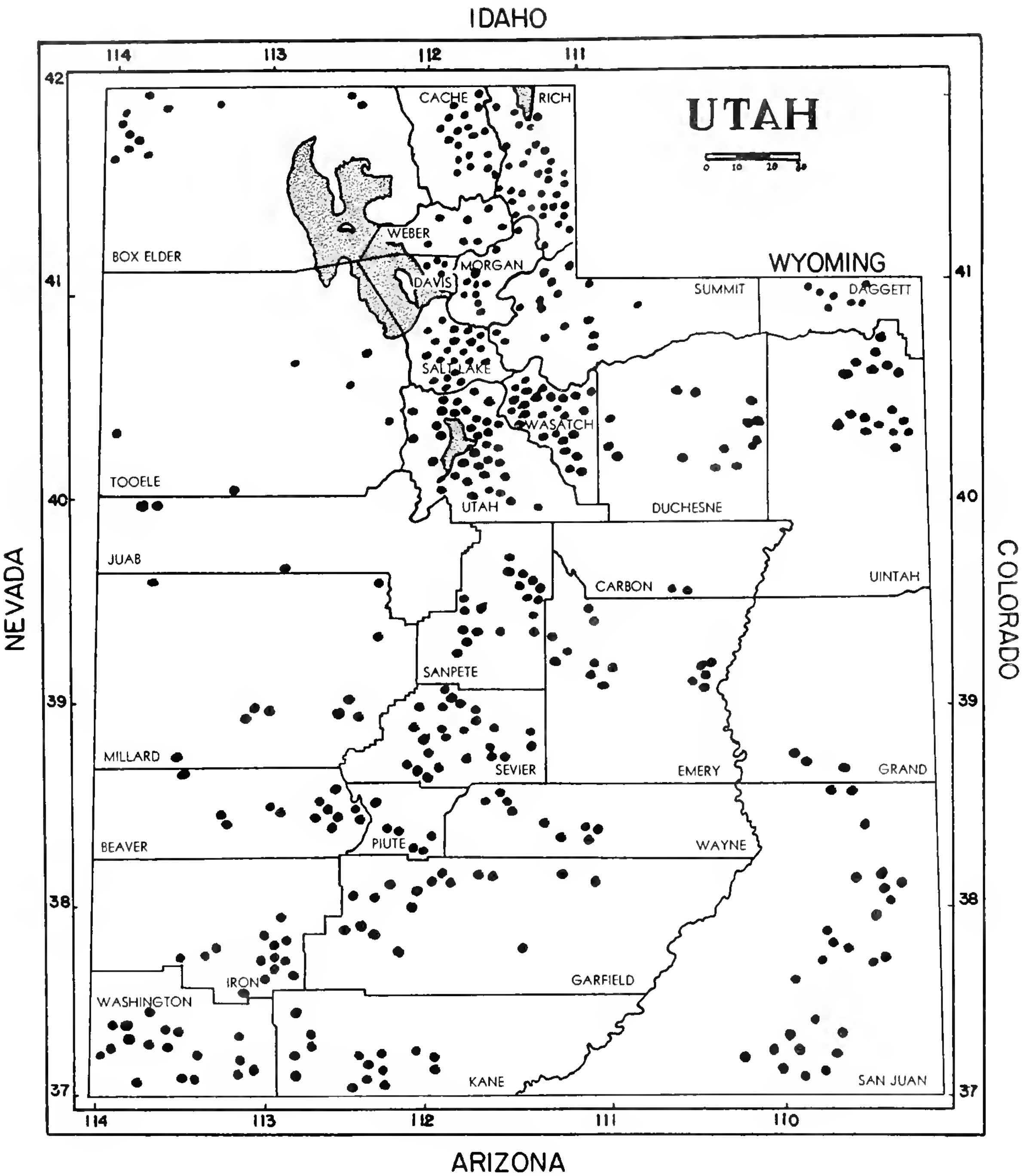

Fig. 14. Map showing the general distributional pattern for fleas listed as capable vectors for plague.

host habitat adaptation. It is found on thirty-four species and subspecies of mammals in Utah including the four species of *Peromyscus*, which constitute its usual host. Another widely distributed potential vector is *Orchopeas sexdentatus* with two subspecies *agilis* and *nevadensis*. Whereas *M. w wagneri* has rather broad host tolerance, *Orchopeas sexdentatus agilis* and *nevadensis* seem to be mainly relegated to woodrats and native mice. *Epitedia wenmanni* another mouse flea, listed as a potential vector of plague, has a fairly wide geographic distribution. It is unusual, however, to find more than two or three specimens on a single host. Other than *Peromyscus maniculatus* the primary host, this species of flea has been taken from field mice *Microtus montanus*, the wood rat *Neotoma lepida*, the kangaroo rat, *Dipodomys ordii*.

Vector distribution pattern for the potential vectors is shown in Table 4. This table shows only the geographic location by counties as space does not permit listing by smaller geographic or political subdivisions.

SUMMARY AND CONCLUSIONS

Through the courtesy of the National Institutes of Health, Grants and Fellowships Division, a project was established at Brigham Young University to study the distribution and host relationships of vectors for Rocky Mountain spotted fever and plague in the state of Utah. This summary has reference only to the latter as the two divisions of the project are discussed under separate sections. Nevertheless it was felt necessary to discuss some subjects common to both in the first division of this report. This includes the statement of purpose and scope of the project, a generalized description of the physiographic features of the state of Utah as it affected the problems at hand, and techniques involved in obtaining data. With strict reference to the problem of vector and host relationship the following conclusions may be drawn regarding plague-vector distribution.

1. Plague as a disease in Utah does exist. It has been known to be present since 1936 and since that time the disease has been identified in thirteen of the twenty-nine counties of the state.
2. Of the sixty-eight species and subspecies of plague-implicated mammals in the western United States, forty-one species and subspecies are represented in Utah. There is not a single county without one or more plague-implicated mammal species being present and widely distributed, and from which plague-implicated vectors have been taken.
3. As a result of these studies it has been found that there are thirty-one species and subspecies of fleas occuring in Utah as plague-implicated vectors. They are classified as being capable (natural) and potential (experimental) vectors. Twenty species are listed as capable and eleven as potential vectors.
4. Both capable and potential vectors have wide geographic distribution and variable host adaptations. For example, *Diamanus montanus*, a very efficient vector for plague, occurs on twenty genera other than the genus *Citellus* in Utah. It is commonly listed as a squirrel flea, but it is found on at least eighteen species of mammals other than members of the squirrel genus as far as Utah is concerned.
5. Every Utah county has one or more capable plague-implicated vectors present. Efficient plague-implicated vectors of several species, and plague-implicated hosts, are found to be densely distributed where human populations are most highly concentrated in the state.

LITERATURE CITED

Allred, D. M., 1952. Plague important fleas and mammals in Utah and the Western United States. The Great Basin Naturalist 12: (4) 67-75.

Augustson, G. F., 1943. Preliminary records and discussion of some species of Siphonapteria from the Pacific Southwest. Bulletin Southern California Academy of Science 42: 69.

——, 1944. The Flea genus *Thrassis* and sylvatic plague, with a description of *T. brennani*. Journal of Parasitology 30 (4): 237-240.

Baker, Carl F., 104. A revision of American Siphonaptera, or fleas, together with a complete list and bibliography of the group. Proceedings of the U. S. National Museum 27: 365-469.

Beck, D Elden, 1953. A study of some consortes at a nesting site of the Northern Cliff Swallow *Petrochelidon albifrons albifrons* (Rafinesque). Proceedings of the Utah Academy of Sciences, Arts and Letters 30: 39-42.

——, Barnum, A. H. and Moore, L., 1953. Arthropod consortes found in the nests of *Neotoma cinerea acraia* (Ord) and *Neo-*

toma lepida lepida Thomas. Proceedings of the Utah Academy of Sciences, Arts and Letters 30:43-52.

Bishopp, F. C., 1915. Fleas. United States Department of Agriculture Bulletin No. 248: 1-31.

Brown, J. H., 1944. The fleas (Siphonaptera) of Alberta, with a list of the known vectors of sylvatic plague. Annals of the Entomological Society of America 37 (2): 207-213.

Burroughs, A. L., 1944. The flea *Malaraeus telchinum* a vector of *P. pestis*. Proceedings of the Society for Experimental Biology and Medicine 55: 10-11.

——, 1947. The vector efficiency of nine species of fleas compared with *Xenopsylla cheopis*. Journal of Hygiene 45 (3): 371-396.

Burrows, William et al., 1949. Jordan-Burrows Textbook of Bacteriology, 15th Ed. 502-510. W. B. Saunders Co., Philadelphia, Pennsylvania.

Byington, L. B., 1940. Two epizootics of plague infection in wild rodents in the western United States in 1938. Public Health Reports 55 (33): 1496-1501.

Costa Lima, A. Da and Hathaway, C. R., 1946. Bibliografia, catologo e animais per elas sugados. Monografias do Instituto (4) Oswaldo Cruz, Brazil.

Craig, C. F., Faust, C. E. and Miller, A., 1951. Clinical Parasitalogy. p. 811, Lea and Febiger Publishers, Philadelphia, Pennsylvania.

Davis, D. H. S., 1948. Sylvatic plague in South Africa: History of plague in man, 1919-1943. Annals of Tropical Medicine and Parasitology 42 (2): 207-217.

Durrant, Stephen D., 1952. Mammals of Utah. University of Kansas Publications, Museum of Natural History. University of Kansas, Lawrence, Kansas, 6: 1-549.

Ecke, D. H. and Johnson, C. W., 1950. Sylvatic plague in Park County, Colorado. Transactions 14th North American Wildlife Conference, March 6, 7. 9: 191-197.

—— and Johnson, C. W., 1952. Plague in Colorado. Public Health Monograph, Pt. 1: 1-37, U. S. Government Printing Office.

Eskey, C. R., 1938. Recent developments in our knowledge of plague transmission. Public Health Reports 53 (2): 49-57.

—— and Haas, V. H., 1940. Plague in the western part of the United States. Public Health Bulletin 254: 1-83.

Ewing, H. E. and Fox, Irving, 1943. The fleas of North America. United States Department of Agriculture, Miscellaneous Publication 500: 1-142.

Fautin, Reed W., 1946. Biotic communities of the Northwestern Desert Shrub biome in Western Utah. Ecological Monographs 16: 251-310.

Fox, Irving, 1940. Fleas of Eastern United States, Iowa State College Press, Ames, Iowa.

Hampton, B. C., 1940. Plague in the United States. Public Health Reports 55 (26): 1143-1158.

——, 1945. Plague infections reported in the United States during 1944 and summary of human cases, 1900-1944. Public Health Reports 60 (46): 1361-1365.

Hoekenga, M. T., 1947. Plague in the Americas. The Journal of Tropical Medicine and Hygiene 50 (10): 190-201.

Holdenried, R., Evans F. C. and Longaneker, D. S., 1951. Host-parasite-disease relationships in a mammalian community in the central coast range of California. Ecological Monographs 21 (1): 1-18.

Holland, George P., 1949. The Siphonaptera of Canada. Publication 817. Techincal Bulletin (70) Dominion of Canada. Department of Agriculture, Ottawa, Canada.

Hubbard, Clarence Andresen, 1947. Fleas of Western North America. Iowa State College Press, Ames, Iowa.

Humphreys, F. A. and Campbell, A. G., 1947. Plague, Rocky Mountain spotted fever, and Tularemia surveys in Canada. Canadian Journal of Public Health 38: 124-130.

Jellison, W. L., 1938. The possible role of birds in the epidemiology of sylvatic plague. Journal of Parasitology 24: p. 12.

—— 1947. Siphonaptera: Host distribution of the genus *Opisocrostis* Jordan. Transactions of The American Microscopical Society. 46(1): 64-69.

——; Locker, Betty, and Bacon, Roma Fullberg. Index to the literature of Siphonaptera of North America Supplement (1): 1939-1950. Rocky Mountain Laboratory, Hamilton, Montana.

—— and Good, Newell E., 1942. Index to the literature of Siphonaptera of North America. National Institutes of Health Bulletin 178: 1-193.

Kelly, F. C. and Hite, E. K., 1949. Microbiology. pp. 399-401. Appleton-Century Crofts, New York., N. Y.

Kohls, Glen M., 1939. Siphonaptera: Notes on synonymy of North American species of the genus *Hoplopsyllus* Baker. Public Health Reports 54 (4_): 2019-2023.

——, 1940. Siphonaptera—A study of the species infesting wild hares and rabbits of North America north of Mexico. National Institutes of Health Bulletin 175: 1-34.

Link, V. B., 1950. Plague. The Journal of the American Medical Association 144 (5): 375-377.

——, 1950. Plague epizootic in Cottontail Rabbits. Public Health Reports 65 (21): 696.

Macchiavello, Atilio, 1954. Reservoirs and Vectors of Plague. Journal of Tropical Medicine and Hygiene 57: 3-8, 45-48.

Merriam, C. H., 1898. Life zones and crop zones of the United States. U. S. Department of Agriculture Division Biological Survey Bulletin Number 10: 1-79.

Meyer, K. F., 1950. Modern therapy of plague. The Journal of the American Medical Association 144 (12): 982-985.

—— and Holdenreid, R., 1949. Rodents and fleas in a plague epizooitic in a rural area of California. The Puerto Rico Journal of Public Health and Tropical Medicine 24 (3): 201-209.

Miles, Virgil I.; Maxwell, J. Wilcomb, Jr. and Irons, J. V., 1952. Rodent Plague in the Texas South Plains, 1947-49. Public Health Monograph, Part II (6): 41-54.

Mohr, C. O., 1948. Domestic rats, fleas and native rodents in relation to plague investigations in Utah. Communicable Disease Center Bulletin, Atlanta, Georgia. (Mimeographed)

Prince, F. M., 1943. Species of fleas on rats collected in states west of the 102nd Meridian and their relation to the dissemination of plague. Public Health Reports 58 (18): 700-708.

——, 1947. Plague. The survival of the infection in fleas in hibernating ground squirrels. Public Health Reports 62 (13): 463-467.

Rothschild, Miriam and Clay, Theresa, 1952. Fleas, Flukes and Cuckoos. The Philosophical Library Inc., 15 East 40th Street, New York 16, New York.

Rucker, W. C., 1915. Plague: Its geographic distribution and its menace to the United States. Public Health Reports 30 (19): 1428-1431.

Simmons, S. W. and Hays, W. J., 1948. Fleas and disease. The Proceedings of the Fourth International Congress on Tropical Medicine and Malaria pp. 1678-1688.

Snodgrass, R. E., 1946. The skeletal anatomy of fleas (Siphonaptera). Smithsonian Miscellaneous Collections 104 (18): 1-89.

Stanford, J. S., 1931. A preliminary list of Utah Siphonaptera. Proceedings of Utah Academy of Science 8: 153-154.

——, 1944. More Utah Siphonaptera. Proceedings of Utah Academy of Sciences, Arts and Letters 19: 173-178.

Stark, H. E., 1948. A Preliminary study of Utah fleas. Unpublished Master of Science Thesis, University of Utah.

Stewart, M. A. and Evans, F. C., 1941. A comparative study of rodent and burrow flea populations. Proceedings of Society for Experimental Biology and Medicine 47: 140-142.

Survey of the recreational resources of the Colorado River Basin. 1950. United States Department of the Interior Publication. Compiled in 1946. U. S. Government Printing Office, Washington, D. C.

Tipton, V. J., 1950. New distributional records for Utah Siphonaptera. The Great Basin Naturalist 10 (1-4): 62-65.

United States Public Health Reports 51 (30): and 65 (39).

Wayson, N. E., 1947. Plague—Field surveys in western United States during ten years (1936-1945). Public Health Reports 62 (22): 780-791.

Wheeler, C. M. and Douglas, J. R., 1941. Transmission studies of sylvatic plague. Proceedings Society of Experimental Biology and Medicine 47: 65-66.

Zetek, James, 1917. The ecology of bubonic plague. Annals Entomological Society of America 10: 189-206.

PART II

ROCKY MOUNTAIN SPOTTED FEVER VECTOR INVESTIGATIONS

INTRODUCTION

It is known that several species of ticks are identified as either capable or potential vectors of Rocky Mountain spotted fever. In the western United States in general and Utah in particular, *Dermacentor andersoni* Stiles is the principal vector transmitting the disease to man.

From an historical point of view the disease at first was supposed to have been confined to the Rocky Mountain area and especially so for the Bitterroot Valley of Montana. At the present time, however, the disease has been found widely distributed throughout the United States and parts of Canada. It became recognized as a medically important disease as early as 1873 in Montana, although not a great deal was known about it at the time. According to Fricks (1915) the United States Public Health Service began investigating the disease in 1902 when J. O. Cobb was ordered to Bitterroot Valley, Montana to instigate studies on the disease The following year, 1903, J. F. Anderson was appointed; in 1904 C. W. Stiles took over, followed by Francis, King, McClintric and Rucker, et al. From a report by Robinson (1908), Wood of the U. S. Army submitted to the Surgeon-General, descriptions of the disease from eight Idaho physicians, and he was the first to refer to it as "spotted fever." The physicians are listed as Bowers, Collister, Dubois, Fairchild, Figgins, Springer, Sweet, and Zipf.

In August, 1906, Dr. Howard T. Ricketts published his preliminary results demonstrating the relationship between the disease and the vector *Dermacentor andersoni*. His carefully done, yet simple experiments stand out as one of the major achievements in the study of tick-borne diseases. He had reported earlier that same year (July 7 - Journal of American Medical Association, Vol. 47, No. 1, pp. 33-36) his studies on the disease, as a result of his investigations by means of animal inoculations. It is of interest to note in his title for the earlier paper the reference to "tick transmission," although he had not completed his investigations to that end. The title was: "The Study of 'Rocky Mountain spotted fever' (Tick Fever?) by means of animal inoculations. A preliminary communication - H. T. Ricketts, M.D., Chicago."

Since the time of the first investigations and initial discoveries, this disease and its very closely related types (of which there are several) have become somewhat cosmopolitan in their significance.

From the very beginning of the occupation of the Rocky Mountain region by white man, there have been records of his being affected by tick-borne diseases. Utah has long contributed far too many records showing incidence of Rocky Mountain spotted fever. Not very much, however, has been known, concerning the kinds of vectors involved, their geographical or seasonal distribution, as well as host relationships for the State of Utah. These, however, have been the primary objectives involved in the tick vector surveys carried out by the writer and his associates and which comprise the main body of this part of the report.

Probably the first reference to the disease "spotted fever" in Utah is that by Stiles (1905). On page 28 of his report, the statement reads as follows:

> "Sweet (1896) states that the disease does not to his knowledge occur in Utah, but Smith (1905) reports a possible case."

On page 116 of this report by Stiles is the account mentioned by Smith in the quote above. The title of Smith's report which was included in the paper by Stiles is shown below:

> "As possible case of "Spotted Fever" in Utah by R. J. Smith, M.D. (Personal letter, dated May 22, 1904, to Dr. Thomas D. Tuttle, secretary, Montana State Board of Health)."

It is important to mention that the patient to which Dr. Smith made reference in his letter was, "A patient, female, age 24, was visiting in Idaho, where within 2 miles of the place she was visiting there were 2 cases of 'spotted fever,' . . . ". Even though this was a case of spotted fever occurring in Utah, it is not positive that the disease was picked up within the confines of the state.

Robinson[1] (1908) refers to the disease with respect to its occurrence in Utah as follows:

> "Geographical Distribution.—The disease has been reported from Montana, Idaho, Wyoming, Nevada, Oregon, Washington, Utah, and Colorado. I am informed by Noyes of American Fork of three cases occurring in Cedar Valley, Utah. One

1 This excerpt is from an article which was the prize essay identified as the Francis W. Shain Prize, Jefferson Medical College, 1908 The essay was made a part of the "Medical Record," a weekly Journal of Medicine and Surgery in New York.

patient was a sheepherder and resided at Fairfield, while the other two, a farmer and his daughter, lived at Cedarfort. Wherritt had several cases at Heber City (Utah). Laymen tell me of having contacted "Mountain fever" while hauling wood from a district designated as "Tickville," which is about fifteen miles north of the villages Fairfield and Cedarfort. From the abundance of ticks in this locality the district gets its name."

The Rocky Mountain Laboratory at Hamilton, Montana, has been the main scientific agency which has checked "spotted fever" incidence as well as vector distribution since studies were first initiated. The records for Utah have been made available for this report through the courtesy of the personnel of the Rocky Mountain Laboratory, especially Dr. William L. Jellison and Mr. Glen M. Kohls (Tables 1, 2, 3, and 4). In Table 1 note that under the county column there is listed, "unknown," date "1849." Below is a copy of a letter which, with special reference to date, offers some explanation.

"DISTRICT DIRECTOR
U. S. PUBLIC HEALTH SERVICE

District No. 8
617 Colorado Bldg.
Denver, Colorado

Sept. 27, 1941

Dr. R. R. Parker
Rocky Mountain Laboratory
Hamilton, Montana

Dear Doctor Parker:

I recall that you are interested in reports of Rocky Mountain spotted fever of an early historical date.

Perhaps you already know about this, but in Salt Lake City recently I was shown a register of deaths kept by the Mormon Church nearly a hundred years ago. In the year 1849 there are several deaths reported from "mountain fever," at least three on one page of the register.

It is an interesting record, and if you have not seen it, it is worth a glance some time. It is kept at Salt Lake City Health Department, Bureau of vital Statistics. I am sure that Doctor Thomas J. Howells, the Health Commissioner, will be glad to show it to you.

Respectfully,
L. B. Byington, Surgeon
In Temporary Charge, Dist. No. 8."

Also of historical interest is a news reference supplied by Jellison and Kohls in correspondence with me on May 12, 1954:

Copied from Oregon City, Ore., Enterprise
June 20, 1941

"BRIGHAM YOUNG'S ILLNESS
DIAGNOSED AFTER 94 YEARS

SALT LAKE CITY—Ninety-four years after he came down with the illness, physicians finally have diagnosed the mysterious fever that afflicted Brigham Young at the arrival of the Mormon pioneers in the Salt Lake Valley in 1847.

Dr. William M. McKay, acting Utah health commissioner, disclosed that intensive research and much careful examination of the daily journals kept by some of Young's companions indicated the Mormon leader suffered from Rocky Mountain spotted fever.

The disease was unknown at that time, and it was only Young's strong constitution that enabled him to survive the ailment, Dr. McKay believes."

In the Kansas State Board of Health Bulletin No. 6, page 103, Rucker (1912) has the following to say with regard to Rocky Mountain spotted fever:

"Two types of Rocky Mountain spotted fever are known—the mild, which occurs in Utah, Wyoming, Idaho, Nevada, eastern California, Oregon, and Washington, and the severe form which is found in Montana."

Fricks (1915) reported in the Public Health Reports:

"The State Health Officer of Utah reports that it is impossible to furnish any accurate data concerning the prevalence of Rocky Mountain spotted fever in Utah, but that several deaths were attributed to this cause during 1914 and there is reason to believe that the disease occurs in Box Elder County."

"Rocky Mountain spotted fever certainly occurs in Utah, but to what extent is not known and will not be until the disease is made reportable."

One of the first references to vectors of the disease in Utah is that of Banks (1908), wherein he refers to *D. venustus* Banks (now considered as a synonym for *D. andersoni*). He lists this species from Bridger Basin, Utah. As closely as can be discovered from the records,

County		1915	1916	1917	1918	1919	1920	1921	1923
Beaver	1917						1(1)		
Box Elder	1915	8(2)	9	6		1	1	1	
Cache	1915	8	4	1	3	3			
Carbon	1915	1							
Daggett	1936								
Davis	1915	3		2	1	1	2(1)		
Duchesne	1915	11	3				1		
Emery	1916		2						
Juab	1916		3				1		
Kane	1937								
Millard	1915	1		1					
Morgan	1934								
Piute	1930								
Rich	1917			1					
Salt Lake	1915	1	1			1(1)	1		
San Juan	1919					1			
Sanpete	1916		2						
Sevier	1939								
Summit	1915	1	2	1	1			2	
Tooele	1916		1				1	1	
Uintah	1916		5			1	1	2	
Utah	1908	1	2	1					
Wasatch	1908			1		2(1)		2	
Washington	1939								
Wayne	1929								
Weber	1917			1					
Unknown	1849?	(2)					1		15(1)
State Total		34(4)	34	16	5	10(2)	10(2)	8	15(1)

Table 1. Rocky Mountain spotted fever cases in Utah. (Figures in parentheses indicate fatal cases).

County	1924	1925	1926	1927	1928	1929	1930	1931	1932
Beaver									
Box Elder							1		1
Cache					2	1			
Carbon									
Daggett									
Davis					1				
Duchesne					1	3			3(1)
Emery									
Juab							1	2	3(1)
Kane									
Millard									1
Morgan									
Piute							1		
Rich						2			
Salt Lake					3				1
San Juan						1			1(1)
Sanpete						2			
Sevier									
Summit					1		2(1)		3
Tooele					1			1	
Uintah						2	2(1)	2	5(1)
Utah						1	1	2(1)	1
Wasatch					1				1
Washington									
Wayne						2			
Weber						1			
Unknown	10(3)	6(1)	4(1)	8					
State Total	10(3)	6(1)	4(1)	8	10	15	8(2)	7(1)	20(4)

Table 2. Rocky Mountain spotted fever cases in Utah from 1924 to 1932. (iFgures in parentheses indicate fatal cases).

County	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942
Beaver		1				1(1)				
Box Elder		1						1		
Cache							1			
Carbon						1	2	1		
Daggett				1(1)		2			1	
Davis		1					1			
Duchesne		1		3(2)		1				
Emery						1(1)	1			
Juab			1		2			1		
Kane					1(1)					
Millard	1								1(1)	
Morgan		1								
Piute										
Rich					1	2	1	2		
Salt Lake		1						1(1)		
San Juan										
Sanpete					1			1	1	
Sevier							1		1(1)	
Summit				2	1	2	1		1	
Tooele				1		1				
Uintah		1	1	1	3(1)	1	5		3(2)	1
Utah	2(2)		1		2(1)	5	1	1	1	1
Wasatch		1	1(1)			1		1		
Washington							1			
Wayne										
Weber	1									
Unknown			1(1)				1			2
State Total	4(2)	8	5(2)	8(3)	11(3)	18(2)	16	9(1)	9(4)	4

Table 3. Rocky Mountain spotted fever cases in Utah from 1933 to 1942. (Figures in parentheses indicate fatal cases).

County	Total Cases	Total Deaths	Fatality Rate %
Beaver	4	2	50.00
Box Elder	30	2	6.66
Cache	23	0	—
Carbon	5	0	—
Daggett	4	1	25.00
Davis	12	1	8.33
Duchesne	27	3	11.11
Emery	4	1	25.00
Juab	14	1	7.15
Kane	1	1	100.00
Millard	5	1	20.00
Morgan	1	0	—
Piute	1	0	—
Rich	9	0	—
Salt Lake	10	2	20.00
San Juan	3	1	33.33
Sanpete	7	0	—
Sevier	2	1	50.00
Summit	20	1	5.00
Tooele	7	0	—
Uintah	36	5	13.88
Utah	23	4	17.39
Wasatch	11	2	18.18
Washington	1	0	—
Wayne	2	0	—
Weber	3	0	—
Unknown	48	9	18.75
State Total	313	38	12.14%

Table 4. Rocky Mountain spotted fever cases in Utah. Case Totals and Fatality rates, State and Counties, 1915 to 1942.

his geographic location for the collection was in the northwestern corner of Daggett County, or in the south-central portion of Rich County in Utah.

Bishopp (1911) listed twelve localities for the Rocky Mountain wood tick in Utah. His accompanying map, however, shows a distributional pattern for the tick indicating that he must have confused or included the common rabbit tick *D. parumapertus* Neumann with *D. andersoni*.

Robinson (1908 loc. cit. p. 916) cited Noyes of American Fork as giving information concerning three cases of Rocky Mountain spotted fever in persons living at Fairfield and Cedar Fort. These towns are only a few miles west of the writer's home at Provo, Utah County, Utah. The towns of Cedar Fort (spelled "Cedarfort" by Robinson) and Fairfield are about five miles apart. They lie at an elevation of about 4,800 to 5,000 feet above sea level. To the west are the foothills of the Oquirrh Mountains, rising to an elevation of 10,403 feet at nearby Lewiston Peak. It will be recalled that Wherritt as reported by Robinson (1908), laymen told him of contacting mountain fever in a district known as "Tickville" about 15 miles north of 'Fairfield' and 'Cedarfort' and that this place was named "Tickville" owing to the number of ticks found there. To one acquainted with the topography of Utah, a point fifteen miles north of Cedar Fort would be located in a mountainous area and at elevations where *D. andersoni* has been commonly found. As recently as April 17, 1954, the writer had first-hand reports and received collections in unusual abundance of *D. andersoni* from mountain areas west, north and south of Cedar Fort. These reports and collections came from elevations of 5,500 to 7,000 feet above sea level.

A survey was conducted on May 29, 1954, at the head of Barlow Canyon in the Boulter Mountain area of central Utah. The general location for this survey is about eight miles north of Eureka in Juab County and about 20 miles south and slightly west of Cedar Fort in the Cedar Valley area. At elevations ranging from 6,100 feet to 6,900 feet ticks were found in sufficient numbers to be listed as common. At the uppermost elevation surveyed (7,000 feet above sea level), a place named, "Hot Stuff Mine," the ticks were most abundant. They were taken by flagging grass and brush situations. The ticks seemed to be more densely distributed along stock trails and in the open grass locations.

Cooley (1938 and 1946), Cooley and Kohls (1944) and Jellison (1945) published several comprehensive articles on ticks, in which the Rocky Mountain spotted fever tick vectors in Utah and other states are listed. Bishopp and Trembly (1945) listed distributional records for Utah, from the Bureau of Entomology. Edmunds (1951) has published the only principal list to date which is restricted to ticks in Utah. Coffey (1953) has recently made some preliminary studies on distribution, seasonal occurrence, and host relationships of *D. parumapertus*, *D. andersoni*, as well as other implicated vectors of Rocky Mountain spotted fever in Utah. He has also been an associate collaborator on some phases of this project and some of his observations are included in this report. Part of his studies, however, have been published (1954) and will be referred to accordingly. There are several other reports which have had reference to Utah ticks. They will, however, be cited at the appropriate place in the main body of the report.

ETIOLOGICAL ASPECTS OF THE DISEASE:

Rocky Mountain spotted fever is caused by *Rickettsia rickettsi* (Wolbach), (Also listed in the literature under the synonym *Dermacentroxenus rickettsi*. It is one of the rickettsial organisms of which there are several species. It would be well to mention here that there are several kinds of rickettsial organisms, tick transmitted, which are immunologically identical (or very closely so) to Rocky Mountain spotted fever but are located at widely separated places on the earth. Nevertheless, the organism in the western United States, including Utah, is the one listed above and is considered to be endemic to the western states. Its pathological effect is mainly directed to the endothelial lining of the blood vessels. The rickettsia are intracellular as well as intranuclear in their invasion, and produce an exanthematic condition in the endothelia of blood vessels.

Case fatality varies with different localities, being characteristically high in the Bitterroot Valley of Montana. Generally speaking, the case fatality rate has been figured from 4% to 90%, depending on the geographic locality where the disease was contracted.

DISTRIBUTION OF THE DISEASE AND CASE FATALITY

IN THE UNITED STATES:

Rocky Mountain spotted fever has been reported from every State of the Union. The incidence, however, is higher in the western part of the United States. Hampton and Eubank (1938) over a five year period of observation (from 1933-37) reported 2,190 cases in the U. S.; 1,435 or 65.5% occurred in the Mountain and Pacific States and 601 or 27.1% occurred in the South Atlantic States. With respect to virulence there is parallel comparison. Topping (1941) reported the case fatality as being 28.1% in the Western States and 18.4% for the Eastern States. In the west it seems to have its most virulent type located in the Bitterroot Valley of Montana.

In Utah:

Through the courtesy of Mr. John Wright of the Utah State Health Department, statistics on the incidence of the disease in Utah were made available to this survey. Coffey (1953) analyzed these statistics and I quote from his report:

"Records on spotted fever in Utah are available at the State Department of Health as far back as 1934. According to these State health records, spotted fever occurs in every county in Utah except Piute. (Rocky Mountain laboratory records show a single non-fatal case for 1930 in Piute County. See Table 2). It is least abundant in the Great Basin and desert areas of the Colorado Plateau. It is important to remember, however, that cases reported from a county may not in all cases have been contracted there. A study of the case histories would no doubt prove valuable as well as interesting. According to the data the higher incidence is found in Salt Lake, Utah, Uintah, and Duchesne counties. The former two counties have high population centers in close proximity to foothills and mountain areas. In the latter two counties population centers also border extensive foothills and mountain areas. In addition, many people enter the brush and forest parts of these counties for reasons of vacation and recreation."

"Rocky Mountain spotted fever in humans has not been reported until April in Utah. The disease usually reaches the peak of its incidence in June, declining thereafter, and does not cease in some years until the last of November. The earliest case of spotted fever recorded in Utah is on April 1, 1938, and the latest on November 25 of the same year. The June peak and the autumn cases show a later incidence for Utah than has been reported by others for the more northern states such as Montana and Idaho (Cooley, 1932). One might logically assume that the October and November cases are probably from hunters and others whose occupation takes them into the mountain areas at these times. It is generally thought that the tick, *D. andersoni*, becomes active early in the spring at low elevations, but that its seasonal appearance is progressively later at higher elevations."

"An analysis of the case fatality statistics of spotted fever in Utah, derived from the records supplied by the Utah State Health Department, presents some interesting facts. For the nineteen year period, 1934 to 1952, the case fatality has averaged 17.4%. By breaking the nineteen year period into two periods of six years and one of seven years, it was found that the highest fatality mark was during the war years, being 27.77% in the period of 1940 to 1945 as compared with 15.2% in the period 1934 to 1939, and 9.5% in the period 1945 to 1952."

For a year-by-year breakdown on incidence and fatality records from 1915 to and including 1942, refer to Tables 1, 2, and 3. The total number of cases and the case fatality reported to the Rocky Mountain Laboratory from 1915 to 1942 is shown in Table 4. The average fatality rate over this period was 12.14% which is slightly above the post-World War II period and under the 15.2 percentage from 1934 to 1939, but markedly under the World War II percentage of 27.77%.

HOST RELATIONSHIP AND THE DISEASE

Jellison (1945) has the following to say regarding the host reservoirs of the disease agent:

"It has long been suspected that Rocky Mountain spotted fever may have its reservoir in some mammal or mammals that are natural hosts of its tick vectors, i. e., *Dermacentor andersoni* in the western United States, *Dermacentor variabilis* (Say) in the eastern United States, and *Amblyomma americanum* (L) in some of the South Central and Southeastern states. Positive statements regarding such a reservoir and names of specific animals have been published, but convincing evidence has not been presented.

In the same paper from which the above quotation was taken, Jellison shows the close geographical association between Rocky Mountain spotted fever and the distribution of Nuttall's Cottontail in the western United States. Nevertheless, he goes on to say:

"Spotted fever infection has never been recovered from this host or any other mammal in nature in the highly endemic area in the western United States."

Philip and Hughes (1953) in a report to the International Congress of Microbiology report as follows:

"The so-called rabbit dermacentor, *D. parumapertus*, is a frequent parasite on rabbits and hares in the southwestern United States, particularly on the black-tailed jack "rabbit" (hare) in the arid and subarid areas. The distributional records of this hare and tick show a remarkable coincidence."

"During population studies of these hosts, opportunity has been afforded to record for the first time, natural infection in these ticks with three agents of human disease: namely, *Bacterium tularense* of tularemia, a Rocky Mountain spotted fever-like Rickettsia, and the virus of Colorado tick fever. The strains of the first were virulent for laboratory rabbits, and for hares imported from Kansas. The strains of *Rickettsia* were less virulent for guinea pigs than a laboratory passage strain of *R. rickettsi* of human origin and showed certain immunological differences."

"*D. parumapertus*, however, has been shown to be as capable of experimental transmission of virulent spotted fever strains as *D. andersoni*, the customary vector to man in the Rocky Mountain area."

"Even though *D. parumapertus* feeds almost exclusively in most areas of its range on rabbits and hares, the above information is suggestive that this species of tick can act in natural maintenance of the above agents and indirectly in infection of man in appropriate localities."

From the studies made to date, it can only be concluded on circumstantial evidence that there are many natural reservoir hosts for the disease organism.

VECTOR AND DISEASE RELATIONSHIP IN NORTH AMERICA

Kohls (1946) reporting at a symposium on rickettsial diseases of man, has the following to say regarding the vectors of the disease:

"In the United States, Rocky Mountain spotted fever has been reported from all states except Maine, Vermont, Connecticut, Rhode Island, and Michigan. In Canada, it is present in the provinces of British Columbia, Alberta, and Saskatchewan. Within this endemic region, four species of ticks are known to be natural carriers (capable vectors), viz., the Rocky Mountain wood tick, *Dermacentor andersoni;* the American dog tick, *Dermacentor variabilis;* the lone-star tick, *Amblyomma americanum;* and the rabbit tick, *Haemaphysalis leporis-palustris* (Parker, 1938; Philip, 1942). *D. andersoni* is the well-known vector in the Rocky Mountain region and adjacent area. *D. variabilis* is the vector in the Great Plains region and eastward to the Atlantic seacoast. It is also found in California and occasionally in Oregon; it occurs in the southern provinces of Canada from Saskatchewan eastward, and it is found in Mexico. *A. americanum*, the most recent addition to the list of proved carriers (Parker, Kohls, and Steinhaus 1943), occurs in the southcentral and southeastern states, and as far south as Panama. Reports of its occurrence in South America have not been verified. *H. leporis-palustris* occurs throughout the United States, southward into South America, and northward into Canada and Alaska."

"In the category of potential carriers (vectors) in the United States are 5 species which are efficient experimental vectors, any one or more of which may be functioning as natural vectors at the present time. These are the Cayenne tick, *Amblyomma cajennense;* the Pacific Coast tick, *Dermacentor occidentalis;* the rabbit dermacentor, *D. parumapertus;* the brown dog tick, *Rhipicephalus sanguineus*, and *Ornithodoros parkeri*. All of these are known to attack man, the last three only rarely. It seems apparent that *R. sanguineus* bites man more frequently in other parts of the world than in this country. It is not known whether this represents an actual difference in host selection or is merely indicative of a greater opportunity for biting provided by a closer association of man with tick-infested animals, especially the dog."

Ricketts (1907) according to Cooley (1932) accidentally demonstrated experimentally that *Dermacentor albipictus* could be a vector of Rocky Mountain spotted fever. Philip and Kohls (1951) reported a spotted fever case as probably due to *D. albipictus* Packard. The list of vectors in the U. S., therefore, includes a total of ten species, five genera and two families.

The vector itself is apparently not affected by the rickettsia. A tick when once infected, however, remains so permanently and can also transmit the disease organism from generation to generation congenitally, (transovarial). When the human host becomes inoculated by an infected tick, a distinct malaise sets in. The degree of pathogenicity is predetermined in part by the virulence of the strain of rickettsia injected, coupled with the inherent resistance man may present to the disease.

VECTOR AND DISEASE RELATIONSHIP IN UTAH

As far as is known, *D. andersoni* is the only tick in Utah which transmits the disease from man to man or from natural reservoir host to man. *Haemaphysalis leporis-palustris* (Packard), the rabbit tick, is fairly widespread throughout Utah (Fig. 9). It is considered as the most prominent capable vector of the disease among rabbits and thus perpetuates the disease reservoir in nature (?).

The common rabbit dermacentor, *Dermacentor parumapertus*, is widely distributed in the Great Basin portion of Utah (Fig. 8). From experimental evidence, it is considered as a potential vector. It is perhaps the tick most commonly met with at lower elevations in the southern part of Utah as well as the western half of the State. *Rhipicephalus sanguineus* (Latreille) the brown dog tick, has been reported from Utah only twice (Edmunds 1951). Davis (1943) by experimental testing showed *Ornithodoros parkeri* Cooley to be a "potential" vector of Rocky Mountain spotted fever. Collections as reported in the literature and from our surveys show scattered distribution for this species in Utah.

Generally speaking, the adult tick of *D. andersoni* and *D. parumapertus*, live on mammals the size of the jack rabbit, and larger when feeding. *D. parumapertus* as adults are somewhat restricted to *L. californicus* as the principal host. The immature stages of both *D. andersoni* and *D. parumapertus*, however, are consortes of smaller animals (Figs. 2 and 5).

LIFE HISTORY AND NOTES ON SEASONAL VARIATION

D. andersoni

The life history of this species of tick has been carefully studied at the Rocky Mountain Laboratory in Hamilton, Montana. However, most of the data derived have been from results of studies made under natural conditions as well as under controlled laboratory conditions at that geographic area. Kohls (1937) describes in some detail tick rearing methods for *D. andersoni*. No complete life history study has been made of *D. andersoni* or any other species of tick under Utah conditions. Some very elementary observations have been made in our studies, however, which, it is felt, should be reported upon. Before referring to these observations, a few general statements would be in order regarding the life history of the Rocky Mountain wood tick, *D. andersoni*.

Generally speaking, the life history stages of *D. andersoni* are as follows: The adult engorged female lays several thousand eggs following her emergence from hibernation in early spring of March and April. The female dies upon completion of egg laying. The eggs hatch as larvae which possess six legs. They attach themselves to the smaller rodents if the latter are present in the vicinity (Fig. 5 and Table 6). After four to seven days' engorgement on the host, the larvae drop off and undergo a molt, emerging as nymphs in late summer. The nymphs then usually hibernate over the winter in that stage. The following spring, the nymphs emerge from hibernation, attach themselves to a large, warm-blooded animal, engorge themselves, drop from the host, molt again, emerge as adults and start the cycle over again. These adults are the ones which become active the following spring. A minimum of two year's time is required to complete the cycle, and three hosts are involved.

Coffey (1953) in making some studies on seasonal variations with respect to populations of *D. andersoni* and *D. parumapertus* at widely separated locations in the northern part of the Great Basin area in Utah, has the following to say:

> "*D. andersoni* first becomes active in the spring of the year at lower elevations, remaining in hibernation at the higher elevations until later in the season."

Coffey's observations, as well as those by the writer, indicate that the appearance of the adults in the springtime is in part regulated by the current climatic conditions and altitude. The earliest record of an adult *D. andersoni* tick being taken in Utah is one collected by the author on March 2, 1954. This tick was removed from a young boy who had been hiking in the foothills near Provo, Utah. The weather

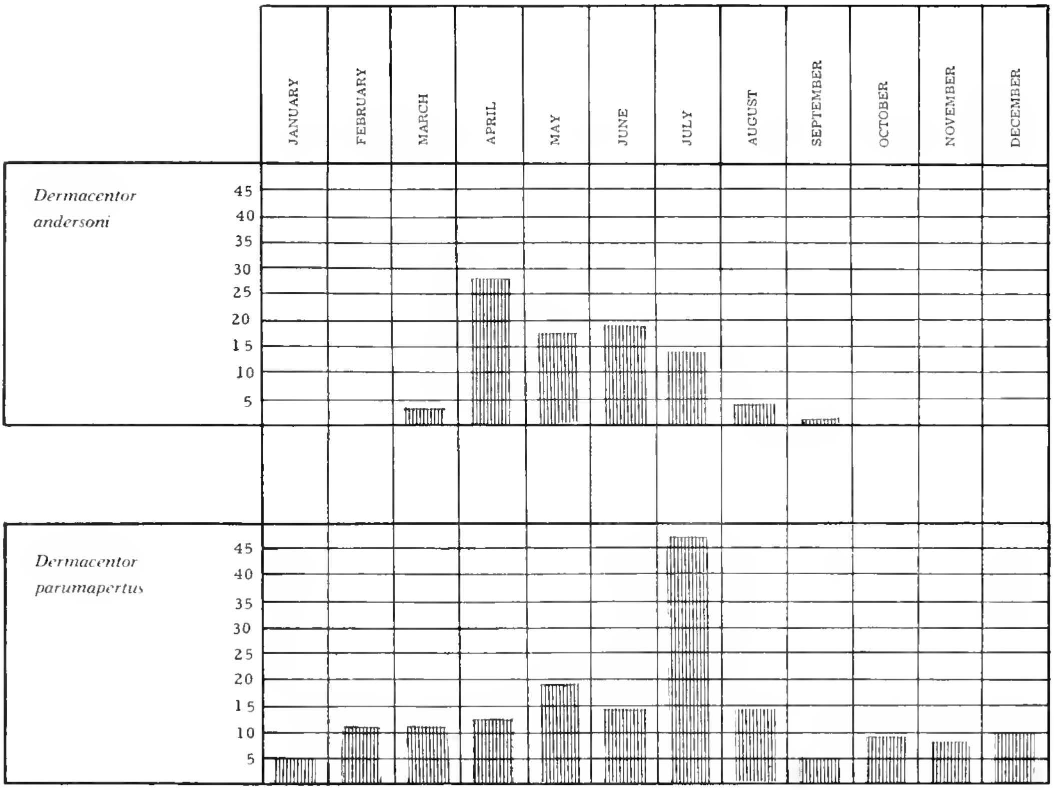

Fig. 1 Seasonal population variations for adult *D. andersoni* and *D. parumapertus*.

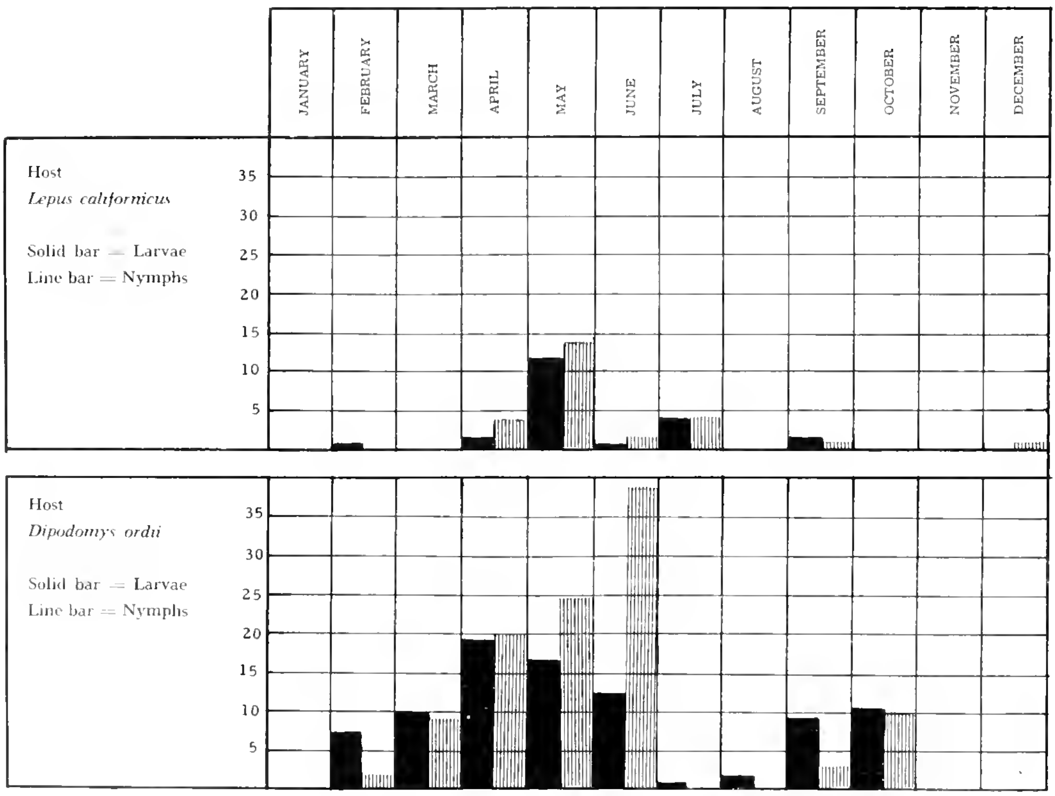

Fig. 2 Collection records for larvae and nymphs from specific hosts. The hosts are so located as to insure that the ticks are *D. parumapertus*.

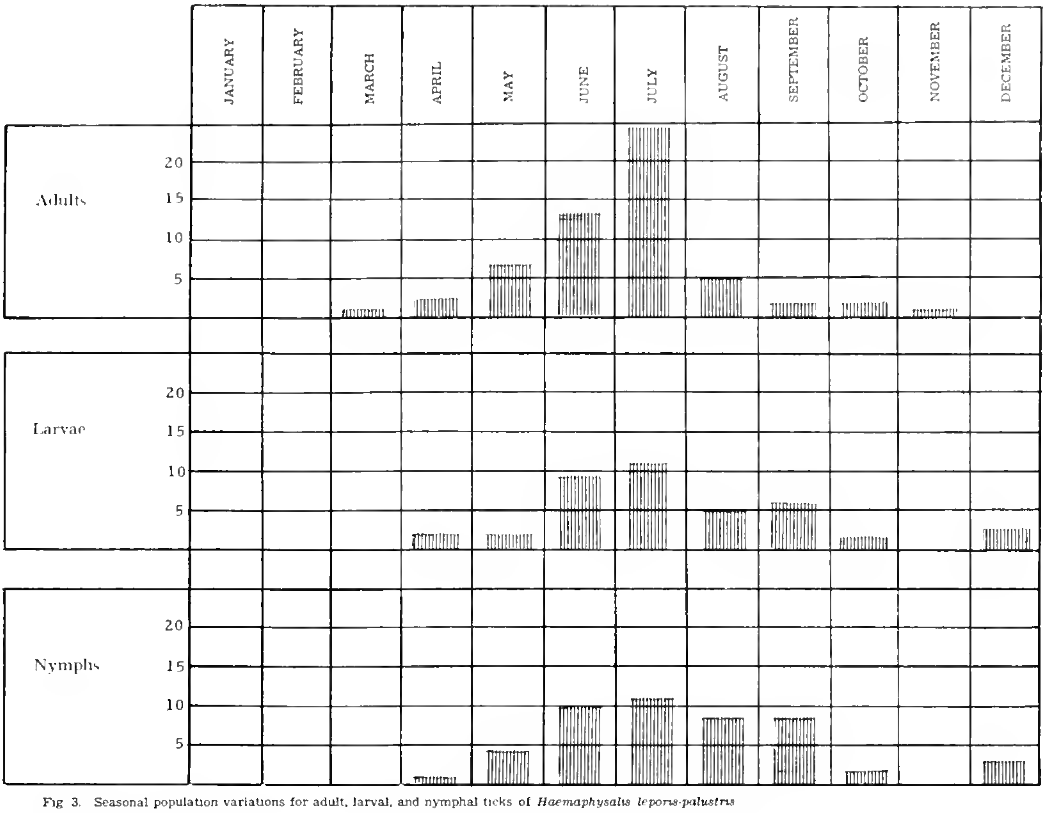

Fig 3. Seasonal population variations for adult, larval, and nymphal ticks of *Haemaphysalis leporis-palustris*

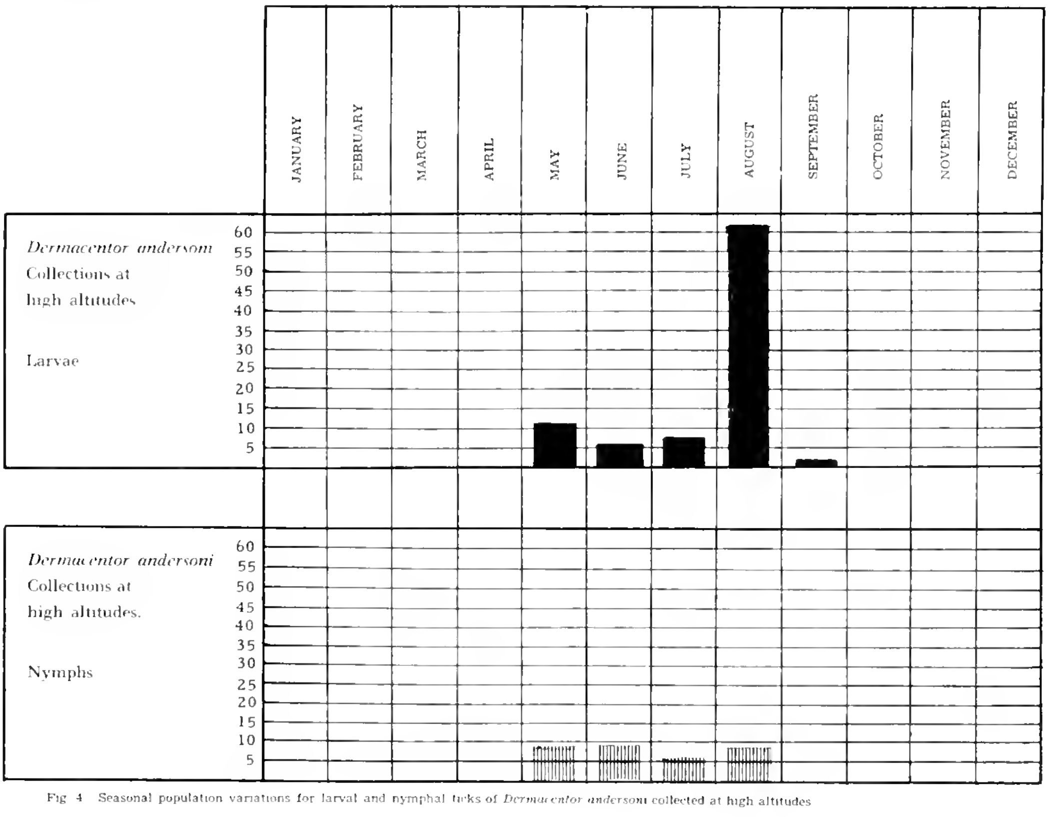

Fig 4. Seasonal population variations for larval and nymphal ticks of *Dermacentor andersoni* collected at high altitudes

had been extremely balmy for a few days. This was followed by a snow storm and a very cool period for several weeks, in which no ticks were found. Following the cold spell, another very warm period occurred and the ticks were active again. On April 10, eighty-three ticks were taken from a student engaged in geological survey work at the south end of Cedar Valley near Eureka, Juab County, Utah. On the 17th of April, 1954, three other student geologists from the Brigham Young University removed 40, 23, and 12 ticks, respectively, from their bodies following the day's work in the same area, and all ticks were adults of *D. andersoni.*

From collection records and reports from literature, it appears that the peak activity of adult populations for most of the range of *D. andersoni* in Utah is later than that determined for Idaho and Montana. It is reached about the last week in April and the first week in May, depending on weather conditions and elevation (Fig. 1). During the late spring, summer and fall *D. andersoni* begin to taper off in numbers at the lower elevations but still can be found at higher elevations. The most consistent host on which this species of tick can be expected to be found in the late months of the year. (August, September, and October) is the Porcupine *Erethizon dorsatum.*

A few rearing experiments were carried out with nymphal stages of *Dermacentor* sp. They were allowed to engorge themselves on guinea pigs until they were ready to molt. In all cases except one the nymphs emerged as adult *D. parumapertus.* The exception was a *D. andersoni.* It was one of two nymphs taken from a jack rabbit, *L. californicus*, in Cedar Valley, Utah County, Utah, in July.

From data at hand it seems safe to say that the majority of *Dermacentor* in all stages of development found at the lower elevations in the Great Basin region (desert valley and basins) in Utah, would be *D. parumapertus.*

Very few immature ticks of *D. andersoni* have been collected at the lower foothill elevations or mountainous areas during the peroid of this survey. This is the level where it might be expected that *D. andersoni* would be located. There are records from our survey which, though isolated, do give definite evidence that both species (*D. andersoni* and *D. parumapertus*q overlap in their distribution (Table 5).

The immature *Dermacentor* ticks found at high altitudes would most likely be *D. andersoni.* An examination of these collections of immature ticks obtained by our survey indicates a close correlation in activity but a wide variation in total numbers of specimens collected. Immature stages are in evidence from May until September (Fig. 4).

D. PARUMAPERTUS[2]

With respect to life history notes and seasonal variations for this species, I will quote from Coffey's (1953, op. cit., p. 61) records on *Dermacentor* sp. He established two stations in the Great Basin area of Utah. One station was at a broad, low-lying desert valley between two mountain ranges known as Cedar Valley in Utah County. The other was at Lucin in Box Elder County at the western edge of the Great Salt Lake Desert in northwestern Utah:

> "In view of the fact that adults of *D. andersoni* have not been taken in the Lucin study and that all of the rearing yielded only one specimen of *D. andersoni*, it seems probable to conclude that the immature *Dermacentor* sp. in these studies (Lucin and Cedar Valley) are in the majority *D. parumapertus.* In the early spring larvae and nymphs are abundant."
>
> "If these ticks are *D. parumapertus* an interesting problem is presented, namely, no engorged females of *D. parumapertus* were found during the winter months which would be necessary unless the larvae hibernate over winter. An interesting problem in its own right would be the rearing of all the immature stages of *Dermacentor* collected in an area such as Cedar Valley."
>
> "Another intriguing problem regarding these ticks is brought to one's attention by a statement in the literature. Bishopp and Trembley (1945) say that the immature forms of *D. parumapertus* are usually found in the cooler months of the year, from September to May. The data gathered in this study does not show this seasonal pattern. Rather, it is nearly the opposite. Of course, as previously pointed out, one cannot be certain that these immature forms are all *D. parumapertus.* Regardless of this, the fact remains that no immature forms of *Dermacentor* were found in this study in the winter months."

In direct contrast with the absence of collections for adult *D. andersoni* during the winter months in Utah, *D. parumapertus* adults have been collected every month of the year

2 The immature stages of *D. andersoni* and *D. parumapertus* are extremely difficult to separate taxonomically. The only reliable method of determination is to rear them through to adulthood and then classification can be done more accurately.

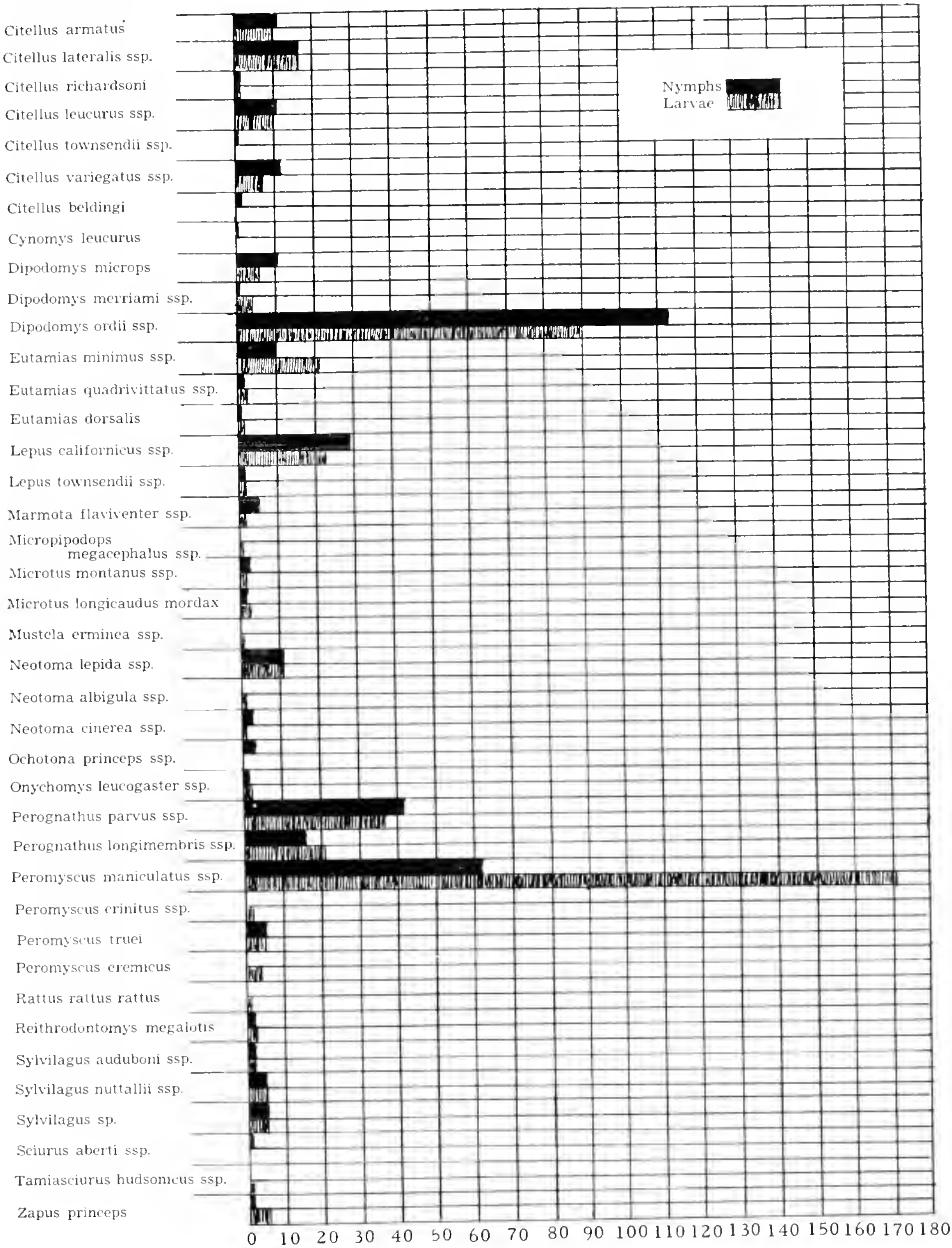

Fig. 5. Comparative numbers of larval and nymphal tick collections of *Dermacentor* sp., removed from various species of hosts over a five year period in Utah. The total number represents in each case the collections made in the five year period and not the total number of ticks collected.

(Fig. 1). The predominant months of activity as adults, however, are from March through September from collection records made by this survey. Immature stages have been observed as having peak activity from March through June. This has been found to be the case for nymphs and larvae collected from hosts in geographic areas mentioned above where it can be assumed that the ticks are *D. parumapertus* (Fig. 2). Figure 6 shows this seasonal variation in the activity of larvae and nymphs as found at the two widely separated geographical locations of Lucin and Chimney Rock Pass—Cedar Valley areas in the Great Basin region.

The collections at Lucin were made in February, May, June and October. At the Cedar Valley-Chimney Rock Pass station collections were made on a monthly basis. An analysis of data from the Chimney Rock Pass-Cedar Valley collections reveals a great abundance of larvae as compared to nymphs for March and April. There were 811 larvae and 103 nymphs removed from 38 hosts during March. In April there were 915 larvae and 59 nymphs removed from 30 hosts. In May the ratio begins to reverse itself for both the Lucin and the Cedar Valley-Chimney Rock Pass collections. In May at Lucin there were 496 larvae and 674 nymphs removed from 54 hosts. At Chimney Rock Pass-Cedar Valley 29 larvae and 436 nymphs were collected from 15 hosts. For the month of June at Lucin, 61 nymphs and the complete absence of larvae were noted on 23 hosts while at Chimney Rock Pass-Cedar Valley 44 nymphs and only 6 larvae were found on 10 hosts for the same month. An unexplained increase in larvae over nymphs for August through October was found in the Cedar Valley-Chimney Rock Pass collections. This was likewise the condition however for the Lucin collections. In October there were 67 larvae and 49 nymphs taken from 15 hosts, while at the Chimney Rock Pass-Cedar Valley area, 50 larvae and the complete absence of nymphs was found to be the result of the examination of 4 host mammals (Fig. 6).

A careful, complete life history of this species under Utah conditions is needed in order to more accurately determine population trends on a seasonal basis.

HAEMAPHYSALIS LEPORIS-PALUSTRIS

The egg-laying activity of this species over most of the State of Utah follows somewhat the same pattern as *D. andersoni*. However, the immature stages are in evidence much longer than *D. andersoni*. Data gathered on this survey agree closely with reference on life history habits as reported in the literature (Fig. 3). As the distributional range is extended southward, the various stages in the life history of this widely spread tick becomes modified. For example, there are both nymphal and adult populations in evidence during winter in the southwestern corner of Utah, which is in the southern desert shrub community and possesses a mild winter climate. On December 21, 1950, sixty nymphs and 121 adults were removed from the cottontail, *Sylvilagus auduboni*, at Beaver Dam Wash, Washington County, Utah. The latest date for a nympal collection in the northern (northern desert shrub community) part of the State has been September 30, 1949. One nymph was removed from a *Lepus californicus* and one from *Sylvilagus nutallii* at Heber, Wasatch County, on that date. It is interesting to note that our survey records for the months of January and February show no reference to specimens of *H. leporis-palustris* of any age having been collected. Edmunds' (1951), op. cit., p. 25-26) references to collection dates all show summer collections. Apparently, this tick does not have a very extensive winter activity in the northern or colder parts of Utah.

ORNITHODOROS PARKERI and DERMACENTOR ALBIPICTUS

The collection records for these species have not been sufficiently numerous to give significant life history data.

VECTOR HOST ASSOCIATION AND DISTRIBUTION

D. ANDERSONI:

Information obtained from the literature and the data resulting from this survey show that this tick does not demonstrate any marked host specificity, either as immature or adult organisms. Very few larvae or nymphs of what could be occurately identified as this species are listed for this survey. It will be recalled that the larvae and nymphs of this species are very difficult to accurately separate taxonomically from the rabbit tick (*D. parumapertus*). With but one exception, at no time during the period of this survey was an adult tick removed from a host smaller than the Snow Shoe rabbit *Lepus americanus*. The one exception was the collection of an adult male on a *Peromyscus maniculatus* at Aspen Grove, Mt. Timpanogos, Utah County, Utah. Most of our adult tick collection records are from man. The next most common

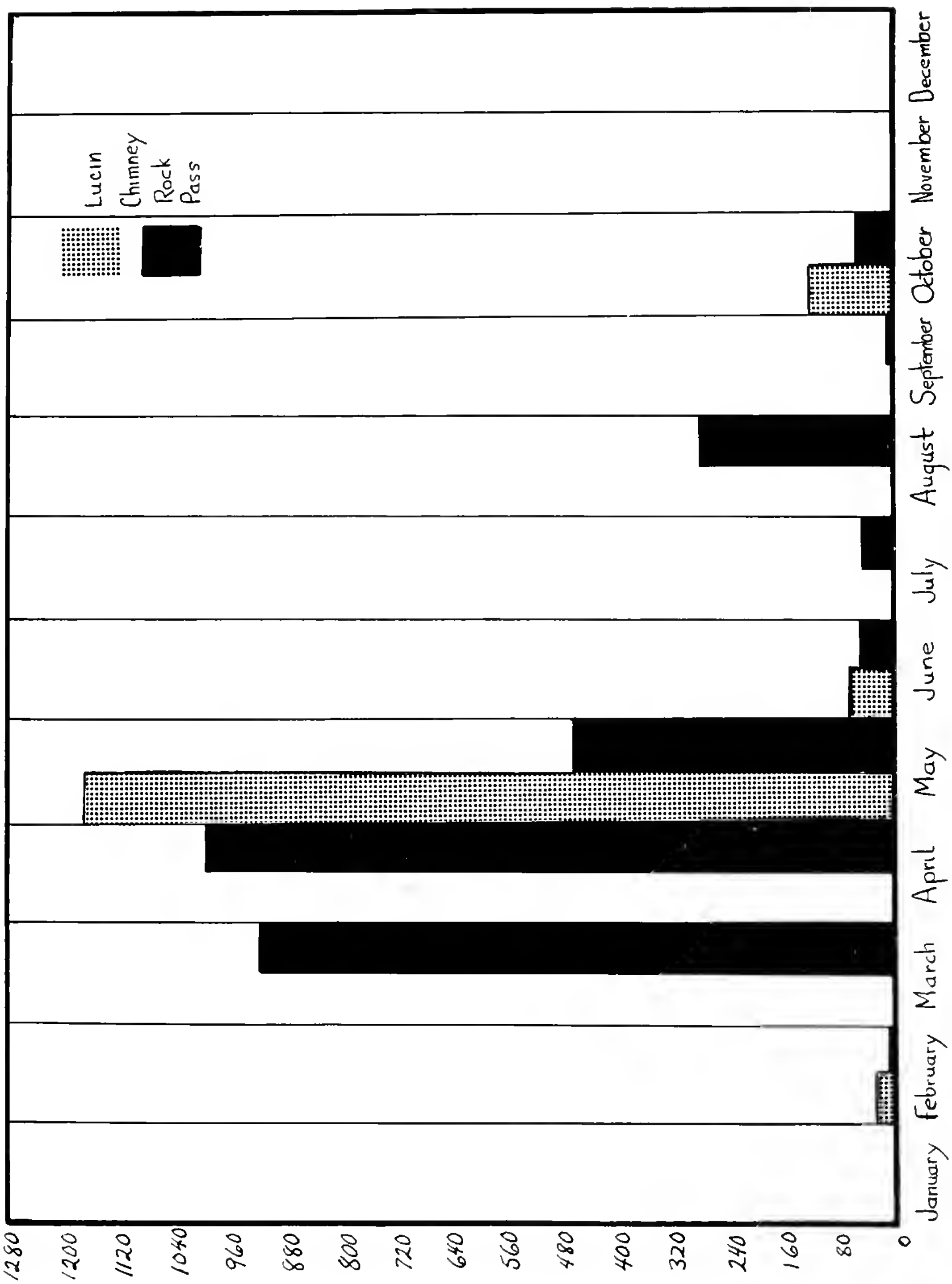

Fig. 6. Seasonal population variation of larvae and nymphs at Lucin and Cedar Valley in the Great Basin region. The Chimney Rock Pass collections from Cedar Valley were made on a monthly schedule. The Lucin collections were made in February, May, June and October.

vector-host was the porcupine *E. dorsatum*. This was followed by the jack rabbit, (*L. californicus*), mule deer (*Odocoilus hemionus*) and the domestic sheep. Other collections are from the bob cat and skunk.

Many specimens of nymphal and larval stages of *Dermacentor* have been collected (Fig. 5). For reasons mentioned previously, these specimens were not given "specific" status and have been here listed as *Dermacentor* sp. Nevertheless, there are sufficient data at hand to indicate that larvae and nymphs of the genus *Dermacentor* collected at higher altitude locations (montane) would most likely be *D. andersoni*. Those immature stages at lower elevations (desert) would probably be *D. parumapertus* (Table 5 and Fig 6).

Those specimens collected at the foothill areas (the ecotonal situation between the montane and valley or desert shrub communities) could be either one of the two species. In this study a single male adult *D. parumapertus* was collected at Aspen Grove, on Mt. Timpanogos in Utah County, May 23, 1951: host, *Peromyscus maniculatus*. The approximate elevation at the place of collection was 7,000 feet. Likewise, in July, 1952, one of two nymphs collected from *Lepus californicus* in Cedar Valley, Utah County, Utah, was reared through to adulthood and proved to be *D. andersoni*. The elevation in the valley where the collection was made is about 4,800 feet.

The most specific host-vector association with regard to nymphal and larval collections of this survey for *Dermacentor* sp. is shown in Table 5.

Space does not permit an extended listing for each collection record made throughout the State during this survey. Distribution by county, however, has been prepared in table form for *D. andersoni* and other ticks implicated with oRcky Mountain spotted fever (Table 6).

Figures 7 illustrates the distributional pattern in the state for the adult of this species. This distributional pattern is derived from both published records and collection records obtained by this survey.

Dermacentor parumapertus

Whereas *D. andersoni* adults show a wide range of host selections, *D. parumapertus* adults are more restricted. *Lepus californicus* is by and large the predominant host animal for adult *D. parumapertus*. Other hosts on which they have been collected during this survey are *Dipodomys ordii*, *Perognathus parvus*, *Sylvilagus nuttallii*, *Peromyscus maniculatus* and *Lepus townsendii*.

The only reliable system for species identifiction of immature stages where *D. parumapertus* and *D. andersoni* are concerned is to rear these stages on through to adulthood. From the few rearing experiments conducted in this project there is sufficient evidence to support the theory that *D. parumapertus* is predominantly a desert inhabiting form.

If such is the case, and it seems to be apparent, then the immature ticks of *D. parumapertus* are found on a variety of hosts (Table 5). Table 6 shows the distribution by county for the adult forms of this species. Figure 8 shows the distributional pattern for adults within the State. This figure includes data from both the records in literature as well as from collections made by this survey.

Haemaphysalis leporis-palustris

This species of tick in Utah has been collected most often on the various species of the family Leporidae (rabbits). The species of rabbits are as follows: *Sylvilagus auduboni*, *Sylvilagus nuttallii*, *Sylvilagus idahoensis*, *Lepus californicus*, *Lepus townsendii*. Other hosts with which the tick was less commonly associated are the pack rat (*Neotoma cinerea*), the ground squirrel (*Citellus variegatus*), and the green tailed towhee (*Oberholseria chlorura*).

It is interesting to note that Green, Evans and Larson (1943) found that snowshoe hares were the preferred hosts in Minnesota and even ruffed grouse were more important hosts than cottontails. In our surveys no ticks of this species have been taken from the aspen or coniferious belts where the rabbits *Lepus americanus* and *Lepus townsendii* have been collected. Generally speaking it may be concluded from our surveys that this species of tick is found commonly in desert situations or under desert-like conditions at higher elevations where the predominant plant growth is sage, greasewood and rabbit brush (Fig. 9) .

Dermacentor albipictus

This tick has been reported from the deer (*Odocoileus hemionus* Rafinesque), the antelope (*Antilocapra americana* Ord), and the horse (Edmunds loc. cit., p. 25). The only collections taken by this survey were from elk (*Cervus canadensis* Allen) in Cache County.

Ornithodoros parkeri

Several sample collections have been taken from burrows of the prairie dog of the genus

MONTANE (high altitudes)	ECOTONAL (foothill)	DESERT (low altitudes)
Vector:	Vector:	Vector:
D. andersoni	*D. andersoni* or *D. parumapertus*	*D. parumapertus*
Host:	Host:	Host:
Lepus townsendii	*Sylvilagus nuttallii*	*Lepus californicus*
Ochotona princeps	*Sylvilagus auduboni*	*Sylvilagus auduboni*
Peromyscus maniculatus	*Peromyscus maniculatus*	*Sylvilagus nuttallii*
Zapus princeps	*Peromyscus truei*	*Peromyscus maniculatus*
Citellus lateralis	*Peromyscus crinitus*	*Peromyscus eremicus*
Citellus armatus	*Rattus norvegicus*	*Reithrodontomys megalotis*
Sciurus aberti	*Neotoma cinerea*	*Rattus norvegicus*
Neotoma cinerea	*Eutamias minimus*	*Peromyscus crinitus*
Marmota flaviventer	*Eutamias dorsalis*	*Perognathus parvus*
Mustela erminea	*Eutamias quadrivittatus*	*Perognathus longimembris*
Erethizon dorsatum	*Citellus variegatus*	*Perognathus formosus*
Microtus longicaudus	*Thomomys bottae*	*Dipodomys microps*
	Oberholseria chlorura	*Dipodomys ordii*
	(Bird host)	*Dipodomys deserti*
		Dipodomys merriami
		Onychomys leucogaste
		Microdipodops sp.
		Citellus variegatus
		Citellus leucurus
		Cynomys leucurus
		Eutamias minimus
		Eutamias dorsalis
		Neotoma lepida
		Thomomys bottae

Table 5. Vector-host relationships for *D. andersoni* and *D. parumapertus* with reference to collections made at low and high altitudes.

	CAPABLE VECTORS	Dermacentor andersoni	Haemaphysalis leporis-palustris	POTENTIAL VECTORS	Dermacentor parumapertus	Rhipicephalus sanguineus	Ornithodoros parkeri	Dermacentor albipictus	DERMACENTOR Sp.	High Elevations	Intermediate Zone (Foothills)	Low Elevations
Beaver		X	X		X						X	
Box Elder		X	X		X						X	X
Cache		X	X				X	X		X	X	
Carbon							X				X	
Daggett		X	X				X	X		X	X	
Davis		X										
Duchesne		X	X							X	X	X
Emery		X	X				X			X	X	X
Garfield		X	X							X	X	
Grand		X	X				X			X	X	X
Iron		X	X		X		X			X	X	X
Juab		X	X		X						X	X
Kane		X	X		X					X	X	X
Millard		X	X		X						X	X
Morgan		X									X	
Piute		X	X							X	X	
Rich		X								X	X	
Sanpete		X	X		X			X		X	X	X
Salt Lake		X	X		X						X	X
San Juan		X	X		X						X	
Sevier		X	X		X					X	X	
Summit		X	X								X	
Tooele		X	X		X						X	X
Uintah		X	X				X	X		X	X	X
Utah		X	X		X					X	X	X
Wasatch		X	X		X					X	X	
Washington		X	X		X		X			X	X	X
Wayne		X					X			X	X	
Weber		X			X							

Table 6. Distribution by county of capable andpotential vectors of Rocky Mountain spotted fever in Utah.

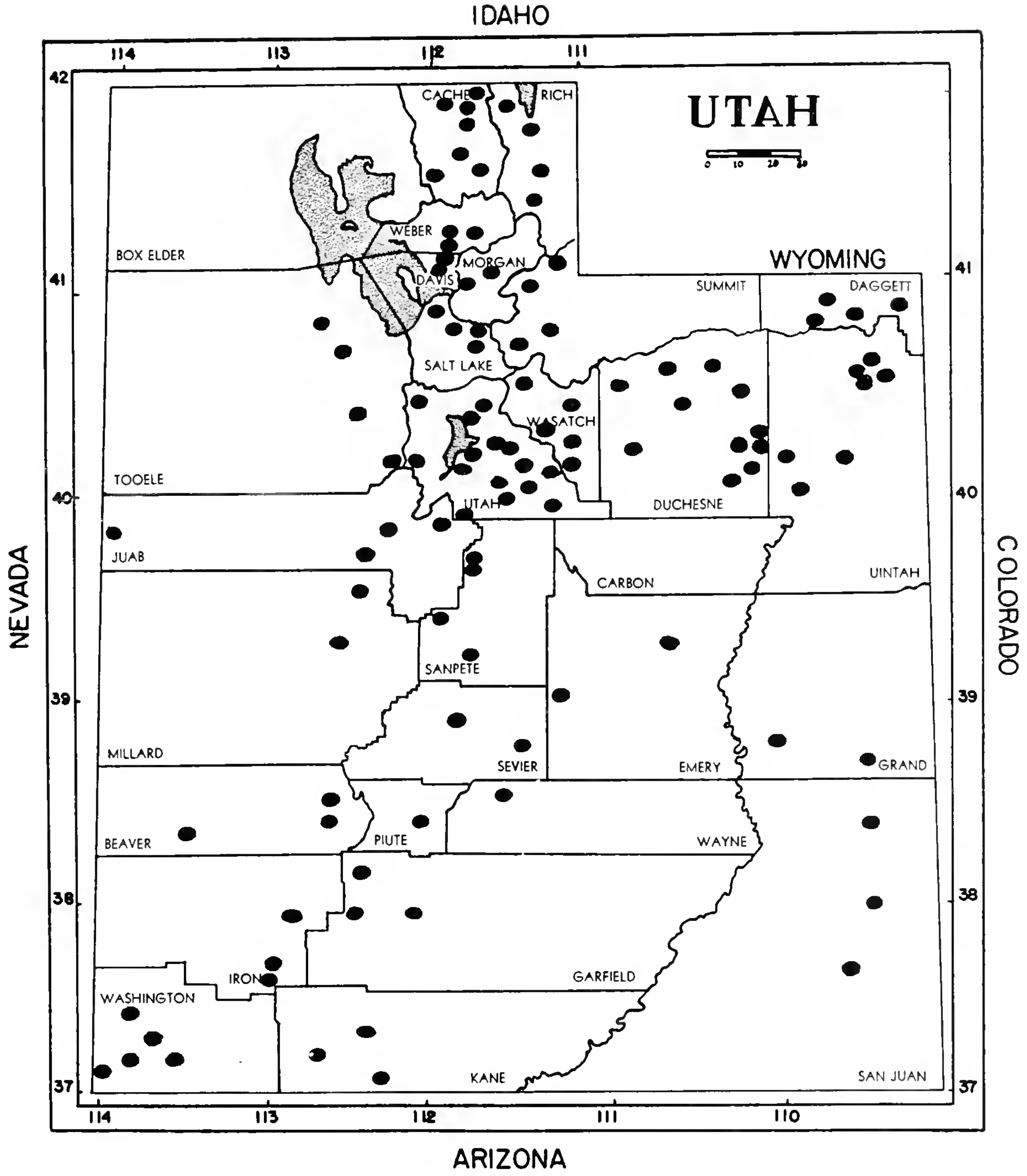

Fig. 7. Distributional pattern for collections of *Dermacentor andersoni* in Utah. Each dot on the map represents a single collection and does not indicate the numbers of specimens taken in each collection.

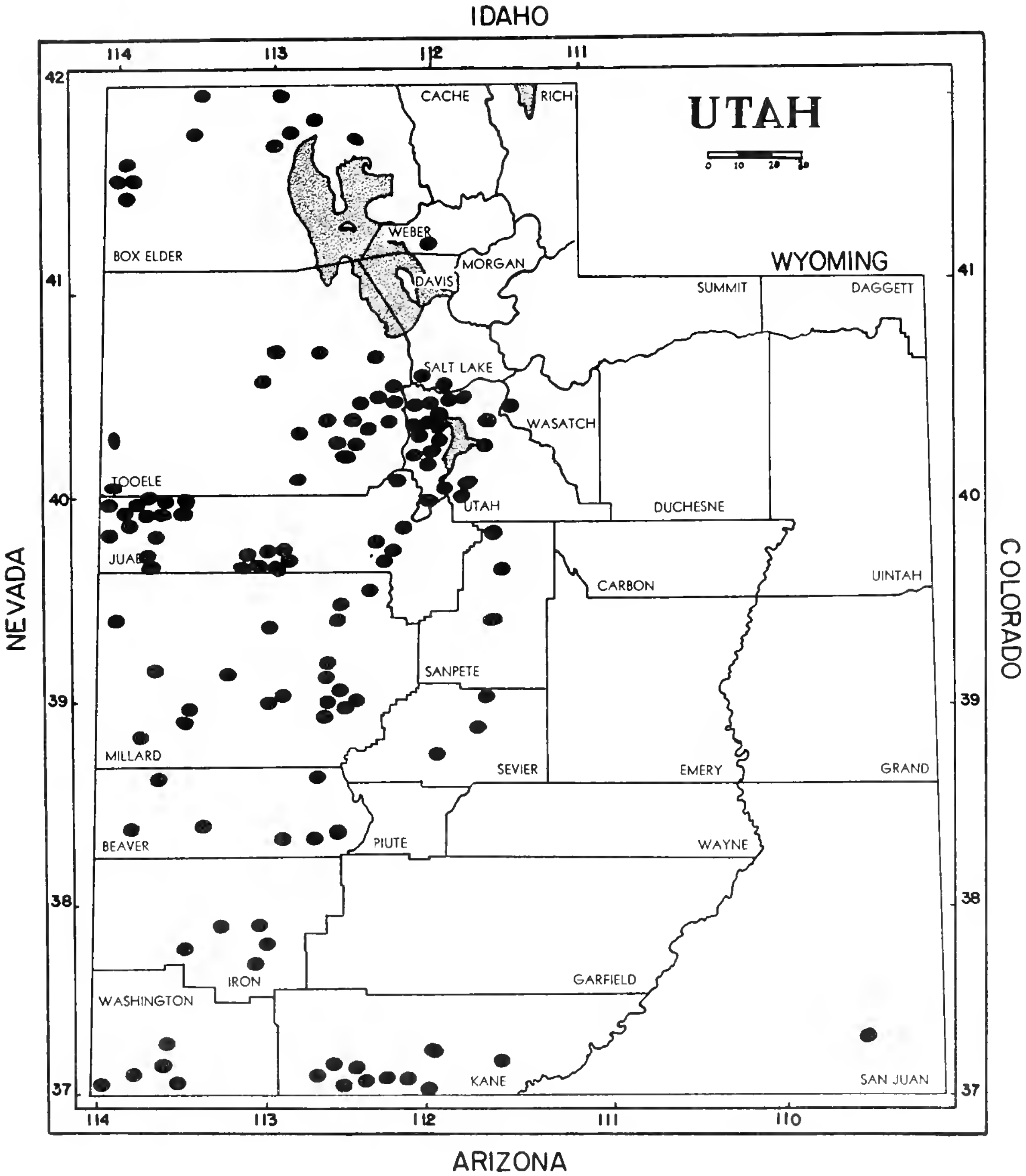

Fig. 8. Distributional pattern for collections of *Dermacentor parumapertus* in Utah. Each dot represents a collection record and does not indicate the numbers of specimens taken in a single collection.

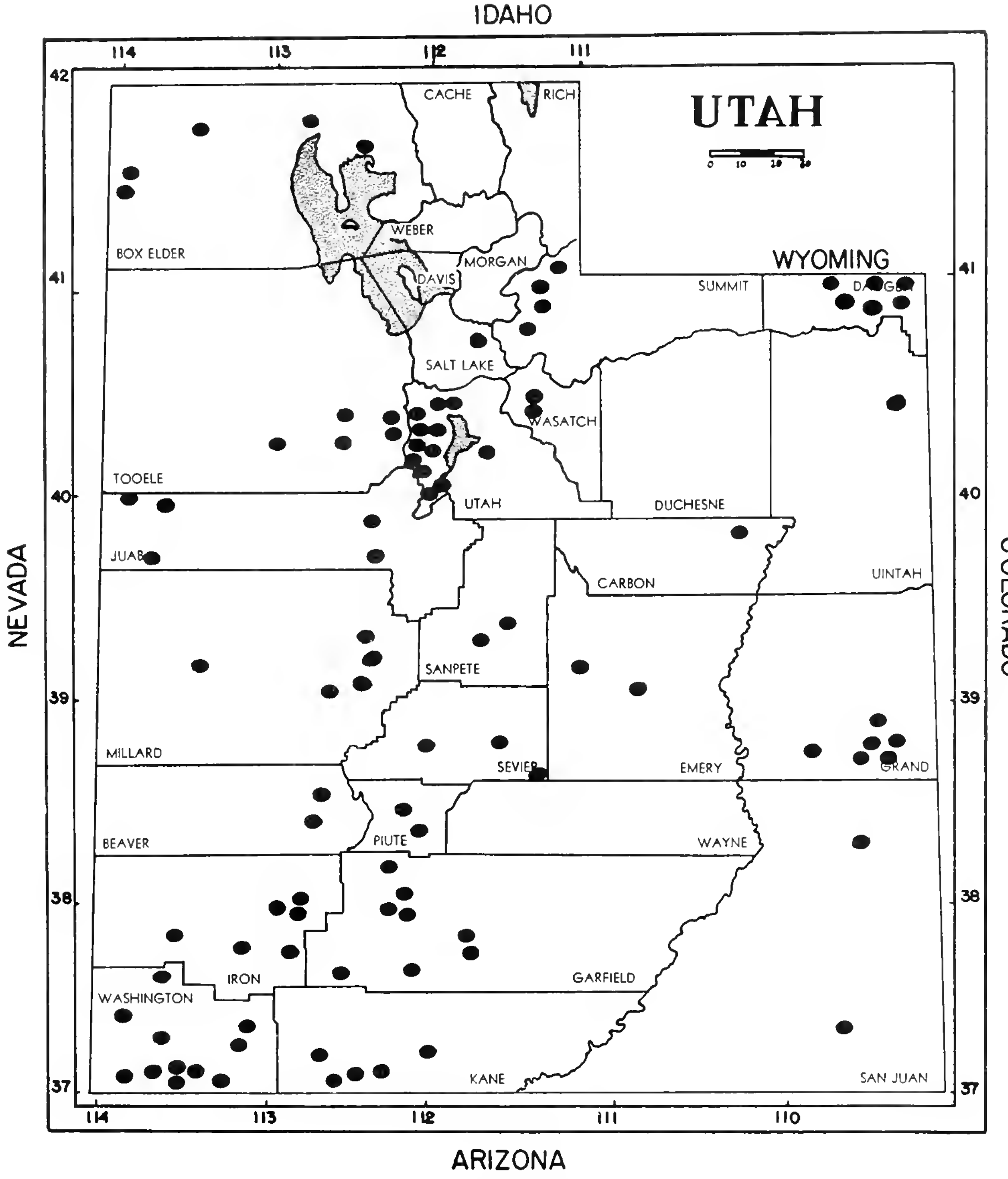

Fig. 9. Distributional pattern **for** collections of *Haemaphysalis leporis-palustris* in Utah. Each dot represents a single collection record and does not indicate the number of specimens collected.

Cynomys. Not all colonies (prairie dog towns) produced these soft-bodied ticks when collections were made. Nevertheless, it is presumed that most of the active "dog" towns will provide ticks when carefully examined at the appropriate season.

SUMMARY AND CONCLUSIONS

Although some data have been gathered in Utah on vectors of Rocky Mountain spotted fever, no state-wide surveys have been conducted. In the present study special attention has been directed to geographic distribution of both vectors and host, vector-host relationships, and seasonal variation in populations of vectors throughout the State. Some data have been gathered on the life history of the vectors, and a brief discussion of the historical aspect of the disease, its incidence in Utah and elsewhere is also given.

Geographic distribution

Of the four capable vectors listed as present in the United States, *Dermacentor andersoni* and *Haemaphysalis leporis - palustris* are found in Utah. Listed for Utah as potential (experimental) vectors are *Dermacentor parumapertus*, *Dermacentor albipictus*, *Rhipicephalis sanguineus* and *Ornithodoros parkeri*. Of the potential vectors *D. parumapertus* is the only species having extensive distribution in Utah.

Dermacentor andersoni has a wide geographic distribution but is generally restricted in altitude to foothills and mountainous areas. When found on hosts in lowlands and desert areas it is possible that the host migrated from a higher altitude to a lower level.

Haemaphysalis leporis - palustris has a state-wide pattern of distribution. It is more common at lower altitudes in basins, valleys and desert-like conditions whether flatland or canyon. This may be due in part to certain preferred hosts, members of the family *Leporidae* being more abundantly distributed at lower elevations.

The geographic distribution of *Dermacentor parumapertus* in Utah is in the main relegated to the Great Basin area. It invades to a limited extent the southernmost part of the Colorado River drainage basin just north of the Utah-Arizona boundary.

Dermacentor albipictus and *Ornithodoros parkeri* apparently are localized in distribution. *Rhipicephalis sanguineus* collections seem to indicate an accidental occurrence of this species in Utah.

Adults of *D. parumapertus* have been taken at all seasons of the year in Utah. No engorged famales, however, have been taken during the winter months. Nevertheless, larvae begin to appear in early February. Both larvae and nymphs are active from February through October with peak activity occurring during May and June. Peak activity for adults is during the month of July.

Collection in Utah of *Dermacentor albipictus* and *Ornithodoros parkeri* are too scanty to be significant, yet our data seem to agree with information obtained from other areas.

Disease and Disease-Vector Relationship

There are sufficient data to indicate that Rocky Mountain spotted fever is indigenous to Utah. The disease was first identified as such in 1905 in Utah, and has since that time been found in every country of the State. From 1915-1942 there were recorded 313 cases with 38 deaths, approximately 12.14% mortality. From data compiled by The Utah State Department of Health in 1934-1952, the average number of cases per year was 12.3%. The fatality rate has averaged 17.4%.

With regard to vector transmission *D. andersoni* is the only tick of consequence in Utah which bites man and can transmit the disease. An abundance of data indicate that other species of ticks are involved in the transmission of the disease among animals and man and thus maintain a disease reservoir in nature. However it should be emphasized as described by Jellison: "Positive statements regarding such a reservoir and names of specific animals have been published, but convincing evidence has not been presented."

HOST RELATIONSHIP

Dermacentor andersoni adults are mainly found on the larger vertebrate hosts, indicating no special host preference. *Lepus californicus*, the black tailed jack rabbit would represent the lower limit in the smaller sized vertebrates. The immature stages of this tick (larvae and nymphs) likewise show no particular host prefernce, being found on a variety of small vertebrate mammals, primarily of the order Rodentia.

The *Haemaphysalis leporis - palustris* ticks have been collected most often on the various species of the family Leporidae. It has been less commonly found on such animals as *Neotoma cinerea*, *Citellus variegatus*, and the green tailed towhee (*Oberholseria chlorura*).

The adults of the potential vector, *Dermacenter parumapertus*, are somewhat restricted in host relationships. *Lepus californicus* is the predominant host animal, in fact the distributional pattern for the tick is almost identical with that of the rabbit. Other hosts on which the adults have been collected are *Dipodomys ordii*, *Perognathus parvus*, *Sylvilagus nuttallii*, *Peromyscus maniculatus*, and *Lepus townsendii*. The immature stages (larvae and nymphs) of this tick species are found on a wide variety of small mammals, primarily of the order Rodentia.

Dermacentor albipictus has been collected from the deer (*Odocoileus hemionus*), antelope (*Antilocarpa americana*), the domestic horse, and the elk, (*Cervus canadensis*).

Ornithodoros parkeri seems to be associated with the various species of the genus *Cynomys*, the prairie dogs. However, examination of some "dog towns" failed to reveal specimens of this vector.

Regarding the immature specimens of *D. andersoni* and *D. parumapertus*, it is practically impossible to accurately classify them to species. Their morphology and anatomy are almost identical. Rearing techniques need to be employed to obtain adults from immature stages in order to accurately identify a vector species.

LIFE HISTORY AND SEASONAL VARIATIONS IN POPULATIONS

A minimum of two years' time is required to complete the life cycle of *D. andersoni*, and three hosts are involved. The earliest record for adult emergence in Utah is March 2, 1954, and adult specimens have been collected as late as October. Emergence of adults, however, occurs progressively later as increase in elevation is encountered. Peak activity is in April and May depending on climatic conditions and elevation. No adult specimens have been collected from November through February.

The egg lying activities of *Haemaphysalis leporis - palustris* is similar to that of *D. andersoni*. This tick seems to be active much longer seasonally in the warmer parts of the state. No specimens, however, have been collected in any part of the State during the months of January and February. In midsummer the tick is most active in all stages of growth. July is the month of peak activity.

LITERATURE CITED

Anderson, J. F., 1903. Spotted fever (Tick fever) of the Rocky Mountains: A new disease. Public Health and Marine Hospital Service of the United States Hygienic Laboratory Bulletin No. 14.

Anigstein, Ludwik, 1944. Recent developments in the problem of spotted fever. Texas State Journal of Medicine 40: 199-202.

Badger, L. F., 1932. Rocky Mountain spotted fever (Eastern type). Virus recovered from the dog tick *Dermacentor variabilis*, found in nature. Public Health Reports 47(53): 2365-2369.

Banks, Nathan, 1908. A revision of the Ixodoidea, or ticks of the United States. U. S. Department of Agriculture, Bureau of Entomology, Technical Series No. 15.

Beck, D E.; Barnum, A. H. and Moore, L., 1953. Arthropod consortes in the nests of *Neotoma cinerea acraia* (Ord) and *Neotoma lepida lepida* Thomas. Proceedings of the Utah Academy of Sciences, Arts and Letters 30: 43-52.

Bequaert, Joseph C., 1945. The ticks or Ixodoidea of the northeastern United States and Eastern Canada. Entomologica Americana 25: 73-232.

Bishopp, F. C., 1911. The distribution of the Rocky Mountain spotted fever ticks. U. S. Department of Agriculture Bureau of Entomology Circular No. 136.

——, 1933. Ticks and the role they play in the transmission of diseases. Smithsonian Institution Annual Report 289-406.

——, 1936. Rocky Mountain spotted fever ticks. Insect Pests Survey Bulletin U. S. Department of Agriculture 16 (10): 534.

——; Smith, C. N., 1936. American Dog tick (*Dermacentor variabilis* Say). Insect Pest Survey Bulletin U. S. Department of Agriculture 16 (5): 210.

—— and Trembly, Helen L., 1945. Distribution and hosts of certain North American ticks. Journal of Parasitology 31 (1): 1-54.

Brown, J. H., 1945. The rabbit tick, *Haemaphysalis leporis-palustris* Packard, as an ectoparasite of man. Canadian Entomologist 77: 176.

Burrows, William, 1949. Jordan-Burrows Textbook of Bacteriology, 15th Edition. Philadelphia: W. B. Saunders Company.

Cobb, J. O., 1902. The so-called spotted fever of the Rocky Mountains, a new disease in the Bitterroot Valley, Montana. Public Health Reports 17(33): 1868-1870.

Coffey, Marvin D., 1953. Some preliminary studies of Rocky Mountain spotted fever vectors in Utah. Unpublished Masters Thesis, Department of Zoology and Entomology, Brigham Young University.

Coffey, Marvin D., 1954. A study of some Rocky Mountain spotted fever vectors and their hosts in Utah. The Great Basin Naturalist 14 (1-2): 31-37.

Cooley, R. A., 1911. Tick control in relation to Rocky Mountain spotted fever. Montana Agricultural Experiment Station Bulletin 85.

——, 1932. Rocky Mountain wood tick. Montana Agricultural Experiment Station Bulletin 268: 1-58.

——, 1938. The genera *Dermacentor* and *Otocentor* (Ixodidae) in the United States with studies in variation. National Institutes of Health, Bulletin 171.

Cooley, R. A., 1946. The genera *Boophilus*, *Rhipicephalis* and *Haemaphysalis* (Ixodidae) of the New World. National Institutes of Health, Bulletin 187.

—— and Kohls, Glen M., 1944. The genus Amblyomma (Ixodidae) in the United States. Journal of Parasitology 30 (2): 77-111.

—— and Kohls, Glen M., 1944. The Argasidae of North America, Central America and Cuba. American Midland Naturalist, Monograph No. 1.

—— and Kohls, Glen M., 1945. The genus Ixodes in North America. National Institutes of Health, Bulletin 184.

Davis, Gordon E., 1941. *Ornithodoros parkeri* and relapsing fever spirochetes in Utah. Public Health Reports 56 (52): 2464-2468.

——, 1942. The Rocky Mountain spotted fever rickettsia in the tick genus Ornithodoros. Proceedings Sixth Pacific Science Congress 5: 577-579.

——, 1943. Experimental transmission of the spotted fevers of the United States, Columbia and Brazil by the Argasid tick *Ornithodoros parkeri*. Public Health Reports 58 (32): 1201-1208.

Dyer, R. E., 1935. Rocky Moutain spotted fever. American Journal of Nursing 35: 633-640.

——; Badger, L. F. and Rumreich, A., 1931. Rocky Mountain spotted fever (Eastern type) transmitted by the American dog tick *Dermacentor variabilis*. Public Health Reports 46 (24): 1403-1413.

Eddy, Gains W., 1942. Notes on the seasonal history of the rabbit tick *Haemaphysalis leporis-palustris*, in Oklahoma. Proceedings Entomological Society, Washington 44 (7): 145-149.

—— and Joyce, C. R., 1944. The seasonal history and hosts of the American dog tick, *Dermacentor variabilis* in Iowa. Iowa State College Journal of Science 18 (3): 313-324.

Edmunds, Lafe R., 1951. A check list of the ticks of Utah. Pan-Pacific Entomologist 27 (1): 23-26.

Fricks, L. D., 1915. Rocky Mountain spotted fever. A report of its investigation and of measures undertaken for its eradication during 1914. Public Health Reports 30 (3): 148-165.

Gregson, J. D., 1951. Notes on the spring activity of the Rocky Mountain wood tick. Proceedings Entomological Society of British Columbia 47: 4-7.

Green, R. G.; Evans, C. A., and Larson, C. L., 1943. A ten-year population study of the rabbit tick, *Haemaphysalis leporis-palustris*. American Journal of Hygiene 38 (3): 260-281.

Hampton, Brock C. and Eubank, H. G., 1938. Rocky Mountain spotted fever: Geographical and seasonal prevalence, case fatality and prevention measures. Public Health Reports 53 (24): 984-990.

Hooker, W. A. and Bishopp, F. C., 1912. The life history and bionomics of some North American ticks. U. S. Department of Agriculture Bureau of Entomology Bulletin (106): 239.

Hunter, W. D. and Bishopp, F. C., 1911. The Rocky Mountain spotted fever tick. U. S. Department of Agriculture, Bureau of Entomology Bulletin 105.

Jellison, Wm. L., 1945. The geographical distribution of Rocky Mountain spotted fever and Nuttall cottontail in the Western United States. Public Health Reports 60 (33): 958-861.

——, 1934. Rocky Mountain spotted fever. The susceptibility of mice. Public Health Reports 49 (11): 363-367.

—— and Parker, R. R., 1945. Rodents, rabbits and tularemia in North America: Some zoological and epidemiological considerations. American Journal of Tropical Medicine 25 (4): 349-362.

Kohls, Glen M., 1937. Tick rearing methods with special reference to the Rocky Mountain wood tick, *Dermacentor andersoni* Stiles. Culture methods for Invertebrate Animals, Ithaca, New York. Comstock Publishing Company.

——, 1946. Vectors of Rickettsial Diseases. Rocky Mountain Laboratory Publication 278 (Mimeographed)

——, 1947. Vectors of Rickettsial diseases. Annals of Internal Medicine 26 (5): 713-719.

—— and Parker, R. R., 1948. Occurrence of the brown dog tick in the Western States. Journal of Economic Entomology 41 (1): 102.

Lillie, R. D., 1941. Pathology of Rocky Mountain spotted fever. National Institutes of Health Bulletin 177. U. S. Public Health Service, U. S. Government Printing Office, Washington, D. C.

Maxey, E. E., 1899. Some observations on the so-called "spotted fever" of Idaho. Medical Sentinel 7: 433-438.

Parker, R. R., 1923. Transmission of Rocky Mountain spotted fever by the rabbit tick *Haemaphysalis leporis-palustris* Packard. American Journal of Tropical Medicine 3: 39-46.

——, 1934. Recent studies of tick-borne diseases made at the United States Public Health Service laboratory at Hamilton, Montana. Proceedings 5th Pacific Science Congress 5: 3367-3376.

——, 1938. Rocky Mountain spotted fever. American Medical Association Journal 110: 1185-1188, 1273.

——; Kohls, Glen M. and Steinhaus, E. A., 1943. *Amblyoma americannums* a vector of Rocky Mountain spotted fever. Public Health Reports 58 (12): 491.

——; Philip, C. B.; Davis, G. E., and Cooley, R. A., 1937. Ticks of the United States in relation to disease in man. Journal Economic Entomology 30 (1): 51.

——; Philip, C. B. and Jellison, W. L., 1933. Rocky Mountain spotted fever. Potentialities of tick transmission in relation to geographical occurrence in U. S. American Journal of Tropical Medicine 13 (4): 341-379.

——; Philip, C. B.; Davis, G. E. and Cooley, R. A., 1937. Ticks of the United States in relation to disease in man. Journal of Economic Entomology 30 (1): 51-69.

Philip, C. B., 1937. Six years intensive observation on seasonal prevalence of a tick population in Western Montana. Public Health Reports 52: 16-22.

——, 1939. Ticks as vectors of animal diseases. Canadian Entomologist 71: 55-65.

——, 1942. Rocky Mountain spotted fever: known and potential tick vectors in the United States. Proceedings 6th Pacific Science Congress 5: 581-584.

—— and Hughes, L. E., 1953. Disease agents found in the rabbit tick *Dermacentor parumapertus* in southwestern United States. Sixth Congress Internazionale di Microbiologia, Sezioni VIII-XVI 2 (793): 600.

—— and Kohls, Glen M., 1951. Elk, winter ticks and Rocky Mountain spotted fever: a query. Public Health Reports 66-1672-1675.

—— and Parker, R. R., 1933. Rocky Mountain spotted fever. Investivation of sexual transmission in the wood tick *Dermacentor andersoni* Public Health Reports 48 (11): 266-272.

Ricketts, H. T., 1906. The study of Rocky Mountain spotted fever (Tick fever) by means of animal inoculations: a preliminary communication. Journal American Medical Association 47 (1): 33-36.

——, 1906. The transmission of Rocky Mountain spotted fever by the bite of a wood tick (*Dermacentor occidentalis*) Journal American Medical Association 47 (5): 358.

——, 1909. Some aspects of Rocky Mountain spotted fever as shown by recent investigations. Medical Record 76: 842.

Robinson, A. A., 1908. Rocky Mountain spotted fever with report of a case. Medical Record 74 (22): 913-922.

Rucker, A. C., 1912. Rocky Mountain spotted fever. Public Health Reports 27 (36) 1465-1482.

Stanford, J. S., 1934. Some ectoparasites of Utah birds and mammals. Proceedings of Utah Academy of Science. Arts and Letters 11: 247.

Stiles, C. W., 1905. A zoological investigation into the cause, transmission and source of Rocky Mountain spotted fever. Hygienic Laboratory Bulletin No. 20: 28 and 116.

——, 1908. The common tick (*Dermacentor andersoni*) of the Bitter Root Valley. Public Health Reports 23 (27): 949.

Topping, N. H., 1940-41. Rocky Mountain

spotted fever studies.
Public Health Reports 55 (2): 41-46.
Public Health Reports 55 (17): 728.
Public Health Reports 56 (34): 1699-1703.
Public Health Reports 56 (42): 2041-2043.

Wilson, L. B. and Chowning, W. M., 1902. The so-called "spotted fever" of the Rocky Mountains. A preliminary report to the Montana State Board of Health. Journal American Medical Association 39: 131-136.

—— and Chowning, W. M., 1903. Report on the investigation of the so-called "spotted fever." First Biennial Report of the Montana State Board of Health.

Wolbach, S. B., 1919. Studies on Rocky Mountain spotted fever. Journal of Medical Research 41 (1): 1-197.

Wood, M. L., 1896. Spotted fever as reported from Idaho. Report Surgeon General, U. S. Army for 1896: 60-65.

Yeatter, R. E. and Thompson, D. H., 1952. Tularemia, weather and rabbit populations. Illinois Natural History Survey Division Bulletin 25 (6): 351-382.

BIOLOGICAL SERIES — VOLUME I, NUMBER II

January 1, 1958

CAREX — ITS DISTRIBUTION AND IMPORTANCE IN UTAH

by

MONT E. LEWIS

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Mont E. Lewis

Forest Service[0]

INTRODUCTION

The purpose of this report is to bring available information concerning the *Carex* species in Utah up to date. This includes such phases as latest nomeclature, notes on specific distribution, habitat requirements and economic notes. Identification keys and descriptions are also adapted for the group of entities found in Utah.

Possibly no group of vascular plants is less understood by range ecologists than are the sedges. This is mainly due to the large number of species and difficulty in identification, and the complexity of the group; however, lack of recent manuals and studies dealing specifically with this area has not helped the situation. It is hoped that this study will aid in the better understanding of this important group.

The genus *Carex* in Utah is represented by over 90 species. This places it among the largest genera in the state. Considering only the montane floras, it has the largest representation of any genus. Most of the plant communities from those of the bogs to the xeric mountain tops have representatives from this group. In the lower montane zones, about 70 percent of the *Carex* species are wet land plants, while in the alpine zone about 55 percent grow in mesic to drier sites. To certain limits, species of *Carex* gain importance in the plant communities as higher elevations are attained.

IMPORTANCE AS A FORAGE PLANT

Based on palatability, species of *Carex* are nearly equivalent to the grasses. Such species as *C. physocarpa* and *C. rostrata* are relatively unpalatable and would have their grass counterparts; others, such as *C. bella*, are highly palatable and would compare favorably with the better native bluegrasses. The large majority of the species fits into the classification of moderate palatability.

Economically speaking, the genus *Carex* would compare favorably as a grass forage producer with the better grass genera with the exception of the *Agropyron*, *Bromus*, and *Poa*. *Carex* is of special importance at the higher elevations, especially in the alpine zone, where it is often the dominant constituent of many plant communities. In the Intermountain valleys, various species of *Carex* are of prime importance in the hay meadows.

SOURCES OF INFORMATION

The author has had free access to the four major herbaria of the state, namely, Brigham Young University at Provo, Intermountain herbarium at Logan, University of Utah at Salt Lake City, and the Region 4 Forest Service herbarium at Ogden. Collections have been made from most of the major physiographic units (see map) over a period of four years. Valuable help in identification has been received from F. J. Hermann of the U. S. Department of Agriculture and J. T. Howell, California Academy of Science. Illustrations by Mrs. Kent H. McKnight.

The body of the report, made up of identification keys and species descriptions, is based primarily on Mackenzie's "North American Flora." Recent nomenclatural changes and additions followed generally Hermann's "Addenda to North American Carices." All keys were adapted to local flora wherever material was sufficient. Works of numerous students of the genus were also reviewed.

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0. This report is the result of a study made under the direction of Dr. Bertrand F. Harrison of the Department of Botany at Brigham Young University, Provo, Utah.

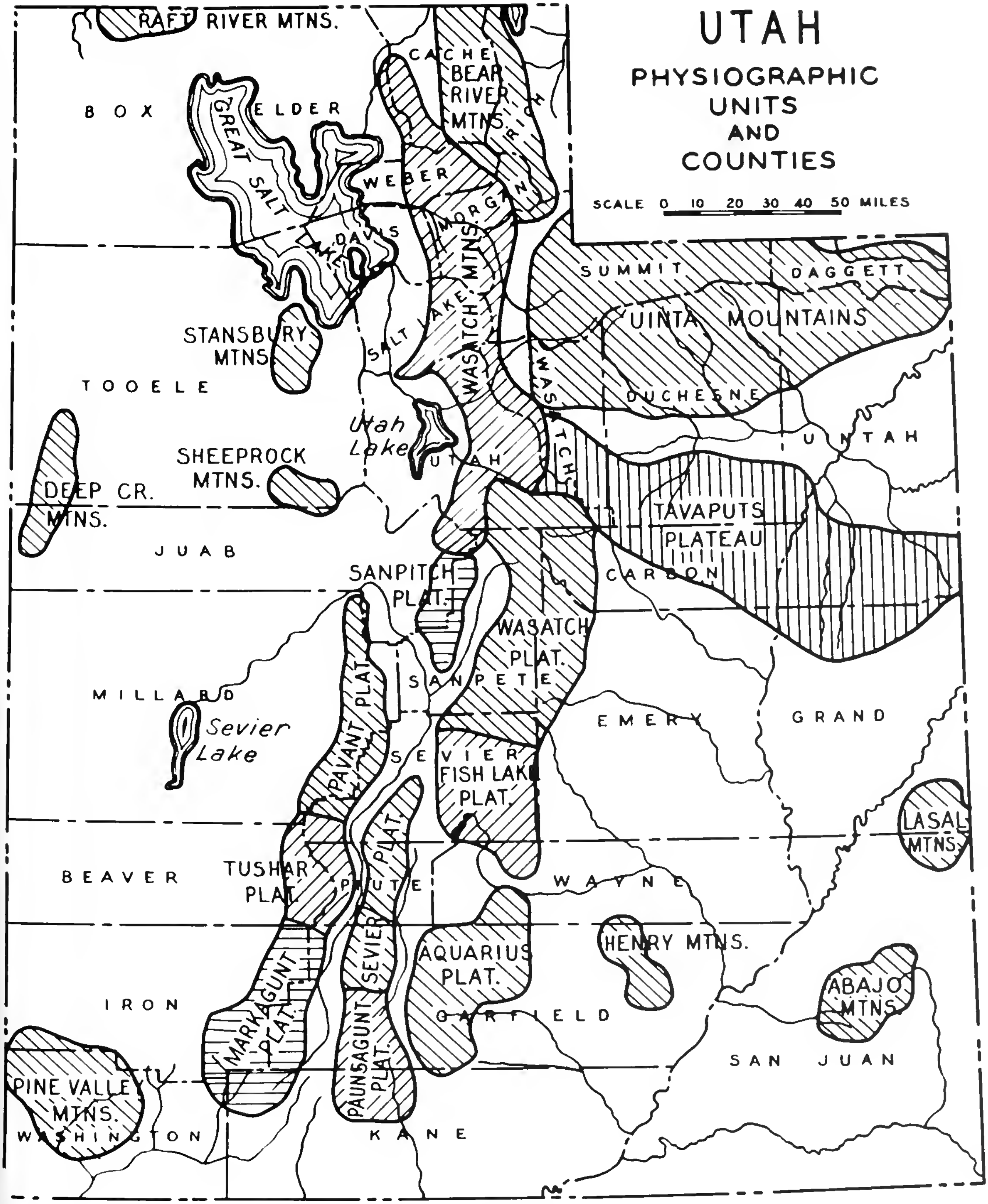
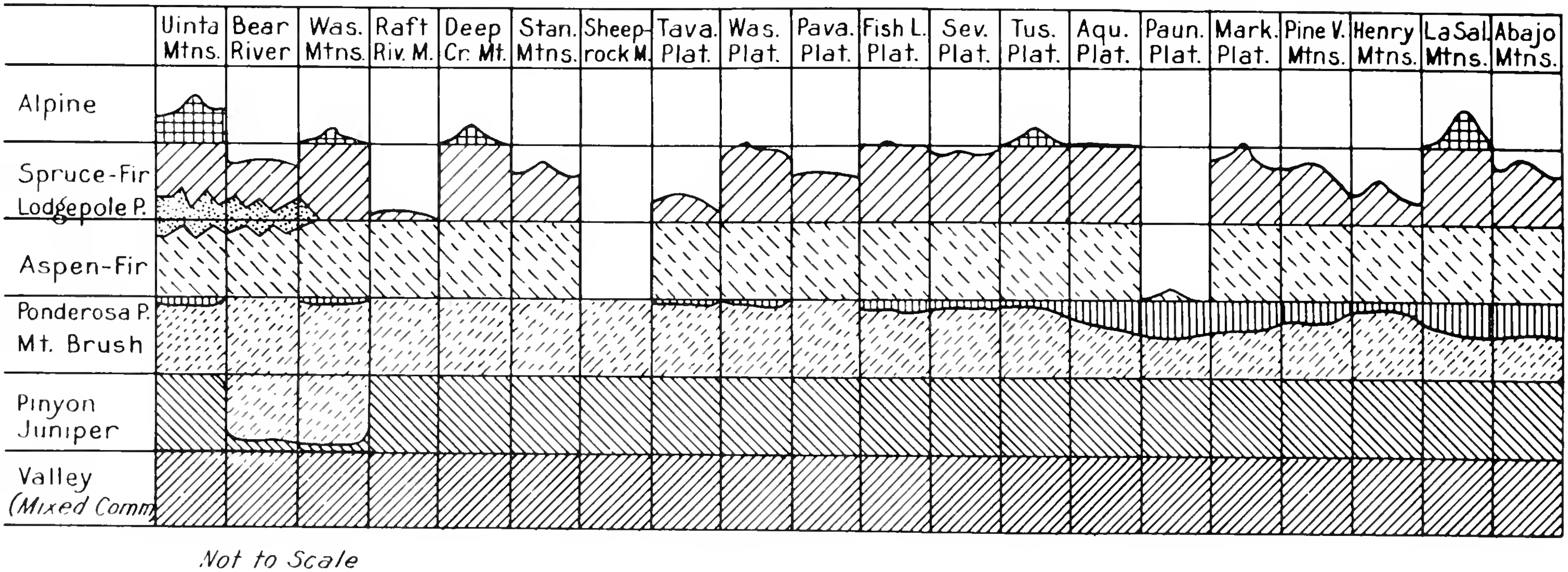

UTAH
PHYSIOGRAPHIC
UNITS
AND
COUNTIES
SCALE 0 10 20 30 40 50 MILES
RAFT RIVER MTNS.
BOX ELDER
CACHE
BEAR RIVER MTNS.
RICH
GREAT SALT LAKE
WEBER
MORGAN
DAVIS
SUMMIT
DAGGETT
UINTA MOUNTAINS
STANSBURY MTNS.
SALT LAKE
WASATCH MTNS.
TOOELE
WASATCH
DUCHESNE
Utah Lake
UTAH
UINTAH
SHEEPROCK MTNS.
DEEP CR. MTNS.
TAVAPUTS PLATEAU
JUAB
SANPITCH PLAT.
CARBON
WASATCH PLAT.
SANPETE
MILLARD
Sevier Lake
PAVANT PLAT.
EMERY
GRAND
SEVIER
FISH LAKE PLAT.
LASAL MTNS.
SEVIER PLAT.
BEAVER
TUSHAR PLAT.
PIUTE
WAYNE
HENRY MTNS.
MARKAGUNT PLAT.
SEVIER
AQUARIUS PLAT.
ABAJO MTNS.
IRON
GARFIELD
PAUNSAGUNT PLAT.
SAN JUAN
PINE VALLEY MTNS.
WASHINGTON
KANE

FIGURE 1

ZONAL DEVELOPMENT BY PHYSIOGRAPHIC UNIT

FIGURE 2



GRAPHIC MATERIAL AND MAP

Distribution of the species within the State is tied to the major physiographic units (Fenneman, *Phy. Prov. of West. U. S.*, 1931). Mountains and higher plateaus are shown on the map. Because the carices in our area are primarily montane, only the elevated portions of the State are shown. Physiographic units instead of counties were used in the distribution studies because they gave a truer representation. Counties in this State cover such broad sweeps of mountains and valleys that true locations would be hard to determine.

Zonal development for each physiographic unit is schematically shown in Figure 2. This is not to scale. Its chief value is to give the reader a quick picture of the zonal arrangement of the State's montane vegetation.

CLASSIFICATION OF CAREX

Carex is a member of the Cyperaceae or sedge family. An artificial key to the Cyperaceae family is included, but only one genus, *Carex*, is treated in this paper.

CYPERACEAE — SEDGE FAMILY

Plants grass-like; culms usually triangular and usually solid; leaves three-ranked when present (rarely two-ranked); sheaths closed; flowers perfect or imperfect, in spikes, each flower (rarely two or more) in axis of a scale; scales imbricate, spirally arranged in several rows, or sometimes two-ranked; perianth wanting or represented by hypogynous bristles, in some genera the pistillate or rarely both flowers enclosed in a sac-like organ (perigynium); stamens one-three; ovary one-celled and one-ovuled; stigma two-three; fruit an achene.

1. Scales of spikes two-ranked; spikes flattened. .... *Cyperus*
1. Scales of spikes spirally imbricated; spikes terete or slightly flattened.
    2. Achenes enclosed in a sac-like organ (perigynium), this may be split on one side; flowers unisexual.
        3. Perigynium split to base or nearly so, enclosing both an achene and a staminate flower or flowers. .... *Kobresia*
        3. Perigynium closed, except for a dorsal suture in the beak of some species, enclosing only the achene. .... *Carex*
    2. Achenes not enclosed in a perigynium; flowers not unisexual.
        4. Styles enlarged at base forming a persistent tubercle on the achene. .... *Eleocharis*
        4. Styles not enlarged at base and not forming a persistent tubercle on the achene.
            5. Perianth a scale; plants annual. .... *Hemicarpha*
            5. Perianth of one to many bristles; plants annual or perennial.
                6. Perianth bristles many, long-silky, appearing as tufts of cotton at maturity. .... *Eriophorum*
                6. Perianth of one to six short bristles, these may be barbed, smooth or pubescent. .... *Scirpus*

A TYPICAL SEDGE PLANT
(Carex raynoldsii)

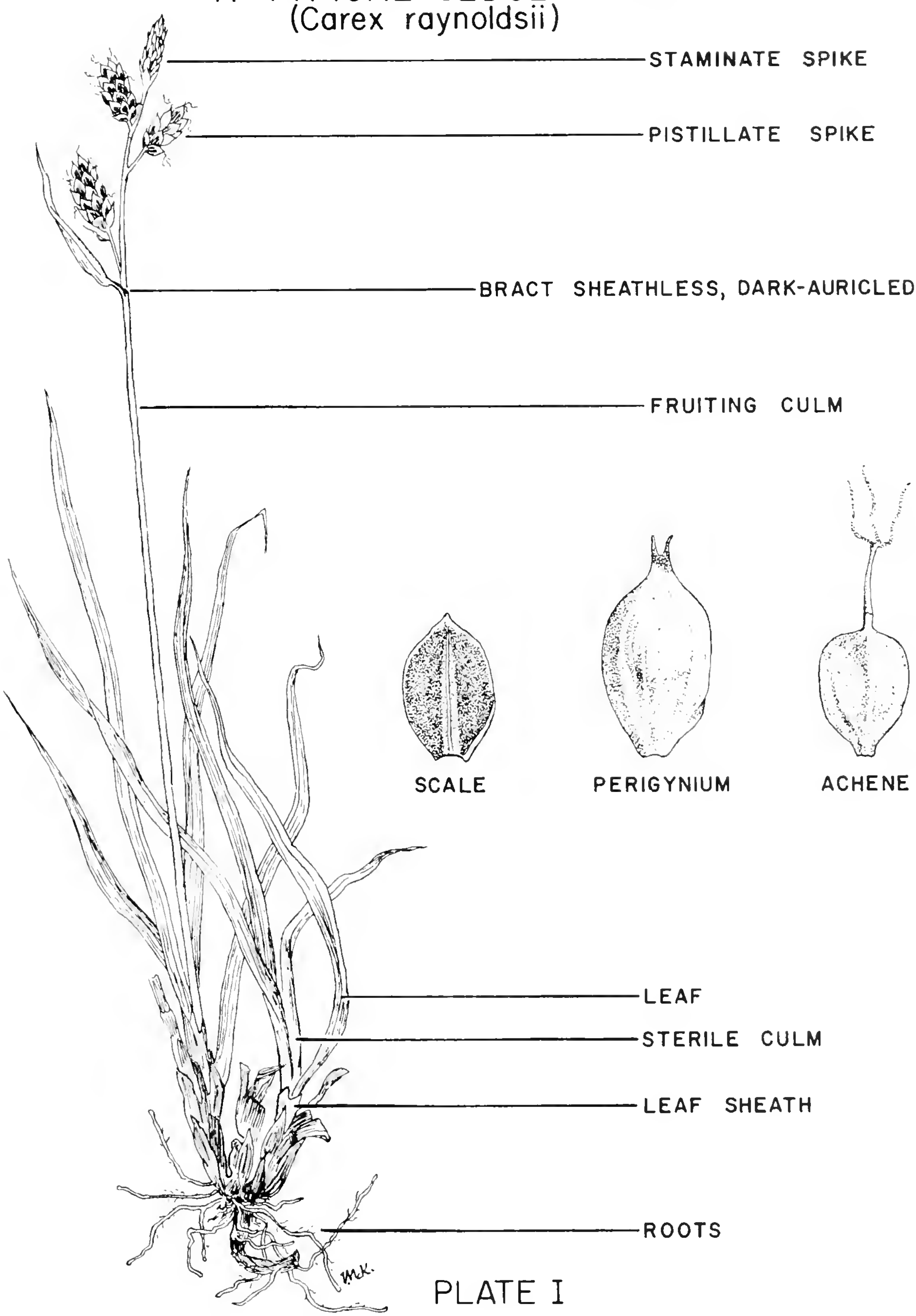


PLATE I

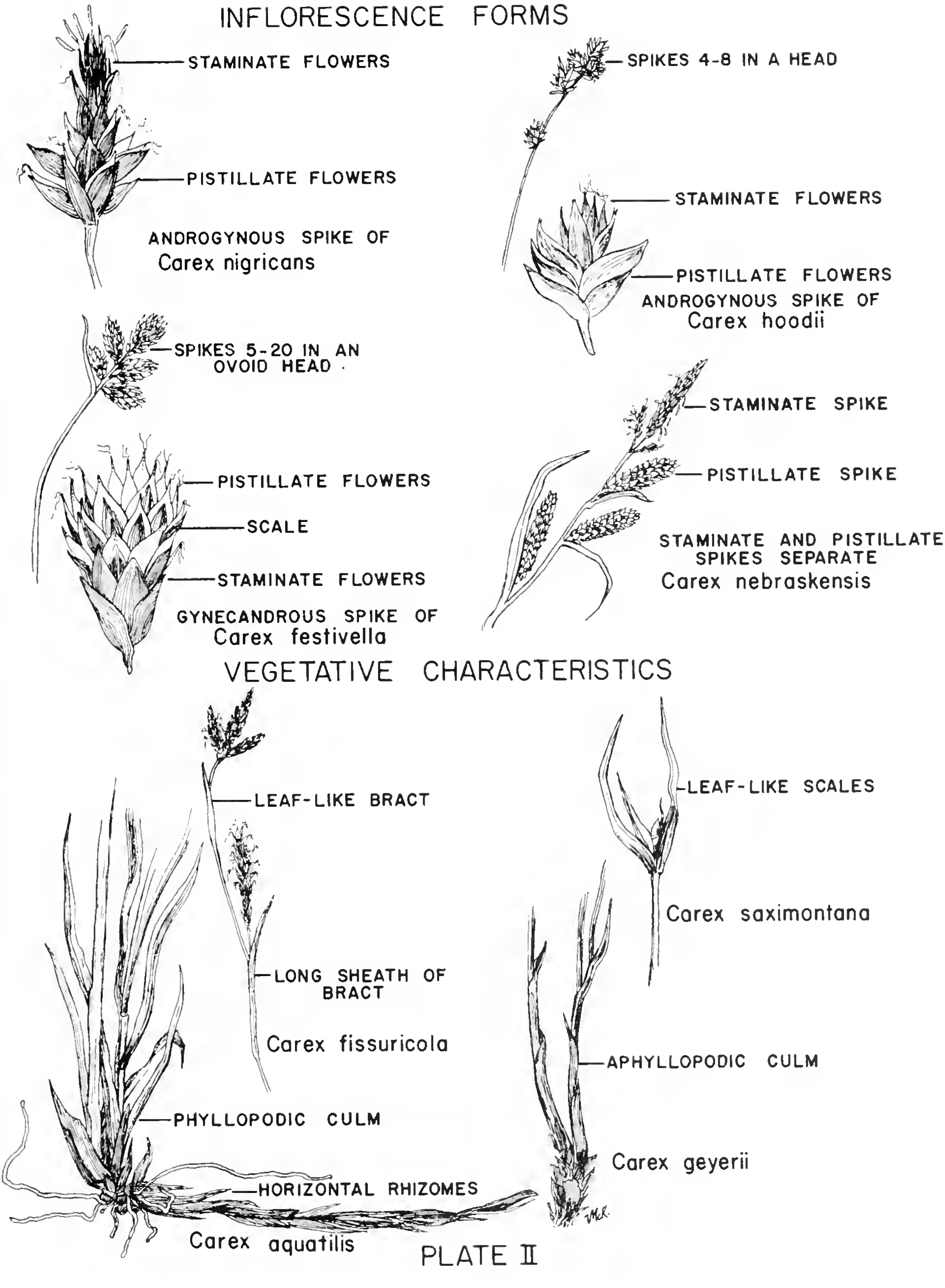

INFLORESCENCE FORMS
STAMINATE FLOWERS
PISTILLATE FLOWERS
ANDROGYNOUS SPIKE OF
Carex nigricans
SPIKES 4-8 IN A HEAD
STAMINATE FLOWERS
PISTILLATE FLOWERS
ANDROGYNOUS SPIKE OF
Carex hoodii
SPIKES 5-20 IN AN OVOID HEAD
PISTILLATE FLOWERS
SCALE
STAMINATE FLOWERS
GYNECANDROUS SPIKE OF
Carex festivella
STAMINATE SPIKE
PISTILLATE SPIKE
STAMINATE AND PISTILLATE SPIKES SEPARATE
Carex nebraskensis
VEGETATIVE CHARACTERISTICS
LEAF-LIKE BRACT
LONG SHEATH OF BRACT
Carex fissuricola
LEAF-LIKE SCALES
Carex saximontana
APHYLLOPODIC CULM
Carex geyerii
PHYLLOPODIC CULM
HORIZONTAL RHIZOMES
Carex aquatilis

PLATE II

REPRESENTATIVE PERIGYNIA OF CAREX

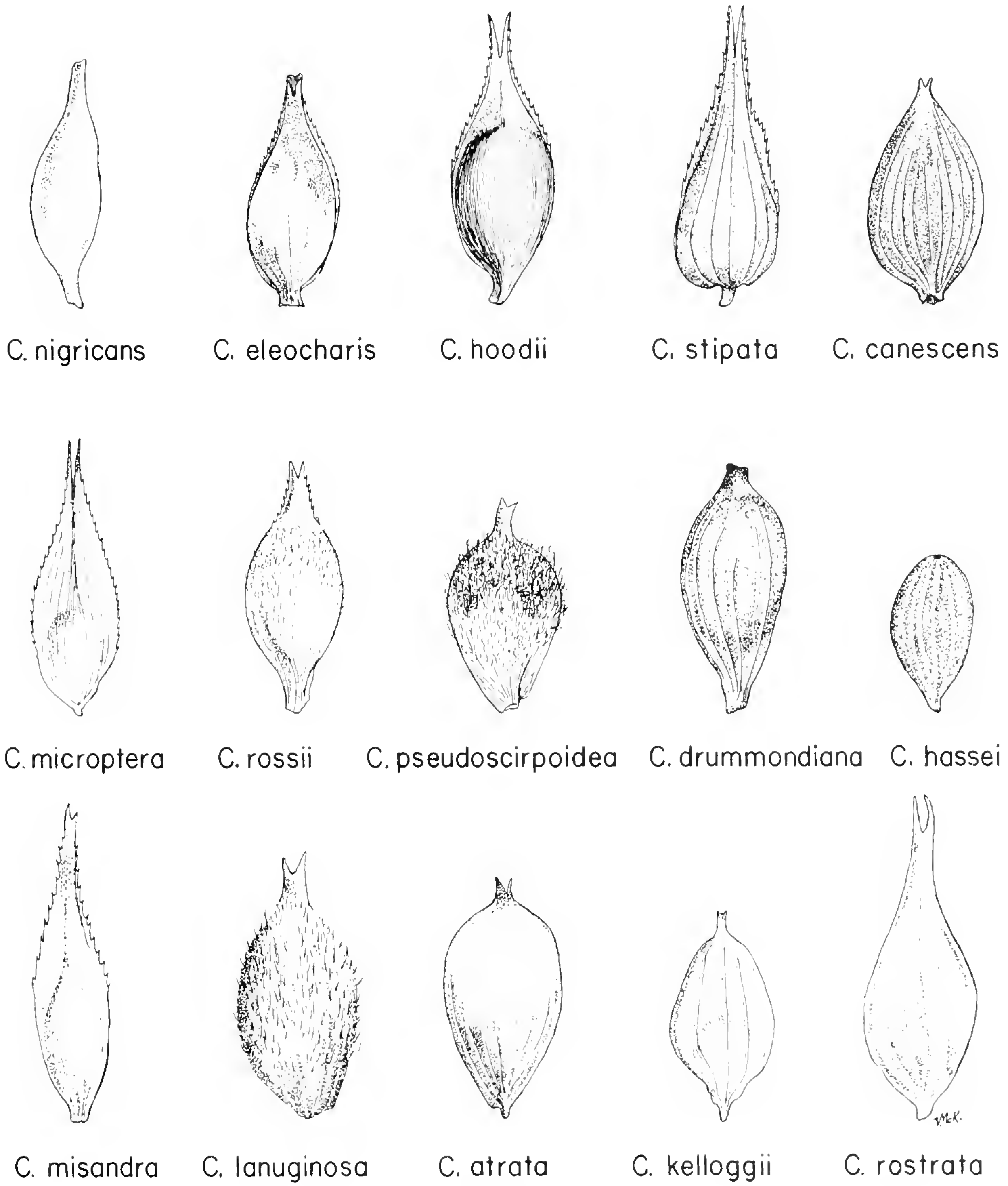


PLATE III

CAREX L. SP. PL. 972. 1753

Plants grass-like, perennial. Culms mostly triangular, generally solid; leaves three-ranked, the upper ones (the bracts) subtending the spikes or inflorescence; plants usually monoecious or dioecious in a few species; spikes one to many; flowers unisexual, solitary in the axis of a scale; stamens three (rarely two); pistillate flowers surrounded by a sac-like organ (perigynium); fruit a lenticular or trigonous achene with a single style branching above into two, three, or rarely four stigmas. A short setiform rachilla is present in some species.

ARTIFICIAL KEY TO SECTIONS

1. Spike one .... A
1. Spikes more than one
    2. Stigmas two .... B
    2. Stigmas three C

A. Spike one

1. Stigmas two	
2. Plants cespitose; perigynia not reflexed.	
3. Perigynia lanceolate, obscurely nerved.	1. NARDINAE
3. Perigynia ovate, nerveless; spikes ovoid.	2. CAPITATAE
2. Plants rhizomatous; perigynia reflexed	4. DIOICAE
1. Stigmas three	
4. Pistillate scales deciduous; at least the lower perigynia reflexed at maturity, stipitate.	5. CALLISTACHYS
4. Pistillate scales persistent; perigynia not reflexed at maturity.	
5. Spikes androgynous.	
6. Leaf-blades filiform.	
7. Plants rhizomatous, with slender, elongate rootstocks; perigynia more or less inflated.	3. INFLATAE
7. Plants densely cespitose; perigynia not inflated; sheaths forming a fasciculate base.	
8. Perigynia puberulent or pubescent above, nerveless; staminate flowers conspicuous (over half of spike).	24. FILIFOLIAE
8. Perigynia glabrous, obscurely striate; staminate flowers inconspicuous (less than half the spike).	1. NARDINAE
6. Leaf-blades flat or canaliculate, not filiform.	
9. Perigynia coriaceous and shining.	25. OBTUSATAE
9. Perigynia not coriaceous and shining.	
10. Perigynia 3-4.5 mm. long, 1-6, closely flowered.	32. RUPESTRES
10. Perigynia 5.5-7 mm. long, 1-3, separate to overlapping.	33. FIRMICULMES
5. Spikes entirely staminate or pistillate.	28. SCIRPINAE

B. Spikes more than one; stigmas two.

1. Lateral spikes sessile, short.	
2. Perigynia not white-puncticulate; Beaks conspicuous	
3. Culms from long creeping rootstocks; terminal spikes generally androgynous or dioecious, gynaecandrous in one species.	
4. Perigynia not wing-margined; spikes androgynous or dioecious.	
5. Spikes aggregated into a globose or ovoid head, androgynous.	6. FOETIDAE

5. Spikes not aggregated, lower distinct, androgynous or dioecious. .... 7. DIVISAE

4. Perigynia wing-margined at least above; terminal spike gynaecandrous (our species). .... 9. ARENARIAE

3. Culms cespitose; occasionally with short rhizomes, never long-creeping.

6. Spikes androgynous.

7. Perigynia bodies abruptly contracted into beaks; culms not flattened on drying.

8. Spikes few, if over 10, greenish. (dry lands) .... 12. BRACTEOSAE

8. Spikes numerous; sheaths often red-dotted ventrally. (wet lands) .... 14. PANICULATAE

7. Perigynia with body tapering into a beak, culms flattened on drying; sheaths cross-rugulose ventrally. .... 15. VULPINAE

6. Spikes not androgynous, upper spike gynaecandrous or rarely staminate, lateral spikes gynaecandrous or pistillate.

9. Perigynia at most thin-edged, the lower part of the body spongy-thickened.

10. Perigynia spreading or ascending to maturity. 19. STELLULATAE

10. Perigynia appressed. .... 20. DEWEYANAE

9. Perigynia wing-margined, not spongy-thickened at base. .... 21. OVALES

2. Perigynia white-puncticulate; beak inconspicuous; spikes usually stiffly compact. .... 17. HELEONASTES

1. Lateral spikes peduncled or elongate; terminal spike staminate or bisexual.

11. Perigynia beakless or very short beaked, not lustrous.

12. Lowest bract long-sheathing; perigynia pulverulent or golden-yellow at maturity. .... 38. BICOLORES

12. Lowest bract sheathless or short-sheathing; perigynia not as above. .... 61. ACUTAE

11. Perigynium beak 0.5 mm. or more long, its body blackish and lustrous. — C. *physocarpa* in.......... 70. VESICARIAE

C. Spikes more than one; stigmas three.

1. Perigynia pubescent or puberulent.

2. Pistillate flowers few (1-20); achenes closely enveloped. .... 27. MONTANAE

2. Pistillate flowers many (15-200); achenes more or less loosely enveloped.

3. Leaves septate-nodulose; styles deciduous; sheaths glabrous in our species. .... 54. HIRTAE

3. Leaves not septate-nodulose; styles persistent; sheaths pubescent. — C. *sheldonii* in .... 68. PALUDOSAE

1. Perigynia glabrous.

4. Staminate scales united at base; at least the lower pistillate scales leaf-like. .... 23. PHYLLOSTACHYAE

4. Plants not as above.

5. Perigynia only slightly inflated if at all, nerveless or moderately nerved; beak not bidentate or only moderately so; styles deciduous; plants usually not coarse and tall.

6. Lower bract long-sheathing.

7. Perigynium beak entire or nearly so.

8. Perigynia suborbicular in cross-section, with many raised nerves; beak conic, rather conspicuous; scales dark-colored. .... 41. GRANULARES

8. Perigynia trigonous, nerves inconspicuous, beak minute; spikes drooping on capillary peduncles; scales light-colored. .... 48. CAPILLARES

7. Perigynium beak bidentate.

9. Perigynia generally broad and trigonous, greenish-colored; scales light-colored; spikes with spreading perigynia. .... 50. EXTENSAE

9. Perigynia lanceolate or ovate, flat or flat-triangular; scales dark-colored; spikes with appressed or ascending perigynia. .... 52. FERRUGINEAE

6. Lower bract sheathless or very short-sheathing (under 2 mm.).

10. Roots clothed with a yellow felt; terminal spike generally staminate, occasionally gynaecandrous; lower bract occasionally short-sheathing. .... 59. LIMOSAE

10. Roots not clothed with yellow felt; terminal spike gynaecandrous or staminate, rarely pistillate; lower bract sheathless. .... 60. ATRATAE

5. Perigynia strongly inflated, smooth, shining and strongly ribbed; beak deeply bidentate (in ours); styles persistent; plants usually stout and tall.

11. Pistillate scales with a scabrous awn; one terminal spike staminate. .... 67. PSEUDO-CYPEREAE

11. Pistillate scales with a rather smooth awn where present; generally more than one staminate spike above.

12. Perigynia subcoriaceous and firm; sheaths (in ours) soft-hairy. .... 68. PALUDOSAE

12. Perigynia membranaceous; sheaths not soft-hairy. .... 70. VESICARIAE

KEY TO SPECIES OF *CAREX* OF UTAH

1. NARDINAE Tuckerm.

Represented by one species in our area .... 1. *C. hepburnii*

2. CAPITATAE Christ

Represented by one species in our area. .... 2. *C. capitata*

3. INFLATAE Kukenth.

1. Perigynia ovoid, thin-membranous, loosely enveloping achene, rounded at base. .... 3. *C. engelmannii*
1. Perigynia lanceolate to ovoid lanceolate, distended by achene which nearly fills it, strongly stipitate at base. .... 4. *C. subnigricans*

4. DIOICAE Wormsk.

Represented by one species in our area. .... 5. *C. gynocrates*

5. CALLISTACHYS (Heuffel) Graebn.

1. Plants densely cespitose; leaf-blades 2-4 per culm, less than 2 mm. wide, folded; staminate flowers few. .... 6. *C. pyrenaica*
1. Plants loosely cespitose, with short rhizomes; leaf-blades 4-9 per fertile culm, 2 mm. or more wide, flat; staminate flowers many and conspicuous. .... 7. *C. nigricans*

6. FOETIDAE Tuckerm.

1. Leaf-blades 2-4 mm. wide; perigynia not inflated; scales brown to blackish, green or light midvein. .... 8. *C. vernacula*
1. Leaf-blades 1.5 mm. wide or less; perigynia inflated, very membranaceous; pistillate scales brownish with lighter midveins. .... 9. *C. perglobosa*

7. DIVISAE Christ

1. Culms obtusely triangular; leaves narrowly involute or canaliculate; rootstocks slender.
   2. Perigynium beak long (1.75 mm.); plants dioecious or nearly so; heads large. (1.5 — 5 cm. long) .... 10. *C. douglasii*
   2. Perigynium beak short (0.5-0.75 mm.); plants monoecious; spikes androgynous; heads relatively small. .... 11. *C. eleocharis*
1. Culms sharply triangular; leaves flat or channeled.
   3. Rootstocks slender; perigynia unequally biconvex, 1.75-3 mm. long. .... 12. *C. simulata*
   3. Rootstocks stout; perigynia plano-convex, 3-4 mm. long. .... 13. *C. praegracilis*

9. ARENARIAE Kunth

Represented by one species in our area. .... 14. *C. foenea*

12. BRACTEOSAE Kunth

1. Perigynium beak obliquely cleft dorsally; spikes with generally 2-5 perigynia. .... 15. *C. vallicola*
1. Perigynium beak bidentate.
   2. Inflorescence ovoid to suborbicular; spikes densely capitate; perigynia soon brownish, 3.5-5 mm. long. .... 16. *C. hoodii*
   2. Inflorescence linear-oblong to oblong; lower spike or two little separate; perigynia 2.5-4.5 mm. long .... 17. *C. occidentalis*

14. PANICULATAE KUNTH

Represented by one species in our area. .... 18. *C. cusickii*

15. VULPINAE Kunth

Represented by one species in our area. .... 19. *C. stipata*

17. HELEONASTES Kunth

1. Spikes androgynous; perigynia unequally biconvex. .... 20. *C. disperma*
1. Spikes (at least uppermost) gynaecandrous; perigynia plano-convex.
   2. Spikes 2-5, congested; plants low-growing (0.5-3 dm. high) in small, loose clumps; scales brownish.
      3. Perigynia small, 1.5-2 mm. long, ascending or rather loosely spreading at maturity; scales somewhat shorter than perigynia; spikes 4-5. .... 21. *C. praeceptorum*
      3. Perigynia 2-3.5 mm. long, closely arranged and appressed-ascending; scales exceeded by tips only of mature perigynia; spikes 2-4. .... 22. *C. bipartita*
   2. Spikes 4-10, lower ones distinct; plants 1-8 dm. high, in dense clumps; scales light-colored.
      4. Perigynium beak fairly long and scabrous with a dorsal suture its entire length; perigynia very thin-walled with distinctly raised veins. .... 23. *C. brunnescens*
      4. Perigynium beak very short and inconspicuous, dorsal suture short or absent; perigynia with thicker walls and obscurely nerved. .... 24. *C. canescens*

19. STELLULATAE Kunth.

1. Perigynia rather abruptly narrowed into a beak one-third to one-fourth its body length, shallowly bidentate, body concavo-convex, ovoid, 1.5-2 mm. wide; sheaths hyaline ventrally, not red-dotted. .... 25. *C. interior*
1. Perigynia contracted into a beak more than half the length of the body, rather deeply bidentate, body plano-convex, lanceolate, 1.25-mm wide; sheaths hyaline ventrally, often red-dotted. .... 26. *C. angustior*

20. DEWEYANAE Tuckerm

1. Spikes usually 3 or 4; perigynia 4.5-5.5 x 1.5-2 mm., obscurely nerved, tapering into a serrulate, shallowly bidentate beak. .... 27. *C. deweyana*
1. Spikes 5-8; perigynia 4-4.5 x 1-1.3 mm., rather strongly nerved, abruptly tapering into a serrulate, deeply bidentate beak. .... 28...*C. bolanderi*

21. OVALES Kunth

1. Bracts not conspicuously exceeding head.
   2: Perigynia with beaks slender, nearly terete and scarcely margined at tip. Predominently Western North America. ...... Group A.
   2. Perigynia with beaks flattened and margined to tip, serrulate to apex. Predominently Eastern North America. .... Group B.
1. Bracts conspicuously exceeding head. .... Group C.

Group A. Perigynia with slender nearly terete beaks.

1. Scales shorter and narrower than perigynia, largely exposing perigynia above.
   2. Perigynia 3.5-7 mm. long, flat and scale-like to strongly plano-convex.
      3. Perigynia strongly plano-convex, thick, copper-colored at maturity, 3.5-5 mm. long. .... 29. *C. pachystachya*
      3. Perigynia not strongly plano-convex, generally much flattened and scale-like.
         4. Perigynia light-green to stramineous, 3.5-5 mm. long; scales dull-brown to blackish-brown.
            5. Perigynia strongly wing-margined (0.3-0.45 mm. wide), ratio of width to length 0.39-0.50; scales dark-chestnut to brownish-black; spikes appressed-ascending. .... 30. *C. festivella*

5. Perigynia narrowly wing-margined (0-0.3 mm. wide), ratio of width to length 0.34-0.40; scales usually dull-brown; spikes with perigynia spreading. .... 31. *C. microptera*

4. Perigynia very dark, brownish-black to blackish tinged, 4.5-7 mm. long; scales dark-brown to black.

6. Perigynia narrowly lanceolate, 5-7 mm. long, finely many-nerved ventrally; beaks appressed; culms stiff, erect. .... 32...*C. ebenea*

6. Perigynia ovate, 4-5 (6) mm. long, nerveless ventrally, beaks conspicuous; culms slender, often decumbent. .... 33. *C. haydeniana*

2. Perigynia small, 3-5 mm. long or less, plano-convex, the lower part of perigynium nearly filled by achene.

7. Perigynia with margins of beak not serrulate; scales blackish. .... 34. *C. illota*

7. Perigynia with margins of beaks strongly serrulate; scales reddish-brown. .... 35. *C. subfusca*

1. Scales about length of perigynia and nearly same width above, largely concealing them.

8. Heads with moniliform spikes, nodding or flexuose. .... 38. *C. praticola*

8. Heads with approximate spikes, erect.

9. Perigynia abruptly contracted into a short (1 mm. long or less), conspicuously hyaline beak; culms 1-3 dm. high, in large stools.

10. Perigynia oblong-ovate, rather conspicuously margined, 4-6 mm. long. .... 36. *C. phaeocephala*

10. Perigynia linear-oblanceolate, very narrowly margined, boat-shaped, 3.5-4 mm. long. .... 37. *C. leporinella*

9. Perigynia tapering into a longer beak (near 2 mm. long), hyaline tipped but not conspicuously so; culms in small clumps, often with short-prolonged rootstocks.

11. Perigynia 5-6 mm. long, culms obtusely triangular, thick at base. .... 39. *C. eastwoodiana*

11. Perigynia 5.8-8 mm. long; culms acutely triangular, slender at base. .... 40. *C. petasata*

Group B. Perigynia with flattened beaks.

1. Scales shorter than perigynia and noticeably narrower above, exposing perigynia above.

2. Perigynia 3-3.5 mm. long, thick, firm, plano-convex; tip of beak little flattened. .... 35. *C. subfusca*

2. Perigynia 4.5-7.5 mm. long, body suborbicular, flat, with broad wings.

3. Perigynia light-green or straw-colored, 4.5-5.5 mm. long; culms 1-4 dm. high. .... 41. *C. straminiformis*

3. Perigynia olive-green or brownish, 6-7.5 mm. long; culms 6-8 dm. high. .... 42. *C. egglestoni*

1. Scales about the length of perigynia and nearly as wide above, nearly concealing perigynia; perigynia wing-margined at base; rootstocks short-prolonged. .... 43. *C. xerantica*

Group C. Bracts conspicuously exceeding head.

Lower bract not appearing like a continuation of the culm. .... 44. *C. athrostachya*

23. PHYLLOSTACHYAE Tuckerm.

Represented by one species in our area. .... 45. *C. saximontana*

24. FILIFOLIAE Tuckerm.

1. Pistillate scales with very broad, bright-white, hyaline margins; perigynia obtusely angled, 3-5 mm. long, puberulent above. .... 46. *C. filifolia*
1. Pistillate scales reddish-brown with dingy-white-hyaline margins; perigynia rather sharply angled, 2.5-4 mm. long, sparsely scabrous above. .... 47. *C. elynoides*

25. OBTUSATAE Tuckerm.

Represented by one species in our area. .... 48. *C. obtusata*

27. MONTANAE Fries

1. Upper pistillate spikes with (1) 3-8 (15) perigynia; perigynia 2.8-4.5 mm. long, ciliate-serrulate and deeply bidentate beak. ...... 49. *C. rossii*
1. Upper pistillate spikes with 1-3 perigynia; perigynia 3.5-5 mm. long, beak shallowly bidentate. .... 50. *C. pityophila*

28. SCIRPINAE Tuckerm.

Represented by one species in our area. .... 51. *C. pseudoscripoidea*

32. RUPESTRES Tuckerm.

Represented by one species in our area. .... 52. *C. drummondiana*

33. FIRMICULMES Kukenth.

Represented by one species in our area. .... 53. *C. geyeri*

38. BICOLORES Tuckerm.

1. Perigynia fleshly, smooth, golden-orange (drying brown); spikes loosely few-flowered. .... 54. *C. aurea*
1. Perigynia dry, whitish-papillose; spikes closely flowered.
   2. Foliose bract with inner summit of sheath truncate; culms slender but erect, 0.5-3 dm. high; perigynia 2.5-3 mm. long. .... 55. *C. hassei*
   2. Foliose bract with inner summit of sheath "V" shaped or arcuate; culms slender and spreading, (1) 3-6 dm. high; perigynia 2-3 mm. long. .... 56. *C. garberi*

41. GRANULARES O. F. Lang

Represented by one species in our area. .... 57. *C. crawei*

48. CAPILLARES Asch.

Represented by one species in our area. .... 58. *C. capillaris*

50. EXTENSAE Fries.

Represented by one species in our area. .... 59. *C. viridula*

52. FERRUGINEAE Tuckerm.

1. Terminal spike generally gynaecandrous, slender peduncled and drooping; culms slender and nodding above. .... 60. *C. misandra*
1. Terminal spike pistillate or occasionally with few perigynia.
   2. Perigynia tapering into a hardly differentiated beak about 1 mm. long; pistillate scales ovate-oblong, obtusish. .... 61. *C. ablata*
   2. Perigynia abruptly contracted into a beak one-fourth to one-third the body length; pistillate scales narrowly ovate, acute, cuspidate or short-awned. .... 62. *C. fissuricola*

54. HIRTAE Tuckerm.

Represented by one species in our area. .... 63. *C. lanuginosa*

59. LIMOSAE Tuckerm.

1. Pistillate scales persistent, ovate to suborbicular, as long to longer than perigynia; plants strongly rhizomatous with forked rhizomes. .... 64. *C. limosa*
1. Pistillate scales soon deciduous, lanceolate to ovate-lanceolate, usually exceeding the perigynia; plants loosely cespitose. .... 65. *C. paupercula*

60. ATRATAE Kunth

1. Terminal spike staminate.
    2. Perigynia strongly flattened, nerved; leaves bunched above the base. .... 66. *C. tolmiei*
    2. Perigynia round or obtusely triangular in cross-section, little or not flattened.
        3. Perigynia suborbicular in cross-section, 3.25-4.5 mm. long; staminate spike nearly sessile; culms stout. .... 67. *C. raynoldsii*
        3. Perigynia triangular in cross-section, 2-3.5 mm. long; staminate spike on a slender peduncle; culms slender. .... 68. *C. aboriginum*
1. Terminal spike gynaecandrous.
    4. Culms leafly at base, persistent leaves of previous years conspicuous.
        5. Perigynia not flat, more or less inflated, obtusely-triangular or compressed-suborbicular.
            6. Perigynia 2-3 mm. long, obtusely-triangular; spikes aggregated into a head 4-8 mm. long; leaves 1-3 mm. wide; scales much shorter than perigynia. .... 69. *C. media*
            6. Perigynia 3-5 mm. long, compressed-suborbicular; spikes aggregated into a head 10-12 mm. long; leaves 3-6 mm. wide; scales shorter to equaling perigynia. .... 70. *C. nelsonii*
        5. Perigynia flat, except where distended over the achene.
            7. Spikes contiguous, closely congested, sessile.
                8. Culms slender and nodding; spikes dense; perigynia smooth, not at all ciliate-scabrous. .... 72. *C. pelocarpa*
                8. Culms stiffly erect; spikes with the perigynia spreading at maturity; perigynia granular and sparsely ciliate-scabrous. .... 73. *C. nova*
            7. Spikes not closely congested, at least the lower one separate.
                9. Spikes sessile or lower short peduncled (peduncle less than the length of its spike.)
                    10. Perigynia papillose or granular above.
                        11. Culms stiffly erect; scales with conspicuous white-hyaline margins. .... 71. *C. albo-nigra*
                        11. Culms nodding, often reclining; scales at most only narrowly hyaline.
                            12. Upper pistillate scales longer than perigynia (usually conspicuously so), brown copper-colored. .... 76. *C. chalciolepis*
                            12. Upper pistillate scales shorter than perigynia; blackish-purple or blackish-brown, fading with age. .... 77. *C. atrata*
                    10. Perigynia not at all papillose or granular. .... 75. *C. epapillosa*
                9. Spikes, at least the lower, long peduncled (peduncles as long as its spike or longer.).
                    13. Lateral spikes linear, gynaecandrous, lower ones nodding on slender, roughish peduncles. .... 74. *C. bella*
                    13. Lateral spikes oblong or ovoid, pistillate; peduncles smooth. .... 77. *C. atrata*
    4. Culms not leafly at base (aphyllopodic); perigynia triangular-biconvex; scales usually strongly exceeding perigynia, awned or cuspidate. .... 78. *C. buxbaumii*

61. ACUTAE Fries.

1. Lower bract shorter than inflorescence; pistillate scales with rather inconspicuous midveins; perigynia purple-blotched above.
   2. Spikes approximate above, lower ones somewhat separate; lower bract leaf-like.
      3. Rhizomes purplish-red, stoutish; leaves numerous (8-20) per culm, clustered near base, all blade-bearing. .... 79. *C. bigelowii*
      3. Rhizomes light-tan, stout (3-4 mm.); leaves few (about 5), basal but few of lower ones not blade-bearing. .... 81. *C. campylocarpa* ssp. *affinis*
   2. Spikes closely aggregated; lower bract squamiform, much shorter than culm. .... 80. *C. scopulorum*
1. Lower bract equaling or exceeding inflorescence; pistillate scales with lighter midvein usually conspicuous; perigynia light-colored in most species.
   4. Perigynia with conspicuous raised nerves.
      5. Plants cespitose, forming rather large clumps; rootstocks slender; perigynia ovate, 1.5-3 mm. long, beaks entire. ...... 82. *C. kelloggii*
      5. Plants loosely cespitose and strongly rhizomatous with stout horizontal rhizomes; perigynia obovate, 2.7-3.5 mm. long, beaks bidentate. .... 83. *C. nebraskensis*
   4. Perigynia nerveless except for marginal ribs.
      6. Culms purplish at base and from long, slender, brown horizontal rhizomes; perigynia 2-3 mm. long. .... 84. *C. aquatilis*
      6. Culms light-tan at base and from thick, light-colored rhizomes; perigynia 2.7-3.5 mm. long. .... 81. *C. campylocarpa* ssp. *affinis*

67. PSEUDO-CYPEREAE Tuckerm.

Represented by one species in our area. .... 85. *C. hystricina*

68. PALUDOSAE Fries.

1. Perigynia glabrous, 7-10 x 2 mm., beak bidentate with teeth 1.2-3 mm. long; sheaths soft-hairy. .... 86. *C. atherodes*
1. Perigynia hairy, 5-6 mm. long, beaks bidentate with teeth 0.75-1 mm. long; sheaths short-pubescent. .... 87. *C. sheldonii*

70. VESICARIAE Tuckerm.

1. Stigma normally two; perigynia scarcely inflated, 3-5 mm. long; beaks 0.5-1 mm. long. .... 88. *C. physocarpa*
1. Stigmas normally three; perigynia from scarcely to much inflated.
   2. Perigynia reflexed or horizontally spreading, 7-10 mm. long and much inflated; sheaths loose, forming a prolonged, truncate summit; bracts several times exceeding the inflorescence. .. 89. *C. retrorsa*
   2. Perigynia ascending or spreading; sheaths tight and concave at mouth; lower bract shorter, moderately exceeding inflorescence.
      3. Rootstocks short-creeping, long horizontal rhizomes absent; culms ascending, not erect.
         4. Perigynia 4-8 mm. long, 3-4 mm. wide, rather abruptly narrowing into a beak; scales narrower than and from half to as long as perigynia. .... 90. *C. vesicaria*
         4. Perigynia 7-10 mm. long and 2-3 mm. wide, tapering into a beak; scales narrower than and from a third to half the length of perigynia. .... 91. *C. exsiccata*
      3. Rootstocks short but sending forth long, stout, horizontal rhizomes; culms erect. .... 92. *C. rostrata*

DESCRIPTION OF SPECIES

1. *Carex hepburnii* Boot., in Hook. Fl. Bor. Am. 2:209. pl. 207. 1839. (*C. nardina* Fries, var. *hepburnii* Kukenth.)

Plants densely cespitose; culms short and wiry, 2-15 cm. long with old sheaths forming a fasciculate base; leaves very narrow (0.25 mm.), wire-like; spikes solitary, androgynous, with 5-15 erect-appressed perigynia, staminate portion inconspicuous; scales, brownish, with narrow white-hyaline margins, wider than and slightly longer to shorter than perigynia; perigynia biconvex or plano-convex, 3-4.5 x 1.2-2 mm., lanceolate, glabrous, obscurely striate on both faces, light to dark brown, ciliate above, abruptly beaked; beak 0.5 mm. long, hyaline and emarginate at apex; stigmas 2 or 3; rachilla present.

This species is often confused with *C. elynoides* which is also a sedge of dry alpine summits. It differs from that plant, however, in the following characters: 2 or 3 stigmas instead of consistently 3, staminate portion of spike inconspicuous. pistillate scales lack the conspicuous hyaline margin, and the perigynia glabrous and generally somewhat larger.

DISTRIBUTION

General—Southern Alaska and southward in the high mountains to Colorado, Utah, and Nevada.

Utah—Collected from the Uinta, Wasatch and La Sal Mountains and the Tushar Plateau.

HABITAT

Mackenzie lists *C. hepburnii* as a species of dry alpine summits and slopes. Some of our specimens have been collected from streamside meadows.

2. *Carex capitata* L., Syst. Nat. ed. 10. 1261. 1759.

Plants loosely cespitose with short-creeping, purplish-red rootstocks; culms 1-3.5 dm. high, slender, triangular and roughened above, purplish at base, old leaves persistent; leaves 2-4 per culm, involute; spikes solitary, androgynous, globose or oval, 4-10 mm. long; scales brown with broad hyaline margin and apex, shorter and narrower than perigynia; perigynia 2-3.5 x 1-2 mm., plano-convex, oval, greenish to light brown, with sharp smooth edges, spreading, abruptly beaked; beak generally from one-fourth to one-third the length of perigynium body, slender; rachilla present but shorter than achene.

DISTRIBUTION

General—An Arctic-Alpine species extending across America from Alaska to Greenland and southward in isolated locations on the higher mountains to New Hampshire, Colorado, Utah, and Nevada; also northern Eurasia.

Utah—Two specimens from Utah have been checked by the author, Maguire 15181, from the Bear River Mountains, and Lewis 512 from the Uinta Mountains.

HABITAT

Mackenzie lists it as a species of alpine summits and slopes. Of the two specimens listed above one was from a rather dry site while the other was from a damp alpine meadow.

3. *Carex engelmannii* L. H. Bailey, Proc. Am. Acad. 22:132. 1886.

Plants cespitose with slender, brown, scaly rhyzomes; culms 0.5-2 dm. high, slender, obtusely angled, generally smooth, with dried-up leaves at base; leaves several, basal, blades filiform, 0.5 mm. wide, stiff; spikes solitary, androgynous, forming a dense oval head, staminate flowers inconspicuous, perigynia spreading at maturity; scales ovate, light to reddish-brown with light centers and hyaline margins, acute to acuminate, near the size of the perigynia; perigynia 4-5 x 2-3 mm., very membranous, somewhat inflated, much larger and only loosely enveloping achene, brownish, smooth, tapering to a minute, hyaline beak.

DISTRIBUTION

General—High mountains, from Washington and southward to Utah and Colorado.

Utah—Three specimens studied would indicate that *C. engelmannii* is an occasional species in some of the higher mountains of the State. One old collection in the Brigham Young University herbarium, collected from near Alta (Salt Lake County, Wasatch Mountains) in 1889 was the first evidence seen as to the presence of that species in the state. Later in working the Forest Service collection at Ogden, Utah, two more specimens were found; McDonald 955 (F.S. 64,684) filed in the herbarium under the name of *C. pyrenaica* Wahl. and McDonald 1099 (F.S. 68,073). The latter plant was one of two different species on one sheet under the name of *C. hepburnii*. Specimens were collected near the head of Bullion Canyon, Tushar Plateau, Piute County, Utah in 1931 and 1932.

HABITAT

Open alpine slopes and ridgetops often found growing in nearly pure stands.

4. *Carex subnigricans* Stacey, Leafl. West. Bot. 2:166 (1930). (*C. rachillis* Mag.) Brittonia 5:199-200. (1944). See also Leafl. of West. Bot. V:36-40 (1947).

Plants rhyzomatous; culms developing singly or few, 5-20 cm. high, obtuse, smooth, exceeding leaves, old leaves conspicuous at base; leaves 3-10 cm. long, 0.25-1.25 mm. wide, blades involute-filiform; sheaths striate dorsally, hyaline ventrally with callous spot generally developing behind ligule; spikes solitary, androgynous, ovoid, 8-12 x 3-5 mm.; pistillate scales reddish-brown to straw-colored, with light centers and white-hyaline margins, equal to shorter than perigynia, persistent; perigynia 2.5-4 x 1-1.5 mm., lanceolate to ovoid-lanceolate, brownish, nerveless, strongly stipitate, beak minute with hyaline orifice; rachilla from shorter to slightly exceeding achene.

Maguire originally assigned the Utah entity to subspecific status, viz. *C. subnigricans* subsp. *pallida*. Later he gave it full specific rank under the name of *C. rachillis*. According to Howell (1947), the differences between Maguire's and Stacey's plants are small. In the former, the callous spot back of the ligule develops only occasionally, and the rachilla is often shorter than the achene. Based on the original description, the Utah plant is not as leafy as Stacey's plant and the perigynia are smaller (Utah plant perigynia 2.5-3 mm. long, Stacey's plant 3.5-4 mm. long.)

Distribution

General—From the Sierra Nevada range of California northward and westward to Oregon, Idaho, and Utah.

Utah—Known only from the Unita Mountains. Maguire, Hobson and Maguire 146688.

Habitat

In the Sierra Nevada Mountains, *C. subnigricans* is a rather common plant of the mountain meadow and moist rocky slopes at about timberline, but may extend into the alpine zone. Data with the Utah collection indicated grassy ridges and slopes at about timberline.

5. *Carex gynocrates* Wormsk.; Drejer, Nat. Tidssk. 3:434. 1841.

Plants with long slender rhyzomes; culms 3-30 cm. high, slender, stiff and smooth; leaves clustered near base, blades 0.5 mm. wide, involute or folded; spike solitary, either dioecious or androgynous, loosely flowered, the 5-10 perigynia at length widely spreading or reflexed; scales light reddish-brown or brownish, short cuspidate to acuminate, shorter than perigynia; perigynia biconvex, 2.5-3.5 x 1.5-2 mm., yellowish or brownish-black at maturity, coriaceous, ribbed, shining, abruptly contracted into a short beak.

Distribution

General—Alaska to Greenland and southward to New York, Michigan, Colorado, Utah, and Nevada.

Utah—Only two specimens from Utah have been seen, McMillan's collection (No. 1105) from the Deep Creek Mountains and Willey's 301 from the Wasatch Plateau. A local and rare species in Utah.

Habitat

C. gynocrates is a species of swamps and wet streambanks, and often associated with willow thickets. It is a plant of higher elevations in our area.

6. *Carex pyrenaica* Wahl., Sv. Vet.-Acad. Nya Handl. 24:139. 1803.

Cespitose in rather large clumps; culms 3-25 cm. high, erect, obtusely triangular, generally exceeding leaves; leaves 2-4 per culm, basal, blades channeled, 2-10 cm. long by 0.25-1 mm. wide; sheaths persistent, old leaves conspicuous; spikes solitary, androgynous, linear-oblong, 5-20 x 3-5 mm., staminate flowers few and inconspicuous; pistillate scales ovate, obtuse, dark-brown with narrow hyaline margins and lighter centers, shorter to as long as perigynia; perigynia jointed to rachis and deflexed at maturity, 3-5 x 0.8-1.5 mm., lanceolate to oblong, dark-brown to straw-colored, shining, glabrous, stipitate; beak about 0.5 mm. long, hyaline tipped.

C. pyrenaica can be separated from *C. nigricans*, a closely related species, in that it is more densely cespitose but generally with fewer and narrower leaves per culm; somewhat narrower, linear-oblong spikes; inconspicuous staminate flowers. However, at times *C. nigricans* will also have this latter characteristic or an occasional spike may be found that is entirely pistillate.

Distribution

General—Our western American form extends south from British Columbia to Oregon, Utah, and Colorado. The species is also common to Europe and Alaska.

Utah—Mackenzie reports seeing a specimen of this entity from Utah, also Hayward (1952) listed it as a plant of the Uinta Mountains. The author also collected the species on the Uinta Mountains in 1956.

Habitat

Hayward lists this species as a member of the alpine subclimax community of the Uinta Mountains. Found also near seeps and on alpine slopes.

7. *Carex nigricans* C. A. Meyer, Mem. Acad. St. Petersb. Sav. Eta 1:211. pl. 7. 1831.

A rather loosely cespitose plant with stout creeping rootstocks; culms 0.3-3 dm. high, usually exceeding the leaves; leaves 4-9 per culm, light green, flat or channeled, 1.5-3 mm. wide; spikes solitary, androgynous, 6-9 mm. thick, the staminate flowers often conspicuous (usually over one-half length); pistillate scales dark-brown, much shorter than perigynia and deciduous; perigynia jointed to the rachis, reflexed and breaking away at maturity, 3.5-5 x 1-1.5 mm., brownish, stipitate at base and tapering into a smooth beak. (Plate II, III.)

Distribution

General—Alaska and southward to Colorado, Utah, Nevada, and California. Also Aleutian and Commander Islands.

Utah—Limited collections available for study indicate that the species is confined to the northern part of the State. Specimens were checked from the Bear River, Uinta and Wasatch Mountains.

Habitat

This is primarily a species of the spruce-fir zone meadows. It is sometimes found, however, in the lower alpine zone. Utah collections were generally from the better drained portions of the meadow and often in partial shade.

8. *Carex vernacula* L. H. Bailey, Bull. Torrey Club 20:417. 1893.

Culms singly or in small clumps and from long creeping rootstocks, 0.3-2 dm. high, obtusely angled, clothed at base with dried-up leaves; leaves clustered towards base, blades flat or channeled, 2-4 mm. wide; spikes numerous, aggregated and undistinguishable into an orbicular head; inconspicuous staminate flowers at the top; scales dark-brown, acute, largely concealing the perigynia; perigynia flattened-plano-convex, 3.5-4.5 x 1.5 mm., brownish in age, sharp-edged, not inflated, stipitate at base and contracted into a short smooth beak.

Maguire (Brittonia 5:199. 1944.) has assigned a plant collected from the Bear River Mountains to a variety of this species, *Carex vernacula* var. *hobsonii*. This entity differs from the main form in several important characters. It is a much taller plant with culms from 4-5 dm. high; leaves are confined to the lower third of the culms; the lower sheaths have undeveloped blades; rootstocks rather coarse and short creeping; scales light brown with lighter centers; perigynia conspicuously nerved dorsally and with serrate margins.

Distribution

General—This species is confined to the Rocky and Sierra Nevada Mountains of western United States.

Utah—Collections were studied from the Bear River and Uinta Mountains and from the Tushar Plateau. This sedge was found to be abundant in meadows near Big Flat and Puffer Lake, Tushar Plateau.

Habitat

According to Mackenzie, this is a species of "open sunny places, and alpine slopes." Data with Utah collections indicates a habitat in meadows and moist sites, primarily of the spruce-fir zone.

9. *Carex perglobosa* Mack., Bull. Torrey Club 34:606. 1908.

Plants loosely cespitose from creeping rootstocks; culms 6-15 cm. high with dried-up leaves at base; leaves short and clustered at the base, 0.75-1.5 mm. wide, flattened at base and narrower above; spikes several in a globose head, androgynous; pistillate scales thin with a hyaline apex and margin; perigynia plano-convex, 4-4.75 x 1.75-2.5 mm., inflated, substipitate at base and gradually tapering into a beak 1/4 to 1/3 the perigynium length.

It can be separated from *C. vernacula* by its filiform leaves, orbicular and silver hyaline margined scales, and inflated perigynia.

Distribution

General—Colorado Rockies to La Sals.

Utah—Only from the La Sal Mountains has this plant been collected in Utah. There, it is locally frequent.

Habitat

Rocky slopes and summits of high mountains.

10. *Carex douglasii* Boot, in Hook, Fl. Bor. Am. 2:213, pl. 214. 1839.

Culms arising, one or few together from long creeping, slender rootstocks, 6-30 cm. high, obtusely triangular; Leaves 3-8 to a culm and clustered near base, blades 1-2.5 mm. wide, thick, flattened or canaliculate towards the base; heads usually dioecious, 1.5-5 cm. long and 7-15 mm. thick, consisting of many closely aggregated spikes; pistillate scales with wide hyaline margins, exceeding the perigynia in lengths; perigynia plano-convex, 3.5-4 mm. long and 1.75 mm. wide, stipitate at base and tapering or rather abruptly narrowed into a long serrulate beak; styles very long and conspicuous at flowering time.

This species is separated from the other members of the section by its large, usually dioecious heads.

Distribution

General—A common species throughout the western states and the northern Great Plains, and extending into southwestern Canada.

Utah—Widely distributed in Utah. Where records were absent from a few of the physiographic units, it was felt that incomplete collecting was the cause rather than the species absence from those areas. Collections examined from the Bear River, Uinta, Wasatch and Deep Creek Countains and from the Tavaputs, Wasatch, Aquarius and Markagunt Plateaus.

Habitat

The zonal range of this species is from the intermountain valleys to the spruce-fir. It is found more commonly, however, at the lower elevations. It prefers dry meadows and may even be found in rather alkaline sites. It is also quite characteristically found in lanes and yards where disturbance and trampling is above normal.

Forage value

Because of its tough, fibrous leaves, *C. douglasii* has a rather low palatability. As a result of its light use by grazing livestock, it has a tendency to increase where grazing pressure is excessive and the more desirable forage plants are weakened through grazing.

11. *Carex eleocharis* L. H. Bailey, Mem. Torrey Club 1:6 1889. (*C. stenophylla* Wahl. subsp. *eleocharis* (L. H. Bailey) Hulten).

Plants low growing (2.5-10 cm. tall) with the culms growing singly or few together from a very slender rootstock; leaves somewhat involute above and stiff; spikes closely aggregated into a solitary head, staminate flowers rather conspicuous, especially at flowering time; only a few perigynia develop at the base of each spike; scales light-brown, hyaline margined, obtuse, shorter to equalling perigynia; perigynia 2.5-3.2 x 1.5-2 mm., black at maturity and coriaceous, rather abruptly short beaked. This species is sometimes mistaken for *C. obtusata* in the field, the two species being similar in size and growth habits. They are rather easily separated, however, when the plants are headed out. *C. eleocharis* has more than one spike while *C. obtusata* is a unispike species. Vegetatively they can be separated by the purplish-black rootstock and flat leaves of *C. obtusata* as compared with the brown rootstocks and narrowly involute leaves of *C. eleocharis*.

Distribution

General—*C. eleocharis* is primarily a plains species and reaches its greatest development in the northern Great Plains. From there its range extends westward to Nevada and eastern Oregon. It is also found in Alaska in prairie relics.

Utah—This species is rather widely distributed but only moderately abundant in Utah. Collections have been checked from the Uinta, Wasatch, La Sal and Abajo Mountains and from the Tavaputs, Wasatch and Fishlake Plateaus.

Habitat

A plant of rather dry sites. Most of Utah's collections came from sagebrush-grass types of midelevations. Here this little sedge often occupies the openings between the sagebrush. It tends to replace the taller herbaceous plants that have been eliminated from these interspaces through heavy grazing use.

Forage value

Limited observations would indicate that this sedge has a moderate palatability. Because of its small size, it is a low producer per unit area but its general occurrence within its type gives it importance as a forage plant.

12. *Carex simulata* Mack., Bull. Torrey Club 34:604. 1908.

Plants with slender, long creeping rootstocks; culms arising singly or few together, sharply triangular, 2-5 dm. high; leaves 2-5 per culm and on the lower third, blades flat or canaliculate; spikes several, densely aggregated, lower spike conspicuously pistillate, the other spikes entirely staminate or with a few perigynia or in some cases the entire head may be either mostly staminate or mostly pistillate; scales brown with hyaline margins, cuspidate, completely concealing the perigynia; perigynia 1.75-3 x 1.4-1.6 mm., unequally biconvex, chestnut-colored at maturity, shining and coriaceous, abruptly narrowed into a short, serrulate beak (about 1/4 length of perigynia).

It differs from *C. praegracilis* mainly in its smaller and abruptly shortbeaked perigynia and its slender, brown, creeping rootstocks.

Distribution

General—A species of western United States which has been collected from all the states of that group.

Utah—The species is widespread in Utah and appears from records to be rather frequent but local. All specimens seen were from Maguire's collection at the Intermountain herbarium. Specimens examined were from Cache Valley, the Wasatch Mountains and the Wasatch, Fishlake, Aquarius and Markagunt Plateaus.

Habitat

A plant of bogs and swamps. Its zonal distribution is from the intermountain valleys upward to the spruce-fir zone.

13. *Carex praegracilis* W. Boott, Bot. Gaz. 9:87. 1884.

Rootstocks long creeping, black, thick; culms 2-7.5 dm. high, sharply triangular, dried-up leaves at the base; leaves 2-5 per culm, blades flat or channeled, 1.5-3 mm. wide; spikes several, densely aggregated into a head, lower somewhat separate, androgynous, staminate flowers inconspicuous; in ours, the heads may sometimes be nearly all pistillate or staminate; scales light-chestnut with conspicuous hyaline margin, concealing the perigynia; perigynia plano-convex, 3-4 x 1.4-1.7 mm., brownish-black at maturity, tapering into a relatively long serrulate beak (1/3—3/4 length of perigynium body).

Distribution

General—Widely distributed in western United States and extending eastward as for as Iowa and Michigan, northward to the Yukon Valley and southward to Texas and northern Mexico.

Utah—A common sedge throughout the State, but especially in the northern half. Collections studied were from the Uinta, Bear River, Wasatch and La Sal Mountains and the Tavaputs, Wasatch, Aquarius and Sevier Plateaus. Also from the intermountain valleys around Utah Lake, Bear River Valley and the Virgin River Valley.

Habitat

Its habitat may be somewhat varied but it is most commonly found in damp bottomlands, often where conditions are alkaline. In the mountains it may be found in sagebrush-grass types, open parks and rarely under aspen. Its zonal range in Utah is from the southwest desert to the aspen-fir.

Forage value

As a forage plant, its palatability is low. Limited observations would indicate that it is about equal to saltgrass. It is, however, abundant in places and furnishes considerable winter grazing for cattle and horses.

14. *Carex foenea* Willd., Enum. pl. 957. 1809. (*C. siccata* Dewey) see Rhodora 40:327-329. 1948.

Plants with long creeping, slender brown rootstocks; culms 1-9 dm. high, slender, arising singly or few together; leaves 4-7 per culm, blades 1-3 mm. wide, stiff; spikes 2-8, gynaecandrous aggregated or lower ones separate, terminal generally larger with a staminate base, middle spikes largely staminate, lower small and pistillate; scales medium-brown with silvery-hyaline margins and tan or green centers, generally acute, shorter to as long as perigynia; perigynia appressed-ascending, 4.5-6 x 1.75-2 mm., narrowly green-margined, more or less nerved, tapering into a beak nearly the length of the perigynium body, obliquely cleft and bidentate with stigma and style protruding from well down the dorsal suture. Sometimes confused with *C. praegracilis* which has not the wing-margined perigynia of this species and has stout blackish rootstocks as compared with the slender brown rootstocks of *C. foenea*.

Distribution

General—Transnorthern United States and southern Canada and extending southward in the western mountains to Colorado, New Mexico and Arizona.

Utah—Generally distributed through the mountains of central and southern Utah. Collections have been examined from the Wasatch, La Sal, Abajo, and Pine Valley Mountains and from the Wasatch, Aquarius and Markagunt Plateaus.

Habitat

C. foenea prefers rather dry sites. On the La Sal and Abajo Mountains it was observed to be growing principally in the *Festuca thurberi* community and other open grasslands. Its zonal range extends from the intermountain valleys upward to the subalpine grasslands.

15. *Carex vallicola* Dewey, Am. Jour. Sci. II.32:40. 1861.

Plant cespitose but with short rootstocks; culms 2-6 dm. high, slender, sharply triangular, rough above; leaves about 3 to a culm, blades narrow (1-1.5 mm.), thin, basal; spikes in a dense terminal head, 15-20 mm. long and about 7 mm. wide, staminate flowers terminal and inconspicuous, with 2-5 or occasionally more perigynia per spike; scales brownish with wide hyaline margins, acute, or some short cuspidate, shorter than the perigyna; perigynia plano-convex, 3-4 x 1.6-2.2 mm., margined above, green or occasionally with brown tinging, abruptly narrowed into a minutely serrulate beak, about 1/4 the length of perigynium body, obliquely cleft and only slightly bidentate. It can be separated from the other Utah species of the section by its short, abrupt, obliquely cleft and entire to shallowly bidentate beak.

Distribution

General—From the northern Great Plains southward and westward to Oregon, California, Mexico, Nevada, Utah and Colorado.

Utah—A frequent and widespread species in the State. Collections have been studied from the Bear River, Uinta, Wasatch, Sheeprock, La Sal and Deep Creek Mountains and the Tavaputs, Wasatch, Pavant, Sevier, and Aquarius Plateaus.

Habitat

Ordinarily this species is associated with the sagebrush-grass type of moderate elevations, but may extend from the foothills to the open grassy slopes of the spruce-fir zone.

Forage value

Preliminary studies indicate that *C. vallicola* was an important constituent of the mountain grasslands and sagebrush-grass communities of our area. Owing to its relatively high palatability, the species has been adversely affected by heavy livestock grazing. This is indicated by its scarcity in ranges in poor condition and its common occurence in those of fair or good condition. In utilization studies on cattle range this sedge is equal to the better native bluegrasses growing in the same site.

16. *Carex hoodii* Boott, in Hook. Fl. Bor. Am. 2:211. pl. 211. 1839.

Plant densely cespitose; culms slender, sharply triangular, 2.5-8 dm. high; leaves two to three per culm and basal, blades flat or channeled at base, 1.5-3.5 mm. wide, spikes 4-8. closely aggregated, forming a dense head, androgynous; scales chestnut-brown, with conspicuous hyaline margins, about as long as perigynia; perigynia plano-convex, 3.5-5 x 1.5-2.5 mm., brownish with age, green margined, beak 1/3 to 1/2 the body length, sharply bidentate and conspicuously sutured on both sides.

It differs from *C. occidentalis* in its larger and denser tufts, more closely aggregated spikes, larger perigynia and beak with both sutures conspicuous. (Plate II, III)

Distribution

General—Western North American mountains, extending south from British Columbia, Alberta and South Dakota to Colorado, Utah, Nevada and California.

Utah—*C. hoodii* is a very common species throughout the mountains of north central Utah. It appears to reach its greatest abundance in the central Wasatch Mountains but it is also an important constituent of the herbaceous cover on the Bear River, and western spur of the Uinta Mountains and the Wasatch Plateau. The species was found to be locally abundant on the west end of the Tavaputs Plateau, the Tushar Plateau and the La Sal Mountains. One collection studied was from the Raft River Mountains.

Habitat

It is a species that requires rather damp sites. Most commonly it is found growing along protected drainage bottoms, in open conifer, along north and east edges of conifer and aspen patches and in protected parks. Occasionally, it is associated with the grass community on open slopes. Its elevational requirement lies between the mountain brush and the spruce-fir zones.

Forage value

This sedge furnishes considerable forage for both cattle and horses. This is mainly due to its abundance. Its relative palatability would be about medium, probably a little below that of slender wheatgrass. The plant is a good soil binder and lays down a good litter cover adjacent to the plant, thus giving it a high value as a watershed plant.

17. *Carex occidentalis* L. H. Bailey, Mem. Torrey Club 1:14. 1889.

Cespitose, rootstocks, short-creeping; culms 2-8 dm. high, exceeding leaves, slender and stiff; leaves about 3 per culm, blades 1.5-2.5 mm. wide; ligule longer than wide; spikes 5-10, upper aggregated, lower little separate, androgynous, staminate spike inconspicuous, and containing 10 or fewer spreading perigynia; scales brownish with opaque margins and green centers, acute to acuminate, slightly shorter to as long as perigynia and nearly concealing them; perigynia plano-convex. 2.5-4 x 1.25-1.75 mm., brownish in age, stipitate at base, nerved, abruptly narrowed into a serrulate, bidentate beak, sutures inconspicuous.

See description of *C. hoodii* for its separation from that species.

Distribution

General—Rocky Mountains from Wyoming and Idaho south to Nevada, Arizona and New Mexico.

Utah—Most of the collections seen in Utah herbaria were from the northern portion of the State, particularly the Uinta, the Wasatch and the Bear River Mountains. Two sheets were studied from the Deep Creek Mountains and one each from the Tushar Plateau and the south edge of the Pine Valley Mountains.

Habitat

This sedge is found growing in somewhat varied habitats. Collection data lists it from meadows, well-drained hillsides, and open timber types. It is most commonly found at mid-elevation zones but may extend upward to the spruce-fir zone or it may follow stream courses downward to the intermountain valleys.

18. *Carex cusickii* Mack., Piper and Beattie, Fl. N.W. Coast 72. 1915.

A rather large, coarse, tufted sedge, culms 7-12 dm. high and 4-6 mm. thick at base, aphyllopodic, much exceeding the leaves; leaves 3-4 blades per culm, 2.5-6 mm. wide, flat; sheaths septate-nodulose dorsally and red-dotted and copper-colored at mouth ventrally; heads decompound with upper spikes aggregated, spikes 4-8, androgynous with inconspicuous staminate flowers and from 5-10 spreading perigynia; scales brown with hyaline margins and light centers, acute to acuminate, near the length of perigynia; perigynia biconvex, thick, 3-4 x 1.5 mm., coriaceous, shining, brownish-black when mature, strongly truncate at base, abruptly narrowed into a setulose-serrulate beak.

Distribution

General—Vancouver, B.C. to Montana and Southward to Utah and California.

Utah—This species was reported from Utah by Mackenzie. There are, however, no specimens from Utah in the Utah herbaria.

Haritat

Mackenzie states it is a wet meadow plant. It is probably confined to the lower elevations and obviously rare in this State.

19. *Carex stipata* Muhl., Willd. Sp. Pl. 4:233. 1805.

A stout, densely cespitose sedge, with weak, concave-sided culms that become flat on drying; leaf-blades 4-8 mm. wide, flat, flaccid; sheaths septate-nodulose dorsally and cross-rugulose ventrally; spikes numerous forming a compound terminal head, staminate flowers above and inconspicuous, each spike containing 4-10 ascending or spreading perigynia; scales thin, hyaline, narrow, from shorter to as long as perigynia; perigynia lanceolate, plano-convex, 3.8-5 x 1.5-2 mm., strongly nerved on both faces and tapering into a long serrulate beak. (Plate III)

Distribution

General—A trans-North American species with a range from southern Alaska to Newfoundland and southward to North Carolina, Tennessee, Indiana, Kansas, New Mexico, Arizona and California.

Utah—Several collections of this species have been made in north-central Utah. All are from the central valleys and mostly from around the Great Salt Lake.

Habitat

In Utah it is found in meadows and swamps of the intermountain valleys. It appears to be tolerant of alkali soils because of its occurence around some of the bays of the Great Salt Lake.

20. *Carex disperma* Dewey, Am. Jour. Sci. 8:266. 1824.

Plant loosely cespitose with long slender rhyzomes; culms 1.5-6 dm. high, slender, weak, nodding; leaves 3-6 per culm and bunched on the lower third, blades 0.75-2 mm. wide, thin and soft; spikes 2-4, small, containing from 1-6 ascending perigynia, upper aggregated, lower somewhat separate, one or two of the spikes with inconspicuous staminate flowers at the tip; scales smaller than perigynia, deciduous, white-hyaline; perigynia unequally biconvex, 2-3 x 1-2 mm., thick, greenish, densely white punctate, abruptly short stipitate at the base, abruptly contracted into a minute beak.

This is the only Utah sedge of this section having androgynous spikes and long rhyzomes.

Distribution

General—Boreal forest zone. Alaska eastward across southern Hudson Bay to Labrador and Newfoundland and southward to Pennsylvania, Indiana, Minnesota, South Dakota, Colorado, Utah, and California.

Utah—Widely distributed in the State. It occurs frequently on the Uinta, Deep Creek and La Sal Mountains and is found occasionally on the Wasatch Mountains and on the Tushar and Fishlake Plateaus.

Habitat

Mackenzie lists it as a species of "boggy coniferous woods." In Utah is has been collected from boggy meadows and damp woodlands. It appears to favor partial shade. Its zonal range extends from the mountain brush to the alpine.

21. *Carex praeceptorum* Mack., No. Am. Fl., pt. 2, p. 95. 1931.

Plants cespitose in small clumps; culms low growing (1-1.6 dm.), sharply triangular; leaves 3-5 per culm and clustered on lower fourth of culm, blades 1.25-2 mm. wide, erect, channeled; spikes 4-5, small, aggregated, gynaecandrous, containing 8-20 ascending to loosely spreading perigynia; scales light chestnut with hyaline margins and broad green centers, acute to acuminate, shorter than perigynia; perigynia plano-convex, thick, 1.5-2 x 1 mm., yellowish-brown to green with brown tinging, nerved, densely white-punctate, abruptly contracted into a small (about 0.33 mm.) serrulate beak, dorsal sutural line present.

Distribution

General—This species was reported by Mackenzie as occuring in the mountains of California, Oregon, and Washington. He did however, include *C. canescens* var. *dubia* L. H. Bailey with the synonomy of *C. praeceptorum* with the type from the Bear River Canyon, Utah. A recent collection of this sedge by F. J. Hermann from Duchesne County and Lewis specimen number 125 from Wasatch County would definitely extend its known range to include Utah. It has also been collected from Nevada.

Utah—Collections would indicate that *C. praeceptorum* is a rather rare species of the Uinta and possibly the Bear River Mountains.

HABITAT

The specimens from which collection data are available shows this species to be a meadow plant. It occurred frequently in a grass-sedge meadow of the spruce-fir zone at approximately 10,000 feet elevation.

22. *Carex bipartita* All., Fl. Ped. 2:265. pl. 89, f. 5. 1785.

Loosely cespitose; culms 0.5-3 dm. tall, sharply triangular above, slender and often curving; leaves clustered on lower fourth of culms, blades 1-2 mm. wide, flat with revolute margins; spikes 2-4, aggregated, the lower slightly separate, gynaecandrous; scales dark-brown with lighter centers and wide white-hyaline margins, obtuse, as wide but slightly shorter than perigynia; perigynia plano-convex, 2-3.5 mm. long, golden brown, veined on both faces, tapering and substipitate at base, tapering above to a conspicuous, reddish-brown, hyaline tipped beak 0.5-1 mm. long (0.8-1 mm. long in ours).

DISTRIBUTION

General—Arctic alpine, from Alaska over northern Hudson Bay to Newfoundland and southward to British Columbia and Montana. Isolated in Utah. Also Greenland and Eurasia.

Utah—From Uinta Mountains. Maguire collected the species in the vicinity of Gilbert Peak.

HABITAT

Meadows and swamps. Spruce-fir zone to alpine.

23. *Carex brunnescens* (Pers.) Poir. in Lam. Encyc. Suppl. 3:286. 1813.

Plants densely cespitose in small to medium sized clumps; culms 1-7 dm. high, slender and rather lax; leaves 1-2.5 mm. wide, flat, thin and deep-green; spikes 5-10, lower strongly separate, terminal gynaecandrous, clavate, lateral usually gynaecandrous; bracts setaceous, prolonged; scales white-hyaline with green centers, shorter than perigynia; perigynia plano-convex, 1.5-2.5 x 1-1.5 mm., greenish or brownish, nerved, tapering into a short (0.5 mm.) serrulate beak, dorsal suture conspicuous for the entire length of the beak and onto the main body of the perigynia. Closely related to *C. canescens*. It can be separated from that species in that its perigynium has thin, easily broken walls, raised nerves, longer beak, with a conspicuous dorsal suture extending its full length and onto the main body of the perigynium (Hulten, Fl. Alas. and Yuk. 1942).

DISTRIBUTION

General—Southern Alaska to northern Labrador and Newfoundland and southward to mountains of Tennessee and North Carolina to Georgia, Ohio, Wisconsin, Minnesota, Colorado, Utah, and Oregon. Also Greenland and Eurasia.

Utah—Confined mostly to the Uinta Mountains where it occurs rather frequently. One collection from the Tushar Plateau was studied.

HABITAT

Bogs and wet meadows of the spruce-fir and alpine zones.

24. *Carex canescens* L., Sp. Pl. 974. 1753.

Plants densely cespitose; culms 1-8 dm. high, erect; leaves 5-8 per culm, blades 2-4 mm. wide, flat, glaucous-green; spikes 4-8, upper approximate the lower separate, heads erect or flexuose; bracts cuspidate; scales hyaline with green centers, ovate, acute, shorter than perigynia; perigynia plano-convex, 1.8-3 x 1.25-1.75 mm. green, thick, nerves usually obscure, contracted into an inconspicuous beak (shorter than 0.5 mm.), dorsal suture inconspicuous or obsolete. (*See C. brunnescens.*) (Plate III)

This sedge is highly variable and is represented by several forms in North America.

DISTRIBUTION

General—Alaska to southern Hudson Bay and northern Labrador and Newfoundland and southward to Virginia, Indiana, Minnesota, Colorado, Arizona, Nevada, and California. Also, Greenland, Eurasia, South America, Falkland Islands, and Australia.

Utah—An occasional species through its range in the state. Collections studied from the Uinta, Wasatch, and La Sal Mountains.

HABITAT

Wet sites along streams, lake edges and meadows of the spruce-fir zone.

FORAGE VALUE

In none of the areas studied has this plant been found in sufficient quantities to be important as a forage plant; however, its relative palatability appears to be high. In areas where cattle are grazing it is difficult to find a plant that has not been grazed.

25. *Carex interior* L. H. Bailey, Bull. Torrey Club 20:426. 1893.

Plants densely cespitose; culms 1.5-5 dm. high, slender and wiry, aphyllopodic; leaves about 3 per fertile culm and on lower third, blades 1-3 mm. wide, thin flat, soft, yellowish green; sheaths tight and hyaline ventrally; spikes 2-4, generally forming a strict terminal head terminal spike peduncled, usually gynaecandrous, occasionally staminate; lateral spikes usually entirely pistillate, containing from 1-10 perigynia which are spreading at maturity; scales very obtuse, as wide but only half as long as perigynia; perigynia concavo-convex, 2.25-3.25 x 1.25-2 mm., thick, body widening just above base, rather abruptly contracted into a beak 1/4 to 1/3 the length of the body, ventral false suture inconspicuous.

This species closely resembles *C. angustior* but can be separated by its shorter, shallowly bidentate perigynium beak and inconspicuous ventral false suture.

DISTRIBUTION

General—Trans-United States and southern Canada, extending southward to Pennsylvania, Indiana, Michigan, Kansas, New Mexico, Arizona and northern Mexico.

Utah—*C. interior* has been collected in both the northern and southern parts of the State. Specimens studied were from the Bear River, Wasatch and Uinta Mountains and from the Markagunt and Paunsagunt Plateaus. It was listed as frequent to abundant on the plateaus. Its zonal distribution is from the intermountain valleys to the spruce-fir.

HABITAT

This plant grows in very wet sites, usually in the wetter parts of a meadow or in bogs. According to Mackenzie, it prefers calcium or non-acid sites.

26. *Carex angustior* Mack., in Rydb. F. Rocky Mts. 124. 1917.

Plants densely cespitose; culms 1-6 dm. high, very slender, aphyllopodic; leaves 2-4 per culm, blades 0.75-2 mm., flat or canaliculate; sheaths hyaline and more or less red-dotted ventrally; spikes 3-5, approximate to little separate, terminal spike gynaecandrous, the lateral pistillate, containing 5-15 widely spreading perigynia; scales yellowish with green centers, ovate, short cuspidate, equal to perigynia in length; perigynia plano-convex, 2.5-3.5 x 1.25 mm., light brown, sharp-edged, tapering into a sharply bidentate beak from one-half to equal the length of the perigynium body; beak conspicuously sutured on both sides (See *C. interior.*)

DISTRIBUTION

General — Trans-North America from Washington to Newfoundland and southward in the eastern U.S. to mountains of North Carolina and in the West to Colorado, Utah, Nevada, and central California.

Utah—The only specimens seen from Utah were collected from the Uinta Mountains and the Wasatch Plateau. Specimens checked were from the spruce-fir zone between 9,000 and 10,000 feet elevation.

HABITAT

Very wet meadows and bogs.

27. *Carex deweyana* Schw., Ann. Lyc. N.Y., 1:65. 1824.

Plants densely cespitose; culms slender, weak and generally spreading, 2-12 dm. high, old leaves conspicuous at base; leaves 3-6 per culm, blades thin, flat, 2-5 mm. wide, light-green; sheaths tight; spikes 3-4, upper approximate, gynaecandrous with staminate flowers often somewhat separate, lower spikes widely separate and usually pistillate; scales very thin, whitish-hyaline with green centers, nearly size of perigynia; perigynia 4.5-5.5 x 1.5-2 mm., plano-convex, nerveless ventrally, obscurely nerved dorsally, strongly spongy at base, tapering above into a long (about 2 mm.) serrulate beak, shallowly bidentate at apex, dorsal suture conspicuous with a hyaline margin.

C. deyeyana differs from *C. bolanderi* in its shorter more basal leaves, tight sheaths and shorter perigynium beak.

DISTRIBUTION

General—A boreal forest species, from upper Yukon River to the Great Lakes, southern Labrador and western Newfoundland, southward to Pennsylvania, Michigan, Iowa, South Dakota, Colorado, and Utah.

Utah—Two collections from the State have been studied, Maguire 21871 and Jones 1218. The Deep Creek and Wasatch Mountains were the only physiographic units represented. Collection data indicates that it is frequent on the Deep Creek Mountains.

HABITAT

Mackenzie lists it as a species of dry woodlands. Utah collections were from moist soils and streamsides, of mid-elevation zones.

28. *Carex bolanderi* Olney, Proc. Am. Acad. 7:393. 1868.

Plants cespitose; culms slender but erect, 1.5-9 dm. high, sharply triangular with concave sides, old leaves conspicuous; leaves 2-5 per culm, 1-5 mm. wide, light or yellowish-green; sheaths loose; spikes 5-8, sessile, upper aggregated, lower more or less separate, staminate flowers basal and inconspicuous; scales brownish with green centers and hyaline margins, as wide but shorter than perigynia; perigynia 4-4.5 x 1-1.3 mm., plano-convex, strongly nerved, stipitate and spongy at base, rather abruptly tapering at apex into a conspicuous beak; beak serrulate, deeply bidentate, dorsal suture with light-brown margin.

DISTRIBUTION

General—A species of the mountains of

western North America. Mackenzie gives its range as extending from British Columbia and western Montana, southward to New Mexico and southern California.

Utah—No specimens from Utah were available for study. Mackenzie lists it as occurring in the State.

HABITAT

Open woodlands.

29. *Carex pachystachya* Cham., Steud. Syn. Cyp. 197. 1855.
(*C. macloviana* D'Urville subsp. *pachystachya* (Cham.) Hulten)

Plants very densely cespitose; culms slender, 3-10 dm. high, sharply triangular above, nearly smooth; leaves 3-5 per fertile culm, blades flat, 2-4 mm. wide, deep-green; spikes 4-12, closely aggregated, gynaecandrous with staminate flowers inconspicuous, containing 10-30, conspicuous, ascending perigynia; lower bract scale-like or short-awned; scales chestnut or blackish, acute, usually with a broad light midvein, about the width but shorter than perigynia; perigynia plano-convex, 3.5-5 x 1.5-2.25 mm., rather thick, copper-colored at maturity, narrow wing-margined, nerved dorsally, beak half the body length.

DISTRIBUTION

General—Alaska and southward down the western mountain chains to California, Utah, and Colorado. Isolated stations in eastern Quebec, Labrador, and Greenland. Also in Mexico, South America, and Falkland Islands.

Utah—A Utah specimen from the Wasatch Mountains has been checked (Cottam 1403, identified by Stacey).

HABITAT

From stream edges to xeric hillsides. Utah collection from near 10,000 feet elevation.

30. *Carex festivella* Mack., Bull. Torrey Club 42:609. 1915.

Plants cespitose; culms slender and stiff above, 3-10 dm. high, aphyllopodic; leaves 3-5 per culm and on lower fourth, flat, 2-6 mm. wide; spikes 5-20, densely aggregated into an ovoid head, gynaecandrous, containing 15-30 appressed-ascending perigynia; lowest bract generally prolonged but usually shorter than head; scales dark-chestnut or brown, shining, narrower and shorter than perigynia; perigynia thin and nearly flat to somewhat plano-convex, 3.65-4.75 (5) x 1.5-2 mm., ratio of width to length 0.39 to 0.5, light colored with dark beaks, strongly wing-margined at base and serrulate to middle, tapering into a long, nearly terete, bidentate beak. (Plate II)

This species is very closely related to *C. microptera*. Mackenzie separates them primarily by the darker, more shining scales and the broad wings of perigynia in *C. festivella*.

Our representatives of the two entities tend to grade into one another and are very hard to distinguish. In order to be consistent in identification, measurements below 0.25 mm. were considered as narrow, winged, 0.26-0.49 mm. medium winged, 0.5 mm. and over, wide winged. (Measurements were made from near the base of the achene.) Most of our *C. festivella* wing measurements fell in the medium class with a few considered as wide.

DISTRIBUTION

General—Primarily a species of the Rocky Mountains and Sierra-Cascade systems. It extends east, however, to Manitoba and the Black Hills of South Dakota and southward to northern Mexico.

Utah—A widely distributed and common species throughout the mountains and plateaus of Utah. Collections were studied from all units except the Stansbury Mountains and the Pavant Plateau.

HABITAT

Principally a plant of meadows and damp hillsides of mid-elevations. It may, however, extend as low as the mountain brush zone or upwards to the spruce-fir. It is often common along stream courses.

FORAGE VALUE

As a forage plant it is medium in palatability for cattle and horses and low for sheep. It is not eaten quite as readily as slender wheatgrass. In its habitat it is an important constituent of range in good condition.

31. *Carex microptera* Mack., Muhlenbergia 5:56. 1909.

Plants very densely cespitose; culms slender but strict, 3-10 dm. high, exceeding the leaves; leaves 3-5 per fertile culm, growing on lower third of culm, flat, firm, 2-4.5 mm. wide; spikes 5-10, aggregated into an ovoid head, gynaecandrous, with 15-30 spreading-ascending perigynia; lowest bract short-awned; scales light to dark-brown, shorter and narrower than perigynia; perigynia flattened to somewhat plano-convex, lanceolate, 3.6-4.8 x 1-1.8 mm., ratio of width to length 0.34 to 0.4, narrowly wing-margined (0.25 mm. or less), light-colored, serrulate, lightly to rather conspicuously nerved, tapering at apex into a beak one-half to one-third the body length; beak dark, nearly terete, bidentate. (Plate III)

In his original description of *Carex festivella*, Mackenzie stated "The closely allied *C. mic-*

roptera Mack. has narrower perigynia which are very narrowly margined at base and have more spreading beaks giving the head an echinate appearance . . . ."

DISTRIBUTION

General—Rocky Mountain and Sierra-Cascade systems from British Columbia and Alberta southward to Arizona and New Mexico.

Utah—This sedge is also common on the Utah mountains and high plateaus. Collections indicate that the species is particularly abundant through the Wasatch, Bear River, western Uinta Mountains and the Wasatch Plateau. Limited collections were available from the Aquarius Plateau and the La Sal, Abajo, Sheep Rock, and Pine Valley Mountains.

HABITAT

Primarily a species of meadows and along stream courses from the mountain brush upward to the spruce-fir zone. Occasionally it may be found growing in drier sites such as the sagebrush-grass community.

FORAGE VALUE

Observations indicate that this species is comparable as a forage plant to *C. festivella.*

32. *Carex ebenea* Rydb., Bull. Torrey Club 28:266. 1901.

Plants cespitose; culms 1.5-6 dm. high, exceeding the leaves, rather thick at base, erect aphyllopodic; leaves 3-5 per fertile culm, basal, blades flat, firm, 2-4 mm. wide; spikes 5-10, forming a dense head, each rather pointed at apex, staminate flowers at base and rather inconspicuous; lower bract shorter than head; scales brownish-black or black, as wide as but shorter than perigynia; perigynia somewhat flattened, narrowly lanceolate, 5-6.5 (7) x 1-2.3 mm., ratio of width to length 0.26-0.36, dark-colored, narrowly wing-margined at base, finely nerved, substipitate, narrowed above into a slender beak with shallow bidentate tip.

Separated from *C. haydeniana* by its generally narrow (0.25 mm. or less) wing-margin of perigynium and gradually narrowing, long, slender beak.

DISTRIBUTION

General—A sedge of the middle and southern Rocky Mountains, from Montana, Wyoming, and Utah southward to New Mexico and Arizona.

Utah—Found most commonly on the Uinta and La Sal Mountains where it may be locally abundant. Limited collections have been made from the Abajo Mountains and Tushar Plateau.

HABITAT

C. ebenea appears to be quite varied in its moisture requirements and may be found growing anywhere from the mountain meadows to the alpine ridgetop. It appears, however, to prefer the moister sites. A species of the spruce-fir to the alpine zones. In the Uinta Mountains it is often found growing in open spruce stands.

33. *Carex haydeniana* Olney, in S. Wats. Bot. King's Sxpl. 366. 1871. *C. nubicola* Mack.)

Plants very densely cespitose; culms 1-4 dm. high, erect to decumbent, sharply triangular above, generally smooth, leaves 3-5 per fertile culm, basal, blades flat, firm, 1.5-4 mm. wide; spikes 4-7, densely aggregated but distinguishable into an ovoid or globose head, gynaecandrous, with 15-35 ascending perigynia; bracts scale-like or short-prolonged; scales black or brownish-black, ovate, acute, shorter and narrower than perigynia; perigynia flat, thin, 4-5 (6) x 1.75-3 mm., ratio of width to length 0.39 to 0.57, blackish or brownish-tinged, strongly winged, doubly serrulate, abruptly contracted into a conspicuous, bidentate beak. (See *C. ebenea.*)

DISTRIBUTION

General—Canadian Rockies and southward to New Mexico, Arizona, Nevada, and California.

Utah—Frequent through most of the mountains and higher plateaus. Collection sheets were studied from the Uinta, Wasatch, La Sal, Henry, and Deep Creek Mountains and from the Wasatch, Tushar, and Aquarius Plateaus.

HABITAT

This is primarily a species of alpine and subalpine slopes and ridges. Occasionally it may be found growing along stream courses. Hayward, 1952, stated that this is one of the common sedges of the late rock-covering stages and xeric sub-climax of the Uinta Mountains.

34. *Carex illota* L. H. Bailey, Mem. Torrey Club 1:15. 1889.

Plants cespitose from short-creeping rootstocks; 1-3.5 dm. high, slender, stiff; leaves 2-5 per culm, basal, blades flat or canaliculate, 1-3 mm. wide, rather stiff; spikes 3-6, forming a small suborbicular head, gynaecandrous; scales blackish with lighter center, wider to about length of perigynia; perigynia thick, plano-convex, 2.5-3.3 x 1.2-1.4 mm., edges not serrulate, dark tinged, strongly nerved, substipitate at base, tapering above into a rather short, smooth beak.

This species does not appear to be closely related to other members of the section. It can be separated from them by its small, black head and lack of serrations on the perigynium beak.

DISTRIBUTION

General—British Columbia and south to Colorado, Utah, Nevada, and California.

Utah—Confined to the Uinta Mountains.

HABITAT

Observations and collection data indicate that *C. illota* grows primarily in meadows of the spruce-fir zone. It is often one of the more important constituents of the wet meadow community.

FORAGE VALUE

Moderately palatable to both sheep and cattle. In meadows near the head of the Whiterocks River where observations were made, it was eaten along with other meadow plants and appeared to be equally palatable to the majority of them. Its relative abundance plus its palatability would make it an important forage plant of the Uinta Mountains.

35. *Carex subfusca* W. Boott, in S. Wats. Bot. Calif. 2:234. 1880.

Plants very densely cespitose; culms 1:5-6.5 dm. high, slender, stiff, sharply triangular, smooth, leaves basal, 3-5 per fertile culm, blades flat, light-green, 1.5-4 mm. wide; spikes 4-12, definite and clustered, gynaecandrous, with 8-24 closely appressed perigynia, lower bract usually shorter than head; scales reddish-brown, nearly as long and as wide as perigynia, acute; perigynia plano-convex, 3-3.5 x 1-1.5 mm., light-colored to occasionally dark brown, venation conspicuous dorsally, wing-margined to base and serrulate, abruptly contracted into a beak; beak about 1 mm. long, reflexed (in ours), light or dark brown, shallowly bidentate, dorsal suture full length of beak and with a hyaline edge.

DISTRIBUTION

General—From Oregon to southern California and eastward to Arizona, Colorado, and Idaho.

Utah—One collection, Lewis 216, from the Thousand Lake Mountain in Wayne County.

HABITAT

The Utah specimen was from a dry meadow bordering the north edge of an aspen strip, spruce-fir zone at near 10,000 feet elevation.

FORAGE VALUE

Carex subfusca appears to be equal to *C. festivella* in palatibility. The specimen collected was from a temporary fenced plot. All herbaceous plants outside the plot had been completely consumed by cattle.

36. *Carex phaeocephala* Piper, Contr. U. S. Nat. Herb. 11:172. 1906.

Plants very densely cespitose and forming large clumps; culms 1-3 dm. high, slender, stiff and rough above; leaves 3-6 per fertile culm, clustered near base, blades canaliculate or nearly involute, 1.5-2 mm. wide; spikes 2-7, aggregated into a head, gynaecandrous; containing 10-20 appressed-ascending perigynia; lower bract short; scales brownish-black to reddish-brown with lighter centers and from narrow to wide hyaline margins, as long and as wide as perigynia and concealing them; perigynia concavo-convex, 4-5 (6) x 1.2-2 (2.5) mm., conspicuously wing-margined from top of achene to narrowed beak, nerved dorsally, abruptly contracted into a dark beak, 0.4-0.8 mm. long and conspicuously hyaline tipped.

DISTRIBUTION

General—Mountains of western North America from British Columbia southward to Colorado, Utah, Nevada and California.

Utah—This species has wide distribution through the mountains and high plateaus of Utah. Collections have been checked from the Bear River, Uinta, Wasatch, La Sal, and Deep Creek Mountains and from the Fishlake, Tushar, Markagunt, and Aquarius Plateaus. It is a particularly abundant species in the high Uinta and La Sal Mountains.

HABITAT

This species is found growing on open, rocky hillsides, on soil patches of talus slopes, or open grasslands. It prefers timberline or a little above. It appears to be one of the early invaders of talus. It is of interest to note that the species is an important constituent of the the *Festuca thurberi* grassland community of the La Sal Mountains.

FORAGE VALUE

Low in palatability. In no instance where observations were made did this species show anything but very light use.

37. *Carex leporinella* Mack., Bull. Torrey Club 43:605. 1917.

Plants densely cespitose in large clumps; culms 1-3 dm. high, stiff, sharply triangular, smooth; leaves 3-5 to culm, basal, blades flat or involute, 0.75-1.5 mm. wide; spikes 3-8, aggregated but distinct, forming a stiff, erect, gynaecandrous head, containing 8-20 closely appressed perigynia; scales reddish-brown with conspicuous white-hyaline margins, concealing the perigynia; perigynia plano-convex, 3.5-4 x 1 mm., very narrow wing-margined; beak about one-fourth the length of perigynia, light-colored, white-hyaline at apex.

It can be separated from its near relative, *C. phaeocephala* by its smaller and much narrower perigynia, narrower leaves and smooth culms.

DISTRIBUTION

General—Mackenzie only knew this species from the mountains of California to Washington. Recent collections have extended its range to Nevada, northern Utah and Colorado.

Utah—Known in Utah by Lewis 122, collected from head of Provo River in the western spur of the Uinta Mountains, Wasatch County.

HABITAT

Mackenzie assigned this species to high mountain summits. The Utah plant was from a grass-sedge meadow (*Deschampsia caespitosa* and associates) of the spruce-fir zone at 9,300 feet elevation.

38. *Carex praticola* Rydb., Mem. N. Y. Bot. Gard. 1:84. 1900.

Plants cespitose in small clumps; culms 2-7 dm. high, sharply triangular, erect or nodding; leaves 2-4 per culm, near base, blades flat, 1-4 mm. wide; spikes 2-7, forming approximate or moniliform, flexuous heads, gynaecandrous; lowest bract scale-like or short-cuspidate; scales greenish to dull-reddish-brown with conspicuous white-hyaline margins, concealing the perigynia; perigynia plano-convex, 4-6.5 x 1.5-2.5 mm., light-colored wing-margined at base, tapering at apex into a long serrulate, obliquely cleft beak, hyaline apex.

DISTRIBUTION

General—Trans-North America from Alaska to Greenland and Newfoundland, southward to northern United States in the east and down the western mountain chains to Colorado, Utah, Nevada, and California.

Utah—One collection record known from the State, Hermann 5096 from the Chain Lake basin of the Uinta Mountains.

HABITAT

Fernald lists this as a species of open woods, meadows, praires and clearings. Its name denotes "prairie dweller". The Hermann specimen was collected from a "dry, rocky, lake shore," at 11,200 feet elevation. (See Graham's Fl. of Uintah Basin 1932).

39. *Carex eastwoodiana* Stacey, Leafl. West. Bot. 2:122. 1938.

Plants densely cespitose; culms 2-4 dm. high, rather stout, stiff, obtusely triangular above; leaves 3-6 per fertile culm, near base; blades flat or canaliculate, 1.5-4 mm. wide; spikes 2-5, aggregated into an erect head, the lower often separate; lower bracts shorter than head; scales reddish-brown with lighter centers and white-hyaline margins, nearly concealing perigynia; perigynia concavo-convex, 5-6 x 1.75 -2.25 mm., reddish-brown at maturity, margins green-winged, serrulate, spongy base, tapering into a long (2 mm.) beak, reddish-brown with hyaline apex.

C. eastwoodiana is very closely related to *C. petasata* and is considered by some taxonomists as a form of this species. It is separated from that species it is generally lower growing, culms are rather stout at their base and obtusely triangular above, perigynia are usually smaller.

DISTRIBUTION

General—Stacey gives its range as Montana, Idaho, Oregon, Wyoming and Utah.

Utah—Stacey observed speciments collected from the Wasatch, La Sal and Henry Mountains.

HABITAT

From meadows to sagebrush-grass communities. It appears to be most common at our mid-elevations.

40. *Carex petasata* Dewey, Am. Jour. Sci. 29:246, pl. W. f. 72. 1836.

Plants cespitose with a short rootstock; culms 3-8 dm. high, slender at base, sharply triangular above; leaves 2-5 per fertile culm, flat, firm, 2-3 mm. wide; spikes 3-6, aggregated into an erect head, gynaecandrous, staminate flowers inconspicuous; lower bract scale-like or short prolonged; scales acute, light-reddish-brown with lighter midvein and broad silvery-white hyaline margins, largely concealing the perigynia; perigynia plano-convex, 5.8-8 x 1.6-2.25 mm., yellowish-brown at maturity, narrow wing-margined, tapering into a long beak, hyaline tipped.

DISTRIBUTION

General—This is a Rocky Mountain species. Reported from Yakutat Bay, Alaska, by Holm. From there it extends southward to British Columbia and Saskatchewan and to Colorado, Nevada and eastern Oregon and Washington.

Utah—*C. petasata* is frequent over most physiographic units of the State. Collections have been checked from the Uinta, Wasatch, La Sal, Henry, and Deep Creek Mountains and the Tavaputs, Fishlake, Pavant, Tushar, Markagunt, Paunsagunt, and Aquarius Plateaus.

HABITAT

All collections of this species by the author have been from the mountain sagebrush-grass or grassland communities. It has, however, been reported from meadows and aspen type.

Zonal distribution may be from the intermountain valleys upward to 11,000 feet. On the La Sal Mountains, it was found growing in the *Festuca thurberi* community.

FORAGE VALUE

When growing in the same sites with *Agropyron spicatum*, it was found to be higher in palatability to that species. On heavily grazed range, it is geneally found only within the protection of sagebrush. It was possibly one of the important sedges found in the mountain grasslands in pristine condition.

41. *Carex straminiformis* L. H. Bailey, Mem. Torrey Club 1.24. 1889.

Plants very densely cespitose; culms 1-4 dm. high; leaves 3-7 per fertile culm, on lower fourth, blades flat, 2-3.5 mm. wide, thick; spikes 3-10, closely aggregated into a head, gynaecandrous, staminate flowers inconspicuous, containing numerous ascending-spreading perigynia; lower bract scale-like or short; scales reddish chestnut with green midrib and white-hyaline margins, shorter and much narrower than perigynia; perigynia flattened, concavo-convex, 4.5-5.5 x 2.5-3 mm., light-colored, strongly winged with crinkled margins, abruptly narrowed into a conspicuous, flat, serrulate beak.

This sedge is very closely related to *C. egglestoni* from which it can be separated by its lower growing form and by its lighter-colored and smaller perigynium.

DISTRIBUTION

General—Cascade and northern Sierra Nevada Mountains and eastward to Utah.

Utah—One Utah collection from Mount Timpanogos of the Wasatch Mountains was available for study, (Castle 76c, identified by F. J. Hermann).

HABITAT

The Utah specimen was collected from a cirque at about 10,000 feet elevation. It was growing in light, rocky soil. Mackenzie listed it as a plant of high mountain summits.

42. *Carex egglestoni* Mack., Bull. Torrey Club 42:614. 1915.

Plants densely cespitose; culms 4-8 dm. high, sharply triangular, stiff, erect, rather stout; leaves 4-6 to a fertile culm, blades flat, 2-6 mm. wide, thickish; spikes 3-6, closely aggregated into an ovoid head, gynaecandrous, staminate flowers few, perigynia numerous and appressed-ascending; lowest bract short-prolonged; scales acute to short acuminate, reddish-brown with lighter midveins and narrow to wide hyaline margins, narrower and much wider than perigynia; perigynia flattened-concavo-convex, 6-8 x 2-3.5 mm., olive-green to brownish; strongly winged and serrulate, abruptly contracted into a conspicuous, broad, flat, bidentate beak.

DISTRIBUTION

General — Northwestern Montana and southward through eastern Idaho to Utah, Nevada, and Colorado.

Utah—An abundant species through the higher mountains and plateaus of the State. Collections examined from the Bear River, Wasatch, Uinta, and La Sal Mountains and the Tavaputs, Wasatch, Fishlike, Tushar, and Markagunt Plateaus.

HABITAT

Most commonly found growing in the grass-forb communities of the upper montane zones. It may also be frequent in open parks of the spruce-fir zone. This is one of the two most common sedges growing in the *Festuca thurberi* community of the La Sal Mountains.

FORAGE VALUE

Limited observations indicate that *C. egglestoni* is moderately palatable to cattle. In areas where abundant, it is an important forage plant for cattle. Sheep seem to make only light use of it where grazing pressure is moderate.

43. *Carex xerantica* L. H. Bailey, Bot. Gaz. 17:151. 1892.

Cespitose from short-creeping rootstocks; culms 3-6 dm. high, stiff, erect; leaves 2-3 to a culm, clustered at base, blades flat, 2-3 mm. wide stiff; spikes 3-6, approximate but distinct, gynaecandrous, staminate flowers inconspicuous, except in the terminal spike, with numerous closely appressed perigynia; lowest bract short; scales whitish to light-reddish-brown with green centers and wide white-hyaline margins, nearly concealing perigynia; perigynia flat, 4-5 (6) x 2-3 mm., greenish, straw-colored or light brown, broadly winged, serrulate, tapering into a flat, serrulate, bidentate beak, white-hyaline at orifice.

DISTRIBUTION

General—Primarily a species of the Great Plains but extending westward to Colorado, Wyoming, and Utah.

Utah—Recent collections would indicate that this is a wide-spread and relatively abundant species. Collections show it to be growing on the Uinta and La Sal Mountains and on the Aquarius Plateau. Future collections will probably bring it to light on other physiographic units.

HABITAT

In Utah *C. xerantica* is a plant of mid to rather high elevations. Also, it is a member of grass-forb communities. On the Aquarius Plateau it was observed growing in large openings in aspen type at about 9,000 feet elevation. A plant considered to be that species was a member of the *Festuca ovina* community of the 11,000 foot top of that plateau. In the aspen opening, this sedge made up as much as 8 percent of the plant composition and was associated with such species as *Stipa lettermanii*, *Festuca thurberi*, *Agropyron subsecundum* and *Poa fendleriana* plus numerous forbs.

A recent collection of the species was made from the head of Lake Creek Basin in Wasatch County. Here it was a common constituent of an open grass-forb community of which *Stipa lettermanii* was the most common species.

FORAGE VALUE

This species could be considered as moderately palatable to cattle. On moderately heavy grazed range, it was utilized to the same intensity as *Stipa lettermanii* or about 25 percent.

44. *Carex athrostachya* Olney, Proc. Am. Acad. 7:393. 1868.

Plants cespitose in small to rather large clumps; culms 0.5-6 dm. high, slender, spreading; leaves 2-4 to a culm, blades flat, 1.5-5 mm. wide, yellowish-green; spikes 4-20, aggregated or somewhat separate below, gynaecandrous, staminate flowers few, containing 15-40 appressed-ascending perigynia; one to three of lower bracts strongly developed; scales brownish with green centers and white-hyaline margins, narrower and shorter to nearly the length of perigynia; pergynia flat, 3-5 x 1-2 mm., wings medium to nearly obsolete, light-colored, tapering to a little flattened, serrulate beak, shallowly bidentate and hyaline at apex.

DISTRIBUTION

General—Alaska southward to British Columbia, Alberta, Saskatchewan, and North Dakota and down the western mountains to Colorado, Arizona, Nevada, and California.

Utah—Widely distributed through the central mountains and plateaus of the state. Collections were studied from the Wasatch, Uinta, and Pine Valley Mountains and from the Fishlake, Aquarius, and Markagunt Plateaus.

HABITAT

Meadow parks and stream sides from the intermountain valleys to the spruce-fir zone. It can often be found in intermittent streambeds or along road banks. Occasionally it grows on rather dry, rocky slopes.

45. *Carex saximontana* Mack., Bull. Torrey Club 33:439. 1906.

Plants cespitose; culms up to 3.5 dm. high, slender, weak, strongly triangular, serrulate; leaves 2-4 to a culm, clustered near base, blades flat and rather lax, glaucous-green, 3-5 mm. wide; spikes 1-3, widely separated, lower on long peduncles, androgynous, pistillate part with 2-5 perigynia on a zig zag, triangular winged rachis, each subtended by a scale, lower scales much elongated to a leaf-like form and exceeding the inflorescence; perigynia 4-5 x 2-2.5 mm., obovoid, green, contracted into a stipitate base, abruptly contracted above into a short, conic beak. (Plate II)

DISTRIBUTION

General—British Columbia to Manitoba, western Minnesota, Nebraska, Colorado, Utah, Idaho, and eastern Oregon.

Utah—Mackenzie listed Utah within the range of this sedge. One specimen was collected by the author from the Wasatch Mountains (drainage of Hobble Creek, Utah County).

HABITAT

Dry woods and thickets, intermountain valleys upward to mid-elevations.

46. *Carex filifolia* Nutt., Gen. 2:204. 1818.

Plants densely cespitose; culms 8-30 cm. high, filiform, wiry, broken off culms and leaves forming a fasciculate base; leaves 2-3 to a culm, bunched at base, blades wiry, acicular, involute, short, 0.25 mm. wide; spikes solitary, erect, linear, androgynous, upper half staminate, lower with 5-15 erect-ascending perigynia; pistillate scales light reddish-brown with conspicuous white-hyaline margins, broadly obovate, completely concealing the perigynia; perigynia ovoid or orbicular, 3-5 x 2-2.4 mm., obtusely triangular, puberulent above, light-colored, truncately narrowed into a short (1 mm. or less), hyaline beak.

C. filifolia and *C. elynoides* are often hard to separate. *C. filifolia* can usually be separated by its more conspicuous broadly white-hyaline pistillate scales and somewhat larger perigynia, with a rather conspicuous puberulence above. In our specimens of *C. elynoides,* the perigynia appear to be nearly glabrous and are only slightly scabrous above.

DISTRIBUTION

General—Praires, from Saskatchewan and Alberta to Texas and New Mexico and westward to Arizona, Nevada, Idaho, eastern Oregon, and California. Also in the Yukon.

Utah—The only known specimen from Utah is Harrison 8114 from the Buckhorn Wash, San Rafael Swell, Emery County.

HABITAT

This is primarily a praire species. In the mountain states it is generally associated with the sagebrush-grass communities of the river plains and intermountain valleys. It may, however, extend upwards to the lower montane zones.

GRAZING VALUE

C. filifolia is rather palatable to livestock. On cattle range where it was associated with *Festuca ovina, Agropyron spicatum* and native *Poa,* it was found to be equal in palatability to the *Agropyron* but more preferred than the *Festuca.*

47. *Carex elynoides* Holm, Am. Journ. Sci. IV. 9:356; 367. f.1. 1900.

Plants densely cespitose; culms 6-12 cm. high, filiform, wiry, erect, old culms and leaf blades broken off and forming a fasciculate base; leaves 2-3 per culm, blades wiry, stiff, acicular, involute, short. 0.25 mm. wide; spikes solitary, erect, linear, upper half staminate, lower with 4-8 erect-ascending perigynia; scales reddish-brown with dingy-white hyaline margins, thin. oblong-ovate, pistillate scales longer and wider than staminate and as long to longer than perigynia; perigynia obpyramidal-triangular, 2.5-4.2 x 1-2 mm., slightly puberulent or scabrous at base of beak, light-colored, often with dark tinging, tapering to base, abruptly narrowed into a cylindric hyaline beak. 0.5-1 mm. long. (See *C. filifolia* for differences.)

DISTRIBUTION

General—A Rocky Mountain species. Montana and Idaho and southward to Wyoming, Colorado, Utah, and Nevada.

Utah—It has general distribution throughout the high mountains and plateaus of the State. Collections were studied from the Uinta, Wasatch, Deep Creek, and La Sal Mountains and the Fishlake, Tushar, and Markagunt Plateaus.

HABITAT

High mountain tops and exposed ridges. All Utah collections checked were from the upper spruce-fir and alpine zones. Where this species is protected by rocks or fallen logs, its height may be several times greater than where growing on more exposed sites.

FORAGE VALUE

Ordinarily this sedge is too short to be of much value as a grazing plant for livestock. At one site horses were observed grazing it.

48. *Carex obtusata* Lilj., Sv. Vet-Akad. Nya Handl. 14:69. pl. 4. 1793.

Culms slender, arising 1-3 together from slender, purple-black rootstocks, 6-20 cm. high; leaves several, from near the base, blades, flat, channeled, 1-1.5 mm. wide; spikes solitary, androgynous, upper 2/3 staminate, lower 1/3 with 1-6 spreading ascending perigynia; scales thin, brownish, smaller than perigynia; perigynia dark, shining, 3-4 x 1.2-2 mm., suborbicular in cross-section, truncately stipitate at base, tapering into a short (0.5-1 mm. long), smooth beak, with hyaline tip and deep dorsal suture.

DISTRIBUTION

General—Alaska to Saskatchewan and southward across British Columbia to northern New Mexico and Utah. Widely distributed in Eurasia.

Utah—A rather common sedge through the central chain of mountains and plateaus. It is very common through the Joe's Valley depression of the Wasatch Plateau, on the Aquarius Plateau and the Thousand Lake Mountain. Collections were studied from the Uinta Mountains and Wasatch. Aquarius, and Sevier Plateaus. It was observed growing on the south end of the Wasatch Mountains and the Fishlake Plateau.

HABITAT

In Utah, *C. obtusata* is generally found at mid-elevations. It may, however, be found at elevations of 11,000 feet on the Aquarius Plateau. This sedge appears to be equally at home in open sagebrush-grass communities, under aspen shade, or in rather thick oakbrush types. When growing in the shade it has a longer and more lax leaf.

FORAGE VALUE

Like many of the low-growing grasses and sedges, *C. obtusata* appears to persist and even increase under heavy grazing use. In Scad Valley on the Wasatch Plateau, this little sedge often occupies the interspaces between the sagebrush while the taller grasses and sedges are confined to the protection of the brush.

49. *Carex rossii* Boott, in Hook. Fl. Bor. Am. 2:222. 1839.

Plants cespitose in medium sized clumps; culms 5-30 cm. high, slender. erect, reddish-purple at base, lower sheaths filamentose; leaves several, basal, blades 1-3 mm. wide, channeled above; terminal spike staminate, sessile or short peduncled; pistillate spikes 3-5, one or two above and contiguous, two or three from near the base on long or short, slender peduncles; lower bract leaf-like, normally exceeding the culms; scales greenish to brownish with green centers and hyaline margins, acute to acuminate, shorter than perigynia; perigynia 2.8-4.5 x 1.2-2.5 mm., short-pubescent, green often dark above, 2-keeled and stipitate; beak conic, 0.75-1.5 mm. long, ciliate-serrulate and deeply bidentate. (Plate III)

Distribution

General—Alaska and Yukon southward to Manitoba, Minnesota, Black Hills of South Dakota, Colorado, Utah, Nevada, and California. Isolated in Michigan.

Utah—*C. rossii* is widespread and common in Utah. Specimens have been examined from the Uinta, Bear River, Wasatch, La Sal, and Deep Creek Mountains and from the Tavaputs, Sanpitch, Tushar, and Markagunt Plateaus and a desert mountain in western Utah. This species was observed growing on the south end of the Pavant Plateau.

Habitat

Ross sedge grows in quite varied sites. It is most characteristically found in open timber stands from the pinyon-juniper to the spruce-fir zones. Occasionally it is found in open grasslands and alpine slopes. This is one of the more common herbaceous plants growing under the ponderosa pine on the east side of the Aquarius Plateau. Above Panguitch Lake on the Markagunt Plateau it can be found growing under the aspen. In the large basins just under the Uinta peaks, it is a common forest floor species under Engelmann spruce. Often it is an associate of *C. geyeri*.

Forage value

As a forage plant it is poor to good depending on the sites on which it is growing. In the dry pinyon-juniper site it may not be grazed evenly by cattle but in the aspen parks sheep were observed to be grazing it rather heavily.

50. *Carex pityophila* Mack., Bull. Torrey Club 40:545. 1913.

Plants cespitose in large, dense clumps; culms 10-15 cm. high, much shorter than leaves, slender, sharply triangular and rough; leaves 5-10 to a fertile culm, blades erect, flat, 0.75-3 mm. wide; lower sheaths filamentose; terminal spike staminate, peduncled; pistillate spikes 2-5, upper 1 or 2 contiguous, the others on slender peduncles from base, upper ones containing 1-3 perigynia; bract of upper spike leaf-like; pistillate scales acute, purplish-brown-tinged, about the size of the perigynia; perigynia 3.5-5 x 1.75-3 mm., 2-keeled, puberulent, green, suborbicular in cross-section, strongly stipitate; abruptly contracted into a beak, 0.75-1 mm. long, shallowly bidentate.

Distribution

General—Southern Colorado and southeast Utah to New Mexico.

Utah—One poor specimen from the La Sal Mountains was available for study. Mackenzie listed it as a species of Utah.

Habitat

Primarily a species of ponderosa pine and oakbrush types.

51. *Carex pseudoscirpoidea* Rydb., Mem. N. Y. Bot. Gard. 1:78. 1900.

Loosely cespitose from long-creeping rootstocks; culms 1.5-3.5 dm. high, stiff, triangular, old leaves conspicuous at base; leaves 5-10 to a culm and basal, blades 2-3 mm. wide, thickish, flat above; spike solitary, dioecious, both kinds of spikes closely many-flowered; scales brownish-black, with white-hyaline margins, staminate erose-ciliate, pistillate with lacerate and ciliate apex, pubescent; perigynia obovoid, 2.4-3.2 x 1.25-1.6 mm., strongly pubescent, abruptly contracted into a slender beak, 0.5 mm. long.

Some of the eariler collections from the state were referred to *C. scirpoidea*. It is now considered that the Utah material belongs to the above described species. (Plate III)

Distribution

General—Montana and Washington and southward to Colorado, Utah and Nevada.

Utah—A common species of the Uinta Mountains. Specimens have been checked from the Bear River, Uinta, and La Sal Mountains.

Habitat

This sedge is an important constituent of the more highly-developed apline tundra community. It tolerates a rather wide range of moisture availability from xeric alpine ridges to meadows. Although common to the drier sites, it grows more luxuriantly where moisture is more plentiful such as seeps and meadows.

Forage value

Moderately palatable and grazed by both sheep and cattle.

52. *Carex drummondiana* Dewey, Am. Jour. Sci. 29:251. pl. Y., f. 82. (*C. rupestris* Bellard:ex All.) 1836.

Plants loosely cespitose from long, slender rootstocks; culms low (6-12 cm. tall), stiff, erect, sharply triangular and roughened above, purple at base, old leaves conspicuous; leaves 8-12, basal, blades flat, canaliculate, 2-4 mm. wide; spikes solitary, androgynous, containing 1-6 erect-ascending perigynia, upper 2/3 staminate; pistillate scales orbicular-ovate, light to dark-brown with conspicuous white-hyaline margins and lighter centers, shorter to as long as perigynia; staminate scales lighter-colored and narrower; perigynia 3-4.5 x 1.6-2.4 mm., 2-keeled, triangular flattened, greenish-white and tinged with brown, substipitate at base and abruptly minutely beaked, apex white-hyaline, rough to entire. (Plate III)

Distribution

General—Rocky Mountains, British Columbia, Wyoming, Utah, and Colorado.

Utah—Collections would indicate that *C. drummondiana* is confined to the Uinta Mountains. Observations on a very limited portion of that mountain would indicate that it is relatively abundant in suitable habitats.

Habitat

Where the collections were made, this species was the dominant plant on very rocky south faces above timberline (about 11,500 ft. elevation). The ground surface area was about 2/3 rock and only about 1/3 soil. This little sedge formed a heavy cover in the soil patches between the rocks. It was also observed to be a common species on dry alpine ridgetops.

53. *Carex geyeri* Boott, Trans. Linn. Soc. 20:118. 1846.

Loosely cespitose with thick, elongate rootstocks; culms 1-4 dm. high, erect or nodding, stiff, sharply triangular, aphyllopodic; leaves generally 2 developed ones to a culm, 2-4 mm. wide, tough, flat or canaliculate, tips often dry; with numerous sterile shoots; spike androgynous, staminate part linear and short peduncled above 1-3 perigynia; pistillate scales greenish, exceeding the perigynia, the lower one often short-awned; perigynia 5.5-7 x 2.5-3.5 mm., triangular, 2 ribbed, short-stipitate and tapering at base, abruptly short beaked at apex. (Plate III)

Distribution

General—British Columbia and Alberta southward to Colorado, Utah and northern California. Introduced to Pennsylvania.

Utah—One of the more common sedges of the state. Collections studied were from the Bear River, Uinta, Wasatch and La Sal Mountains; the Sanpitch, Pavant and Tushar Plateaus. It has also been observed on the Wasatch Plateau.

Habitat

C. geyeri is primarily a species of open woodlands. In Utah, it is most commonly found associated with oakbrush and with the Douglas fir-white fir association. On the La Sal Mountains where the species seems to reach its greatest importance in Utah it is the dominant herbaceous plant under the oakbrush and some of the younger stands of aspen. Although this species is most common at mid-elevations, it is not confined to those zones. It grows commonly under Engelmann spruce and lodgepole pine on the Uinta and Wasatch Mountains and may extend up to timberline. It appears to have been an important constituent of its community in pristine condition.

Forage value

The foliage of this plant is tough and fibrous, consequently it is only lightly grazed during the season when other forage plants are green and lush. However, in the fall when other herbaceous plants begin to dry up, *C. geyeri* remains green. Cattle have been observed to graze the plant heavily at that time. This sedge remains green even under a snow cover. Elk are reported to dig it from under 2 to 3 feet of snow.

54. *Carex aurea* Nutt., Gen. 2:205. 1818.

Plants loosely cespitose with long, slender rootstocks; culms 0.5-5.5 dm. high, slender, erect, triangular and roughened above; leaves several per culm, basal, 2-4 mm. wide, flat above; spikes loosely few-flowered, terminal spike staminate or occasionally gynaecandrous or androgynous; lateral spikes 3-5, generally pistillate, upper approximate, lower separate; bract leaf-like, long sheathing, exceeding inflorescence; scales ovate, obtuse to short-cuspidate, reddish-brown to greenish with conspicuous 3-nerved green centers and white-hyaline margins, smaller than perigynia; perigynia orbicular-obovoid, 2-3 x 1.5 mm., fleshy, translucent and golden-yellow or brownish at maturity, short stipitate, nearly beakless.

Distribution

General—Boreal forest species. Alaska and Mackenzie Mountains to Newfoundland and southward to Pennsylvania, Indiana, Michigan, Nebraska, New Mexico, northern Arizona, Nevada, and California.

Utah—Rather common throughout the state. Study was made of collections from the Bear River, Uinta, Wasatch, Deep Creek, and La Sal Mountains and the Wasatch, Tushar, Markagunt, and Paunsagunt Plateaus. Also one collection from the White River Canyon in San Juan County.

Habitat

Bogs, meadows and streamsides from the intermountain valleys to above timberline. In Ephraim Canyon on the Wasatch Plateau it was found growing in freshly deposited calcareous mud.

55. *Carex hassei* L. H. Bailey, Bot. Gaz. 21:5. 1896.

Loosely cespitose; culms .5-2.5 dm. tall, from long rootstocks; leaves 2-4 mm. wide, flat; spikes 3-5, mostly remote, the terminal usually staminate but many gynaecandrous, androgynous or all the spikes pistillate; lower bract leaf-like, short-sheathing, inner summit of sheath truncate; pistillate scales ovate, firm, obtuse, to acuminate or with awns (2-6 mm. long), dark-brown to tan or mostly hyaline with broad 3-nerved light centers and white-hyaline margins and apex, generally shorter and narrower than perigynia; perigynia 2.5-3 mm. long, whitish or greenish, ovate to obovate, biconvex and somewhat flattened, rounding to tapering at base, cantracted at apex to a very short beak. (Plate III)

Distribution

General—A species of western United States (Colorado, Arizona, Utah, Nevada, and California).

Utah—Limited collections. Found on and near the Uinta and Wasatch Mountains and from Colorado drainage in southeast Utah.

Habitat

Wet meadows and bogs, intermountain valleys and canyons to the aspen-fir zone.

56. *Carex garberi* Fern., Rhodora 37:253. 1935.

Loosely cespitose from long slender rootstocks; culms 3-5 dm. high, slender, triangular; leaves flat, erect, shorter to longer than culms, blades 1.5-2 mm. wide (ours), light green, roughened, especially on the attenuate tips; terminal spikes staminate or androgynous, occasionally all spikes of a culm may be pistillate; lateral spikes 2-7, pistillate, densely crowded, especially above, sometimes the basal ones are on long, slender peduncles; lower bract leaf-like, shorter to exceeding culms, rather long sheathing (ours), "V" shaped or arcuate at inner summit of sheath; scales brown with 3-nerved green centers and white-hyaline margins, nearly as wide and half as long as perigynia, rounding to short mucronate at tip; perigynia 2-2.5 mm. long (ours), biconvex, rather plump, ellipsoid to obovoid, green, dry, somewhat white papillate, substipitate at base, rounded to somewhat tapering to a nearly beakless apex.

The small perigynia would indicate that our entity belongs to the typical variety rather than to var. *bifaria* Fern., Rhodora 37:255. 1935. The culms of our entity are rather tall and lax, however, as is common to the var. *bifaria*. This latter form has perigynia from 2.5-3 mm. long. Ripley and Barneby (Leafl. West. Bot. IV:208. 1945) considered their collection No. 6286 from White Pine County, Nevada as the typical variety.

Distribution

General—Area of the Great Lakes, Canada and United States, westward and southward to North Dakota, Nevada and Utah.

Utah—This form appears to be confined to the deep canyons of the Colorado in the southeastern portion of the state.

Habitat

River banks and seeps.

57. *Carex crawei* Dewey, Am. Jour. Sci. II. 2:246. 1846.

Culms growing singly or few together from long-creeping rootstocks, 1-3 dm. high, obtusely triangular, phyllopodic, old leaves conspicuous at base; leaves numerous, basal, light-green with blades 1.5-3 mm. wide; terminal spike staminate and long peduncled; pistillate spikes 2-4, separate, nearly sessile, oblong-cylindric with 10-45 ascending perigynia; bracts leaf-like, sheathing, 15 mm. long or less; scales reddish-brown with hyaline margins and green centers, mucronate to cuspidate, smaller than perigynia; perigynia ovoid, orbicular in cross-section, 3-3.5 x 1.25-2 mm., light-colored, beak very short with hyaline tip.

Distribution

General—Alberta to Quebec southward to Maine, northwest Connecticut, New Jersey, Alabama, Missouri, Kansas, Wyoming, Utah, and Washington.

Utah—Only one specimen from Utah was available for study. Maguire 18,828 from the Marl Bogs at the base of the Paunsagunt Plateau in Kane County.

Habitat

Wet, high calcium soils. Our specimen was from relatively low elevation.

58. *Carex capillaris* L., Sp. Pl. 977. 1753.

Plants cespitose in small clumps; culms 0.3-4 dm. high, very slender, reclining or spreading, smooth, old leaves conspicuous at base; leaves numerous, basal, flat, 0.75-3 mm. wide; terminal spike staminate or occasionally gynaecandrous, very slender, usually overtopping the uppermost pistillate spike; pistillate spikes 2-3, very slender, elongate, on drooping peduncles, containing from 3-20 ascending, loosely arranged perigynia; bracts long or occasionally short-sheathing, tubular; scales small and thin, light-chestnut, broadly hyaline margined, early deciduous; perigynia 2-4 x 0.5-1.5 mm., obtusely triangular in cross section, strongly stipitate, beak minute, scabrous at base, conic, purple-tipped.

Distribution

General—Alaska to Labrador and Newfoundland southward to New York, Indiana, Michigan, Wisconsin, Manitoba, New Mexico, Utah, and Nevada. Also Greenland, Iceland, and Eurasia.

Utah—Specimens checked from the Bear River and Deep Creek Mountains and the Markagunt Plateau. Hermann collected the species on the Uinta Mountains.

Habitat

Utah collections were from wet meadows

and rocky alpine tundra, with elevations from lower montane to alpine.

59. *Carex viridula.* Michx., Fl. Bor. Am. 2:170. 1803.

Plants densely cespitose in small clumps; culm 0.5-4 dm. high, stiff, erect, leafy; leaves 4-8 per culm, blades light-green, thickish, flat or channeled, 1-3 mm. wide; terminal spike normally staminate; pistillate spikes 2-6, oblong to globose-oblong, containing 15-30 spreading perigynia; bracts much exceeding inflorescense, short- to long-sheathing (2-15 mm.); scales small, rounded to short cuspidate, reddish to brown with green centers, shorter than perigynia; perigynia 2-3 x 1.25-2 mm., obovoid, yellowish-green, substipitate at base, strongly nerved, with minutely bidentate beak about ⅓ the length of perigynium body; achenes black and shining at maturity.

Distribution

General—Alaska to Ontario and Newfoundland, southward to New Jersey, Illinois, Indiana, New Mexico, Utah, Nevada, and California. Also southern Greenland and eastern Asia.

Utah—Two collections by Maguire were examined. Maguire 18,839 from the south end of the Paunsagunt Plateau and Maguire 19,546 from the vicinity of Navajo Lake on the Markagunt Plateau.

Habitat

Mackenzie lists this as a species of "seepy lake and river banks in calcareaus districts." One of the Utah specimens was from a marl bog and the other from near a mountain lake in basaltic formation. Zonal distribution was from the mountain brush to the spruce-fir.

60. *Carex misandra* R. Br., Chlor. Melv. 25. 1823.

Plants densely cespitose; culms 1-5 dm. high, slender and erect but nodding above, much exceeding leaves, old leaves conspicuous at base; leaves numerous and clustered at base, blades 1.5-4 mm. wide, stiff, canaliculate below; terminal spike gynaecandrous or staminate, slender peduncled and drooping; pistillate spikes 2-3, the lower ones nodding on slender peduncles; lower bract long-sheathing; scales ovate to lanceolate, thin, blackish with white hyaline apex, shorter to equalling perigynia; perigynia narrowly lanceolate, 3-5 x 1-1.5 mm., light colored below, purplish black above, 2-edged, tapering and short stipitate at base, long tapering above to a long beak, beak with ciliate-serrulate margins and while-hyaline apex. (Plate III)

Distribution

General—An arctic-alpine species. Alaska to Greenland south to northwest Labrador, southern Hudson Bay, and Alberta. Isolated in the mountains of Utah and Colorado.

Utah—An occasional species in the mountains of Northern Utah. Collections checked from the Uinta and Wasatch Mountains.

Habitat

More mesic portions of the open alpine tundra and grasslands.

61. *Carex ablata* L. H. Bailey, Bot. Gaz. 13:82, 1888.

Plants growing in dense, medium-sized clumps; culms slender, erect, 2.5-6 dm. high, exceeding leaves, old leaves conspicuous at base; leaves several, lower clustered at base, blades 2-5 mm. wide, light-green, flat; terminal spike staminate or with few perigynia, generally sessile, lateral spikes pistillate or occasionally androgynous, oblong, the lower separate on rough, rather long peduncles, drooping; bracts leaf-like, exceeding culm, long sheathing; scales ovate, purple-black with lighter center which is often extended dorsally to a short serrulate tip, shorter than perigynia; perigynia lanceolate, 3.5-5.5 x 1.25-2 mm., straw-colored to brown, usually purplish tinged, 2-ribbed, rounded and short-stipitate at base, hardly differentiated into a bidentulate beak.

Distribution

General—British Columbia and southward to Montana, Wyoming, Utah, and Nevada.

Utah—Species reported from the State by Mackenzie, no Utah material seen.

Habitat

Mackenzie lists it as a species of "mountain bogs and meadows."

62. *Carex fissuricola* Mack., Muhlenbergia 5:53. 1909.

Plants densely cespitose; culms 5-8 dm. high, erect, much exceeding leaves, old leaves conspicuous at base; leaves several per fertile culm, lower clustered, upper 2 or 3 separate, blades 3-8 mm. wide, striate; terminal spike staminate or with few perigynia at base; pistillate spikes 4-5, upper sessile and aggregated, lower separate and peduncled; bracts long-sheathing, with short leaf-like blades; scales brownish-black with light midvein extending beyond to form an acute to short-awned apex, narrower and shorter than perigynia; perigynia 4.5-5 x 1.75-2 mm., ovate, much flattened, sparsely hairy when young, green, purplish tinged, ciliate-serrulate margins, rounded and short stipitate at base, abruptly contracted into a bidentate beak (Plate II)

Distribution

General—Sierra Nevada Mounains of California and eastward to Nevada, Idaho, and Utah.

Utah—Only one specimen from Utah was available for study; Cottam 3585 (identified by Stacey) from the Tushar Plateau. Mackenzie listed it as a species of the Wasatch Mountains.

Habitat

The Utah specimen was collected from a streamside meadow at 8500 feet elevation on Tushar Plateau.

63. *Carex lanuginosa* Michx., Fl. Bor. Am. 2:175. 1803.

Plants loosely cespitose with long horizontal rhizomes; culms 2-10 dm. high, erect, sharply triangular, aphyllopodic, dark-purple base; leaves 2-5 to a culm, blades flat, 1.5-5 mm. wide, septate-nodulose; sheaths purplish-tinged; staminate spikes usually two, slender, long-peduncled; pistillate spikes 2-3, oblong-cylindric, separate, sessile or short peduncled; lower bract nearly sheathless, exceeding culm; scales reddish-brown with green centers, narrower and longer than perigynia; perigynia 2.5-4 x 1.75-2 mm., densely soft-hairy, many nerved, abruptly short-beaked, deeply bidentate.

Distribution

General—Very widely distributed in North America. Alaska to Quebec and New Brunswick and southward to Virginia, Tennessee, Texas, New Mexico, Arizona, and southern California.

Utah—Common in the state. Collections were checked from the Bear River, Uinta, Wasatch, and La Sal Mountains and the Tavaputs, Wasatch, and Markagunt Plateaus. Also, from the intermountain valleys and the lower Colorado River canyons.

Habitat

Meadows and grassy streambanks. Zonally, it may be found from the lower river canyons upwards to the aspen-fir.

64. *Carex limosa* L. Sp. Pl. 977. 1753.

Strongly rhizomatous with loosely forked rhizomes; culms 2-6 dm. high, arising obliquely, exceeding the leaves, purplish base, aphyllopodic; leaves 1-3 to a fertile culm, blades 1-3 mm. wide, deeply canaliculate, blades of sterile culms longer and more numerous; terminal spike staminate, on long, slender peduncle; lateral spikes 1-3, pistillate, separate, drooping on long smooth peduncles; lower bract leaf-like, very short-sheathing or sheathless, auricles brownish; scales brownish, with prominent green mid-nerve, ovate, as wide to wider and from as long to longer than perigynia, often with short mucronate tip; perigynia 2.5-4 x 2 mm., compressed-triangular, 2-edged, prominently nerved, truncate at base, rounded and minutely beaked at apex.

Distribution

General—Alaska to southern Hudson Bay, Labrador and Newfoundland, southward to Delaware, Indiana, Iowa, Saskatchewan, Manitoba, Idaho, Utah, Nevada, and California. Also Eurasia.

Utah — Mackenzie lists the species from Utah. Maguire also collected it from the Uinta Mountains.

Habitat

Common to sphagnum bogs. Maguire's collection was from a lake edge in the spruce-fir zone.

65. *Carex paupercula* Michx., Fl. Bor. Am. 2:172. 1803.

Loosely cespitose from short or elongate rootstocks; culms 1-8 dm. high, slender and erect or bending, old leaves conspicuous at base; leaves numerous, blades flat, 2-4 mm. wide; sheaths red-dotted ventrally; terminal spike staminate or with few perigynia above, long peduncled; lateral spikes 1-4, pistillate or few staminate flowers at base, approximate, on smooth, slender peduncles, suborbicular to oblong; lower bract leaf-like, exceeding the inflorescence, slightly sheathing; scales purplish-brown with greenish mid-vein, lanceolate to ovate-lanceolate, long acuminate, usually somewhat longer than perigynia; perigynia pale, 2.5-3.5 x 1.5-2.25 mm., compressed-triangular, 2-edged, nerved, stipitate base, rounded and scarcely beaked at apex. A varied species.

Distribution

General—Alaska to southern Hudson Bay to Labrador and Newfoundland, southward to Pennsylvania, Michigan, Wisconsin, Minnesota, Saskatchewan, British Columbia and Washington. Isolated in the mountains of Colorado Utah, and Nevada. Also widespread in Eurasia.

Habitat

A sphagnum bog species. Utah collections were from bogs and wet meadows of the spruce-fir zone.

66. *Carex tolmiei* Boott, in Hook. Fl. Bor. Am. 2:224. 1839. *C. podocarpa* Mack., not R. Br.) cf. Porsild, Bull. Nat. Mus. Canada 121:117. 1951.

Loosely cespitose from long rootstocks; culms 1-6 dm. high, erect, sharply triangular, old basal leaves conspicuous; leaves numerous, basal, 2.5-6 mm. wide, flat, firm; staminate spikes 1-2, short-peduncled; pistillate spikes 2-6, short-oblong to obling-cylindric, separate, upper sessile, lower on slender peduncles; lower 1 or 2 bracts leaf-like, exceeded by inflorescense; scales usually acute, purplish-black with conspicuous to nearly obsolete light mid-vein, shorter than to slightly exceeding perigynia, perigynia ovate, flat, 2-5 x 1.25-3 mm., papillose, lightly to moderately nerved, light green and purple blotched, beak about 0.2 mm. long, bidentulate, purple tinged.

C. Tolmiei can be separated from its nearest relatives in our area by its staminate terminal spike and flat perigynia.

Distribution

General—Alaska to Mackenzie district and southward to Wyoming, Colorado, Utah, and Nevada.

Utah—Uinta Mountains.

Habitat

A species of alpine meadows and tundra.

Forage value

In areas where abundant, this sedge is an important forage plant. Its palatibility is moderate. It appears to be resistant to heavy grazing which could partially be attributed to its rhizomatous growth habits and thus its ability to reproduce vegetatively.

67. *Carex raynoldsii* Dewey, Am. Jour. Sci. II. 32:39. 1861.

Loosely cespitose with stout, creeping rootstocks; culms 2-8 dm. high, stout, erect, phyllopodic; leaves several per culm, clustered towards base, blades flat, 3-8 mm. wide; terminal spike staminate, sessile, linear; lateral spikes 2-4, pistillate, generally approximate, lower ones on smooth peduncles, oblong, containing 15-40 ascending spreading perigynia; lower bract leaf-like, about length of inflorescence; scales broad, purplish-black with light-colored centers generally, acute, as wide as and shorter to exceeding perigynia; perigynia 3.25-4.5 x 1.75-2.5 mm., greenish to light brown, inflated, suborbicular in cross section, 2-ribbed, strongly nerved, substipitate at base, abruptly contracted into a minute, purple beak. (Plate I)

Distribution

General—British Columbia and Alberta and southward to Colorado, Utah, Nevada, and California.

Utah—The species is more common to the northern half of the state. Collections have been studied from the Uinta and Wasatch Mountains and from the west Tavaputs, Wasatch, and Tushar Plateaus.

Habitat

Meadows and open grasslands. Ellison 54 listed this sedge in his "Mixed Upland Herb Association." This is a frequent species within its range. Zonal distribution from the aspen-fir upwards to the alpine.

Forage value

Its palatability is relatively high for both cattle and sheep. Because of its heavy use by livestock it has undoubtedly suffered a considerable reduction in population.

68. *Carex aboriginum* M. E. Jones, Bull. Univ. Mont. 61:69. 1910.

Cespitose with very short rootstocks; culms 5-9 dm. high, slender, sharply triangular, smooth, aphyllopodic; leaves clustered above the base, blades erect, channeled, 1.5-3 mm. wide; terminal spike staminate, on a slender peduncle; lateral spikes usually two, upper sessile, lower on short peduncles, containing 10-30 crowded and ascending perigynia; lowest bract short and squamiform; scales as wide but only half the length of perigynia, purplish-red with light centers and hyaline margins; perigynia obtusely triangular in cross-section, 2-3.5 x 1.5-2.5 mm., 2 ribbed and finely nerved, abruptly contracted into a short, flat, bidentate beak.

Distribution

General—West Vancouver Island, British Columbia and southward to Idaho and Utah.

Utah—Only known in the state from the Bear River Valley in Cache County.

Habitat

The Utah collections were from wet swales and moist meadows of the Bear River Valley.

69. *Carex media* R. Br., var. Stevenii (Holm), Fern. Rhodora 44:303.

Cespitose in rather small clumps, culms 0.6-6 dm. high, more or less arch-ascending, sharply triangular, smooth to slightly roughened; leaves basal, rather soft, 1-3 mm. wide, old leaves persistent; spikes generally 3, terminal gynaecandrous, slightly separate in a small (4-10 mm. long) head, sessile to short (3-8 mm. long) peduncled; lower bract setiform or obsolete; scales generally shorter than perigynia, dark reddish-black, with narrow to medium wide hyaline margins, obtuse to acute; perigynia early deciduous, triangular, 2-3 mm. long, yellowish-green to dark reddish-brown, granular above, tapering at base, tapering above to a dark, rather conspicuous, shallowly bidentate beak with smooth to scabrous margins.

Distribution

General—Mountains of Colorado, Utah, and Idaho.

Utah—Specimens have been studied from the Uinta and Wasatch Mountains and from the Wasatch, Tushar, and Markagunt Plateaus.

Habitat

This form has only been observed growing along drainage courses in spruce-fir forests in this area. The sites on which it grows may vary from wet to damp.

70. *Carex nelsonii* Mack., in Rydb. Fl. of Rocky Mts. 137. 1917.

Loosely cespitose; culms 1.5-4 dm. high, stiff, erect, phyllopodic, old leaves conspicuous; leaves clustered at base, blades 3-6 mm. wide, flat, thick; spikes 2-3, closely aggregated into a dense head, sessile, terminal gynaecandrous; bracts inconspicuous; scales blackish, midvein narrow to obsolete, margins very narrow to rather conspicuous, obtuse to acuminate, narrower and from shorter to slightly longer than perigynia; perigynia 3-5 x 1.5-3 mm., suborbicular in cross-section, inflated, greenish, dark-purple blotched, 2-ribbed, puncticulate, granular, roughened and ciliate-serrulate above, contracted into a dark, cylindric beak, about 1 mm. long and spinulose-toothed.

Distribution

General—A species of the middle and southern Rocky Mountains of Wyoming, Colorado, and Utah.

Utah—To date it has been found only in the Uinta Mountains.

Habitat

Dry to wet meadows of the spruce-fir and alpine zones.

71. *Carex albo-nigra* Mack., in Rydb. Fl. Rocky Mts. 137. 1917.

Cespitose; culms 1-3 dm. high, stiffly erect, sharply triangular, phyllopodic, old leaves conspicuous; leaves basal, blades 2.5-5 mm. wide, flat, firm; spikes three, upper approximate and sessile, lower on a short peduncle and slightly separate, terminal spike gynaecandrous and clavate at base; lower bract leaf-like, about equal to inflorescence; scales broadly ovate, purplish-black with conspicuous white-hyaline margins and apex, as wide or wider and about length of perigynia; obtuse to acutish; perigynia triangular or rounded to somewhat flattened in cross-section, (2) 2.5-4 x 1.4-2.25 mm., granular, purplish-black, rounded at base and apex, beak short, shallowly bidentate, or from entire to spinulose at apex. This species is characterized by its relatively large, broad, usually blunt scales with a conspicuous white-hyaline margin and apex.

Distribution

General—Washington to Alberta and southward to Colorado, Arizona, and California.

Utah—This sedge has been collected primarily from the Uinta, La Sal, and Deep Creek Mountains where it has frequent occurrence. One specimen from the Tushar Plateau was also studied.

Habitat

A species of high mountain slopes and summits. It is often an important constituent of tundra communities. Occasionally it is a wet meadow inhabitant.

72. *Carex pelocarpa* Hermann, Rhodora 39:492. 1932.

Cespitose; culms 2.5-4.1 dm. high, sharply triangular, smooth, slender, nodding; leaves 3-6 to a fertile culm, mostly basal, blades 1.5-4 mm. wide, flat, firm; spikes 2-5, closely aggregated into a dense head, terminal spike gynaecandrous; bracts one and occasionally two below head, not exceeding inflorescence; scales oblong-lanceolate, pointed, dark-reddish-purple, narrower and from shorter to as long as perigynia or may exceed perigynia near apex; perigynia broad, 3.5-4.5 x 2-3 mm., flat, smooth, dark purple, glossy, rounded base and apex, beak short (0.5-1 mm.), bidentate, dark; achene long-stipitate. To quote Hermann "Its large, dark and glistening heads nodding on slender flexuose culms are a striking characteristic in the field."

Distribution

General—Montana and Idaho and southward to Wyoming and Utah.

Utah—Possibly confined to the Uinta Mountains.

Habitat

Hermann lists *C. pelocarpa* as a frequent species above timber line. It grows in more or less dry sites which includes the alpine tundra and barren slopes. It appears occasionally along the upper portion of the Bald Mountain trail, growing among the rocks.

73. *Carex nova* L. H. Bailey, Jour. Bot. 26:322. 1888.

Cespitose; culms 1.5-6 dm. high, stiffly erect, head nodding, sharply triangular, smooth or rough, phyllopodic, old leaves conspicuous; leaves chiefly basal, blades flat, firm, 2.5-6 mm. wide; spikes 3-4, sessile, closely aggregated into a dense head, terminal gynaecandrous, lateral pistillate, perigynia widely spreading at maturity; bract somewhat below the head; scales varied, purple-black with narrow hyaline margins, occasionally with lighter midvein, narrower and from shorter to about the length of perigynia; perigynia flat, 3-5 x 1.5-3.5 mm., granular, sparsely ciliate-scabrous, purple-black with green margins and straw-colored base, round to somewhat pointed at base, rounded above, beak short (0.5-1 mm.), sharply bidentate, entire to erose-cilliate at apex, purple-black.

Distribution

General—Rocky Mountains from Montana southward to New Mexico and Utah.

Utah—Collections indicate that *C. nova* is a frequent species on the Uinta and La Sal Mountains and is found occasionally on the Bear River and Wasatch Mountains and the Tushar Plateau.

Habitat

Normally found growing along streams and in mountain meadows. It may also be found in alpine grasslands. Elevational distribution is from the spruce-fir to alpine zones.

74. *Carex bella* L. H. Bailey, Bot. Gaz. 17:152. 1892.

Cespitose; culms 3-6 dm. high, very slender and often drooping, sharply triangular and rough above, old leaves conspicuous; leaves on lower half of culm, blades 2-6 mm. wide, flat, firm, erect; ventral sheath reddish-brown or dotted; spikes 3-4, cylindrical, approximate, terminal one nearly sessile and gynaecandrous, lateral ones usually drooping on long peduncles, occasionally nearly sessile, pistillate but generally with few staminate flowers at base; scales ovate, obtuse to acuminate, dark purplish-brown, generally with light-colored centers and shining white-hyaline margins, shorter than perigynia; perigynia flattish to triangular in cross-section, oval, 2.7-4.1 x 1.7-2 mm., greenish, some purplish tinged, smooth, rounded to rather pointed at base, contracted to a beak about 0.3 mm. long, purplish to brownish, shallowly bidentate.

Distribution

General—Montana and South Dakota, southward down the Rocky Mountains to New Mexico, Arizona, and Mexico.

Utah—An occasional species of the higher elevations of Utah. Collections studied were from the Uinta, La Sal, Abajo, Henry, and Deep Creek Mountains and from the Fishlake, Aquarius, Tushar, and Markagunt Plateaus.

Habitat

This species requires rather moist sites and is found most commonly along streams and in damp woods. Its elevational range extends from the aspen-fir upwards to the lower alpine zone.

Forage value

Because of this sedge's scattered occurrence, it does not contribute much as a forage plant. It is, however, highly palatable to all classes of livestock. Observations would indicate that it is equal in palatability to the better native bluegrasses.

75. *Carex epapillosa* Mack., in Rydb. Fl. Rocky Mts. 138. 1917.

Densely cespitose; culms 1.5-6 dm. high, erect, sharply triangular, smooth, phyllopodic, old leaves conspicuous; leaves on lower fourth of culm, blades flat, 2-7 mm. wide, stiff, erect; spikes 3-6 oval, terminal gynaecandrous, lateral pistillate, upper aggregated, lower on peduncles 3-10 mm. long; lower bract leaf-like, shorter than head; scales blackish with light midveins, pointed, narrower and about length of perigynia; perigynia oval, flat, except where distended by achene, 3-4.5 x 1.75-3 mm., puncticulate, very smooth, greenish or with purple blotches, rounded at base and apex, beak about 0.5 mm. long, bidentate, purple; achene strongly stipitate.

Distribution

General—Oregon to Montana and southward to Colorado, Utah, Nevada, and California.

Utah—This sedge is widely distributed in the state but is rather sparse. Collections studied were from the Uinta, Wasatch, and La Sal Mountains and from the Aquarius and Tushar Plateaus. The type species was from the Tushar Plateau.

Habitat

Generally found in seeps and meadows, occasionally found in damp shade. Elevational range is from the aspen-fir belt upwards to the lower alpine zone.

76. *Carex chalciolepis* Holm, Am. Jour. Sci. IV. 16:28, 29. f.1-5. 1903.

Densely cespitose; culms 2-7.5 dm. high, slender, weak, nodding or reclining, sharply triangular, old leaves conspicuous; leaves on lower half of culm, lower bunched, blades 2.5-6 mm. wide, erect, stiff, flat; spikes 2-4, terminal gynaecandrous, lateral pistillate, aggregated or lower separate, sessile to short peduncled, perigynia appressed-ascending; lower bract leaf-like, from shorter to longer than inflorescence; scales reddish-brown to blackish-purple with narrow to rather conspicuous hyaline margins, midrib inconspicuous, lanceolate, acute or acuminate, thin, much narrower but exceeding perigynia; perigynia 3-5 x 1.5-3 mm., broad, flat, granular or papillose above, dark purple or with green margins, sparsely ciliate-serrulate on margins, beak about 0.5 mm. long, emarginate, dark purple; achenes very short stipitate.

C. chalciolepis is similar and closely related to *C. atrata*. Kukenthal in his treatment of the group gave the former variatel status.

DISTRIBUTION

General—Wyoming and Colorado and westward to northern Arizona and eastern Nevada.

Utah—Widely distributed in the higher elevations of the state. Collections indicate that it is a frequent species on the Uinta and La Sal Mountains and has an occasional occurrence on the Wasatch and Deep Creek Mountains and on the Fishlake and Tushar Plateaus.

HABITAT

The site requirements of *C. chalciolepis* appears to be rather varied. It grows along streams and in meadows or on open mountainsides and exposed summits.

FORAGE VALUE

Moderately palatable to both sheep and cattle.

77. *Carex atrata* L., Sp. Pl. 976. 1753.

Cespitose; culms 1.5-5 dm. high, stiff below, slender and nodding above, sharply triangular, phyllopodic, old leaves conspicuous; leaves basal, blades flat, 2-8 mm. wide, stiff, papillose, ventral sheaths high-convex at mouth; spikes 3-7, approximate or lowest little separate, long or short peduncled, terminal and often upper ones gynaecandrous, lower pistillate, lower bract leaf-like, from shorter to exceeding head; scales ovate, black, brownish-black or purplish-black, fading with age, occasionally with light midvein and narrow hyaline margins, about as wide and shorter to slightly longer than perigynia; perigynia 3-4.5 x 1.5-3 mm., broad, flat, brownish, purple-blotched, papillose-margined, beak about 0.5 mm. long, emarginate, purple-tipped; achene short stipitate. (Plate III)

DISTRIBUTION

General—A circumpolar species ranging in North America from Greenland to Alberta and southward to Colorado, Utah and Nevada.

Utah—Relatively common through the higher elevations of the Uinta Mountains. Limited collections were seen from the Wasatch Mountains and the Tushar Plateau.

HABITAT

Principally a species of meadow edges and high grasslands. Hayward (1952) listed it in his subclimax community. Zonal range is through the spruce-fir and alpine.

FORAGE VALUE

Limited observations would indicate that this sedge has a palatability higher than that of slender wheatgrass. Where observed on sheep range, it had been moderately utilized.

78. *Carex buxbaumii* Wahl., Sv. Vet.—Akad. Nya Handl. 24:163. 1803.

Loosely cespitose with long, slender rhizomes; culms 2-10 dm. high, erect, very slender, aphyllopodic, sharply triangular and rough above, lower sheaths breaking to form a filamentose base; leaf blades 1.5-4 mm. wide, sharply keeled, flat, erect, thin; sheaths purple-dotted ventrally; spikes 2-5, approximate or lower separate, terminal gynaecandrous and short peduncled, lateral pistillate and sessile; bracts squamiform, may be as long as inflorescence; scales lanceolate, narrower and usually longer than perigynia, purple-black or purple-brown with light midvein; perigynia 2.5-5 x 1.5-3 mm., triangular-biconvex, glaucous-green, densely papillose, beak about 0.2 mm. long, bidentate, purple tipped.

DISTRIBUTION

General—Alaska to Newfoundland and southward to Georgia, Missouri, Colorado, Utah, Nevada, and California.

Utah—Both Mackenzie and Hulten show this species as occuring in Utah. Apparently it is rather rare as no material was found in any of the state herbaria.

HABITAT

A plant of sunny slopes and meadows of lower and mid-elevations.

79. *Carex bigelowii* Torr., Schw. Ann. N. Y. 1:67. 1824. (*C. concolor* R. Br.)

Strongly rhizomatous; culms stout, 1-4 dm. high, erect, sharply triangular, strongly phyllopodic with old leaves conspicuous; leaves numerous and clustered near base of fertile culm, blades 2-6 mm. wide, thickish, blue-green, papillate; terminal spike staminate or rarely with a few perigynia, usually strongly peduncled; upper lateral spikes often with staminate apex, lower ones short peduncled and pistillate; lower bract leaf-like, generally shorter than culm, black auricled; scales oblong-obovate, obtuse to acute, lighter midrib narrow or obsolete, strongly puncticulate, usually longer and wider than perigynia; perigynia unequally biconvex, 2-4 x 1-2 mm., 2-ribbed, light colored with purple-black blotches above, rounded at base, abruptly and minutely beaked.

DISTRIBUTION

General—Widely distributed in northern North America from Alaska to Greenland and southward in the higher mountains to New Hampshire, Alberta and British Columbia. Isolated in the high mountains of Colorado, Idaho and Utah.

Utah—Collections checked from the Uinta and Wasatch Mountains.

HABITAT

Mackenzie lists the species from "sunny, rocky shores and exposed places." Utah collections were from meadows of the spruce-fir zone.

80. *Carex scopulorum* Holm, Am. Jour. Sci IV. 14:421,422. f. 1-6. 1902.

Strongly rhizomatous with stout, purplish-red rhizomes; culms 1-4 dm. high, stiffly erect, sharply triangular, old and new leaves numerous at base; left blades flat, 2-7 mm. wide; terminal spike usually staminate but often partly pistillate, sessile or short-peduncled; lateral spikes 2-6, closely aggregated or occasionally separate, pistillate or upper androgynous, perigynia squarrose-spreading; lower bract squamiform, short, black auricled; scales usually obtuse, black, narrow with hyaline margins, narrower than and from shorter to as long as perigynia; perigynia biconvex and turgid, 2.5-4 x 1.5-2 mm., papillose, red-dotted, pale at base but purplish-black blotched above, may be remotely serrulate above, beak 0.2-0.5 mm. long, entire and often abruptly bent.

DISTRIBUTION

General—Rockies from Montana to Colorado and westward to the Sierra Nevada and Cascade ranges.

Utah—The only record of this species available was McMillan's listing from the Deep Creek Mountains. This species was collected by the author in Cassia County, Idaho, not far from the northwest corner of Utah.

HABITAT

Streambanks associated with willow. The Idaho plant was found growing along a small stream in open lodgepole pine and occupying the drier portion of the bank.

81. *Carex campylocarpa* Holm, ssp. *affinis* Mag. and Holmg., Leafl. West. Bot. 14;262. 1946.

Plants rhizomatous with stout (3-4 mm. thick), light tan, scaly rhizomes, roots covered with a silvery-gray felt; culms singly or few in clumps, 3.8-4 dm. high, sharply triangular and slightly roughened above, aphyllopodic, light tan at base, old leaves persistent; leaves about 5 per fertile culm, light green, flat, rather thin and soft, blades up to 7 mm. wide; lower bract leaf-like, shorter to exceeding the inflorescence, not sheathing; spikes generally about 7, upper 1-3 staminate or often androgynous, center 1 or 2 androgynous, lower 2-3 pistillate, upper aggregated, lower separate; scales blackish-purple, with wide to narrow light midribs, not extending to tip, obtuse to acutish, narrower and from shorter to as long as perigynia; perigynia 2.7-3.5 mm. long, straw-colored to light brown, dark brown or purplish tinged above, obovate, rather plump when mature, nerveless except for margins, rounding or tapering to a substipitate base, abruptly minutely beaked, beak usually with a ciliate orifice; stigma 2 or 3.

DISTRIBUTION

General—Typically this is a species of the Cascade Mountains of Oregon and Washington.

Utah—The subspecies is known only from the Deep Creek Mountains (Mag. and Holmg. 21949, Intermountain Herbarium).

HABITAT

Wet boggy soils of the spruce-fir zone. A locally frequent species.

82. *Carex kelloggii* W. Boott, in S. Wats. Bot. Calif. 2:240. 1880.

Cespitose in large clumps; culms 1-6 dm. high, old and new leaves conspicuous at base; leaf-blades flat above, light green, 1.5-3 mm. wide; sheaths thin-white hyaline, yellowish brown dotted ventrally; terminal spike staminate, rarely with few perigynia, peduncled; lateral spikes 3-5, pistillate, slightly separate; lower bract leaf-like, exceeding the inflorescence; scales dark-purplish-brown with broad light centers, obtuse to acuminate, narrower than and from shorter to nearly length of perigynia; perigynia ovate, 1.5-3 x 1-2 mm., early deciduous, light green, 2-ribbed, several nerved, often substipitate at base, abruptly short beaked, beak entire and black-tipped. (Plate III)

It separates from *C. nebraskensis* which also has a nerved perigynia in its lack of long horizontal rootstocks often smaller perigynia, shorter beak with entire orifice.

DISTRIBUTION

General—Alaska and southward to British Columbia and Alberta and to Colorado, Arizona, Nevada, and California.

Utah—Collections would indicate that *C. kelloggii* is a rather frequent species in the northern part of the State but rare in the south. Most of the specimens seen were from the Bear River, Wasatch, and Uinta Mountains. Only one specimen, from the Aquarius Plateau, came from the southern part of the state.

HABITAT

Grows in marshes, lake edges and streamside meadows. It is somewhat of a pioneer in that it often occupies the strip at the water's edge or even extends into shallow water. It is often locally abundant. Zonal preferences in Utah is from the aspen-fir to the spruce-fir zones.

83. *Carex nebraskensis* Dewey, Am. Jour. Sci. II. 18:102. 1854.

Strongly rhizomatous. Rhizones long, horizontal, stout, light-colored; culms 2-12 dm. high, old leaves conspicuous, usually brownish at base; leaves numerous, blades 3-8 mm. wide, light-green to glaucous-green, septate-nodulose; staminate spike one or with an additional smaller one at its base, peduncled; lateral spikes 2-5, pistillate, cylindrical, sessile to peduncled, the lower may be somewhat separate; lower bract leaf-like, usually exceeding inflorescence; scales lanceolate, from shorter to much exceeding the perigynia, purplish or brownish-black with a light center, often extending to a serrulate awn or tip; perigynia 2.7-3.7 x 1.5-2.5 mm., straw-colored, strongly many ribbed, beak 0.5-1 mm. long, bidentate, sometimes with spiny apex; stigma generally 2, occasionally 3. (Plate II)

Distribution

General—British Columbia and southward to South Dakota, Kansas, New Mexico, Arizona, Nevada, and California.

Utah—This is one of the most common and widely distributed sedges in the state. Either collections have been checked or the plant observed in the field on all of the major physiographic units with the exception of the Stansbury, Henry and Abajo Mountains. More likely than not it can also be found on those units.

Habitat

Nebraska sedge is a species of swamps and wet meadows mostly of the intermountain valleys and upwards to mid-elevations. Occasionally it is found in the spruce-fir zone. Characteristically, it grows in nearly pure stands.

Forage value

Because of its common occurrence, this sedge furnishes considerable forage both as a hay crop and for grazing. Its palatability is moderate when compared with the better grasses, yet under heavy grazing pressure, it may be completely consumed.

84. *Carex aquatilis* Wahl., Sv.-Vet. Akad. Nya Handl. 24:165. 1883.

Cespitose with long slender rhizomes; culms erect, 5-10 dm. tall, rather slender, obtuse-triangular and usually smooth, leafy and reddish-tinged at base; leaf blades 2-5 mm. wide, flat or channeled at base, light-green or glaucous-green; sheaths septate-nodulose dorsally and thin, whitish to purple ventrally; terminal spike staminate and peduncled, usually with a smaller sessile one at base, lateral spikes 2-4, pistillate or upper ones androgynous, cylindrical, erect, peduncled, containing 20-100 appressed-erect perigynia; lower bract leaf-like, normally exceeding culm; scales blackish-brown or purplish, usually with lighter center, ovate to obovate, narrower than and from shorter to longer than perigynia; perigynia biconvex flattened, not turgid, 2-3 x 1-2 mm., light-green to straw-colored, glandular-dotted, nerveless, abruptly contracted into a short, entire beak. (Plate II)

Distribution

General—Alaska to Labrador and Newfoundland and southward to New York and Illinois. In the West to Colorado, New Mexico, Arizona, Nevada and California.

Utah—Widespread and rather common throughout the state. It is especially common in the Uinta Mountains. Specimens checked were from the Bear River, Uinta, Wasatch, and La Sal Mountains and from the Wasatch, Sevier, Aquarius, and Markagunt Plateaus.

Habitat

A species of very wet sites. It grows in nearly pure stands in meadows and often occupies the water's edge of lakes and sluggish streams.

Forage value

Moderately palatable. Cattle and horses will graze it heavily in pastures and on overgrazed ranges.

85. *Carex hystricina* Muhl., Willd. Sp. Pl. 4:282. 1805.

Cespitose with few long slender rhizomes; culms slender, erect, 1.5-10 dm. high, exceeded by bracts and often by upper leaves, old leaves conspicuous at base of central culms; basal sheaths filamentose; leaf-blades 2-10 mm. wide, flat, thin, flaccid, septate-nodulose; terminal spike staminate, slender peduncled, usually with a conspicuous bract; lateral spikes 1-4, pistillate, the lower nodding on long rough peduncles, containing numerous spreading perigynia; scales light-colored, rough-awned, early deciduous; perigynia narrowly ovoid, 5-7 x 1-2 mm., greenish, membranaceous, shiny, conspicuously veined, narrowing to a slender and deeply bidentate beak.

Distribution

General—Trans-United States and Southern Canada and southward to District of Columbia, Tennessee, Oklahoma, Texas, New Mexico, Arizona, and California.

Utah—Probably confined to the lower Colorado Canyon in Utah. Two collections were examined; Rydberg and Garrett 8494 from the

Colorado River Canyon below Moab and Holmgren and J.M.G. 9984 from the lower Colorado River in San Juan County.

HABITAT

In our area it is frequent along the canyon bottoms in wet, sandy soils.

86. *Carex antherodes* Spreng., Syst. 3:827. 1826.

Cespitose with long, slender horizontal rhizomes; culms 3-15 dm. high, rather stout, sharply triangular, aphyllopodic, filamentose at base (lower sheaths); leaf-blades 3-12 mm. wide, flat, thin, dull-green, septate-nodulose and hairy towards base; sheaths soft hairy; staminate spikes 2-6, slender, rarely with a few perigynia; lateral spikes 2-4, pistillate or upper often androgynous, widely separated and short peduncled, containing 30-100 ascending-spreading perigynia; lower bract strongly sheathing and exceeding the culm; scales dull brown, awned, short-ciliate, shorter to longer than perigynia; perigynia lanceolate to ovate-lanceolate, 7-10 x 2-3 mm., glabrous, ribbed, tapering into a strongly bidentate beak with teeth 1.2-3 mm. long.

DISTRIBUTION

General—Yukon and Mackenzie to the St. Lawrence River and southward to New Jersey, Pennsylvania, Ohio, Illinois, Missouri, Nebraska, Colorado, Utah, Nevada, and Oregon. Also Eurasia.

Utah—Specimens examined from Utah were from Cache Valley, from around Utah Lake, and from Fish Lake on the Fishlake Plateau.

HABITAT

A marshland plant. Utah collections were from around fresh water lakes and along rivers, from intermountain valleys to the aspen-fir zone.

87. *Carex sheldonii* Mack., Bull. Torrey Club 42:618. 1915.

Loosely cespitose and strongly rhizomatous; culms 5-10 dm. high, phyllopodic, angles obtuse and smooth; leaves on lower fourth of culm, blades 3.5-6 mm. wide, flat, light-green, sparsely short pubescent; sheaths hyaline ventrally, dark-tinged at edge, lower ones filamentose; pistillate spikes 2-3, widely separate, containing 25-60 closely packed perigynia; bracts leaf-like, the lower sheathing and exceeding the perigynia; scales ovate-lanceolate, acute to awned, purplish-brown, thin towards edges, nerved, staminate scales erose at apex; perigynia ovate-lanceolate, 5-6 x 2 mm., little inflated, short-pubescent, nerved, tapering into a purplish-red, deeply bidentate beak.

DISTRIBUTION

General—Oregon and Idaho southward to Utah and northern California.

Utah—Mackenzie lists this species as occurring in the state. No specimen has been seen.

HABITAT

A marsh species.

88. *Carex physocarpa* Presl. Rel. Haenk. 1:205. 1828.

Culms arising singly or few together from long-creeping rootstocks, slender, erect, 1.5-8 dm. high, purplish-red at base; leaf-blades light-green, stiff, flat, 1.5-5 mm. wide; basal sheaths shredding; terminal spike staminate, strongly peduncled, often with an additional sessile staminate spike at its base; lateral spikes 1-3, strongly separate on slender peduncles, containing 20-75 perigynia; scales ovate-lanceolate, acute to acuminate, purple-black with a conspicuous white-hyaline apex, shorter than perigynia; perigynia 3-5 x 1.75-2.25 mm., suborbicular in cross-section, not inflated, smooth, shining, brown, purple or black-tinged, beak 0.5-1 mm. long; style usually bent downward against the achene; stigma 2, rarely 3.

This species has been confused with *C. saxatilis L.* to which it is closely related. Some early collections from the Uinta Mountains were referred to that species.

DISTRIBUTION

General—Alaska to northern Hudson Bay and southward to Colorado, Utah, and Nevada. Also Asia.

Utah—It is one of the more common sedges of the Uinta Mountains. It has also been collected from the Aquarius and Markagunt Plateaus.

HABITAT

C. physocarpa is a wet meadow species generally; however, it may ossasionally extend into somewhat drier sites at higher elevations. Often it is found growing at the water's edge in nearly pure stands. As a sedge-grass meadow component, it may be associated with a large number of species. Where growing in drier, more exposed sites its growth form may be similar to that of *C. saxatilis*.

FORAGE VALUE

Palatability is low. When observed on the Aquarius Plateau (Beaf Meadows), its use was very light when other sedges and grasses were almost completely consumed by cattle.

89. *Carex retrorsa* Schw., Ann. Lyc. N. Y. 1:71. 1824.

Densely cespitose with very short rootstocks; culms stout, stiff, 2-10 dm. high, obtusely triangular; leaves exceeding inflorescence, blades thin, firm, flat, 3-10 mm. wide; sheaths long, loose, cross-rugulose ventrally; staminate spikes 1-4, often with few perigynia, linear, peduncled; pistillate spikes 3-8, lower may be separate and long peduncled, containing numerous widely spreading perigynia; bracts leaf-like, much exceeding inflorescence, lower one sheathing; scales light-colored, lanceolate, narrower than and from shorter to equaling perigynia; perigynia ovoid, tan, 7-10 x 3-4 mm., much inflated, glabrous, shining, coarsely nerved, contracted into a slender, conic, bidentate beak.

Distribution

General—British Columbia to Quebec and Nova Scotia and southward to New Jersey, Ohio, Indiana, Iowa, Colorado, Utah, and Nevada.

Utah—A rare species in Utah. Only known by the author from Garrett No. 6915G from the lower Weber River in Weber County.

Habitat

Mackenzie lists it as a plant of "swampy woodland."

90. *Carex vesicaria* L. Sp. Pl. 979. 1753.

Loosely cespitose with stout, short-creeping rootstock; culms 3-10 dm. high, obliquely ascending (Leafl. West. Bot. VI:110. 1951), slender to stout, acutely angled and rough above, aphyllopodic; leaf-blades flat, 3-7 mm. wide, septate-nodulose; staminate spikes 2-4, slender, upper peduncled, lower ones may be androgynous; pistillate spikes 2-4, cylindric, sessile to short peduncled, separate, containing numerous ascending-spreading perigynia; lower bract leaf-like, exceeding inflorescence; scales ovate to lanceolate, acute to short-awned, narrower and from half to as long as perigynia; perigynia 4-8 x 3-4 mm., inflated, shining, yellowish-green or brown-tinged, strongly nerved, narrowed into a smooth, slender, bidentate beak.

Distribution

General—British Columbia to Newfoundland and southward to Delaware, Indiana, Missouri, New Mexico, Arizona, and California.

Utah—This sedge does not appear to be too common in Utah. Collections checked were from the Bear River, Uinta, and La Sal Mountains.

Habitat

Swamps and meadows. Utah collections were from the aspen-fir to the spruce-fir zones.

91. *Carex exsiccata* L. H. Bailey, Mem. Torrey Club 1:6. 1889.

Cespitose with stout, short-creeping rootstocks; culms obliquely-ascending, 3-10 dm. high, acutely triangular, rough or smooth above, aphyllopodic, purplish-tinged at base; leaves 4-8 per culm, lower clustered, blades 3-7 mm. wide, flat; staminate spikes 2-4, linear, upper peduncled; pistillate spikes 1-3, separate, short-peduncled or sessile, cylindric, containing many ascending-spreading perigynia; bracts leaf-like, exceeding culm; scales sharp-pointed, brownish with light centers and hyaline margins, narrower than and from one-third to one-half the length of perigynia; perigynia lanceolate, 7-10 x 2-3 mm., little inflated, smooth, shining, greenish, several ribbed, tapering into a slender, smooth bidentate beak.

Distribution

General—Southern Alaska and southward to Montana, Utah, Nevada, and California.

Utah—Only Johnson's collection No. 93 from the Markagunt Plateau was available for study. Van Eseltine, in Tidestrom's "Flora of Utah and Nevada," listed it earlier from the same general area.

Habitat

A plant of marshes and swamps.

92. *Carex rostrata* Stokes, With. Brit. Pl. ed. 2. 2:1059. 1787. (*C. inflata Huds.*)

Culms one to few together, arising from long, stout, whitish rhizomes, 3-12 dm. high, erect, obtusely triangular, smooth or rough above, phyllopodic, exceeded by upper leaves; leaves 4-10 per culm, septate-nodulose, blades stiff, flat above, 3-15 mm. wide; staminate spikes 2-4, upper on rough peduncles; pistillate spikes 2-5, some may have few staminate flowers at top, separate, lower flowers peduncled, all cylindric to oblong, containing many flowers, the perigynia ascending or becoming squarrose-spreading at maturity; bracts leaf-like, exceeding inflorescence; scales brownish or purplish, ovate-lanceolate, acute or awned, narrower than and from somewhat shorter to longer than perigynia; perigynia 4-6 (10) x 2.5-3.5 mm., inflated, greenish or dark-tinged, strongly nerved, contracted into a smooth, conic, bidentate beak. (Plate III)

Distribution

General—Alaska to Greenland and southward to Delaware, West Virginia, Indiana, South Dakota, New Mexico, Arizona, and California.

Utah—A common species throughout the state. Collections examined from the Bear River, Uinta, Wasatch, La Sal, and Abajo Mountains and the Tavaputs, Wasatch, Fishlake, Tushar, Aquarius, Markagunt, and Paunsagunt Plateaus.

Habitat

Meadows and marshes. In many areas it appears to be a pioneer at lake edges and may extend some distance into the water. Ordinarily it grows in nearly pure stands. Its zonal range extends from rather low intermountain valleys upward to the spruce-fir zone. It is found most commonly, however, at mid-elevations.

Forage value

Palatability rather low. Only under heavy grazing pressure do cattle seem to eat it.

LITERATURE CITED

Ellison, Lincoln, "Subalpine Vegetation of the Wasatch Plateau, Utah," *Ecological Monographs*, 24:89-184. April 1954.

Graham, Edward H. "Botanical Studies in the Uinta Basin of Utah and Colorado," *Annals of the Carnegie Museum*, 1932, XXVI, p. 144.

Hayward, C. Lynn. "Alpine Biotic Communities of the Uinta Mountains, Utah," *Ecological Monographs,* 1952, 22:104.

Hermann, F. J. "Extensions of Range and a New Species in Carex," *Rhodora*, 39: 491-495. December 1937.

Hermann, F. J. "Addenda to North American Carices." *The Am. Midl. Nat.* Vol. 51, No. 1, pp. 265-286, January 1954.

Howell, Thomas. "Studies in Carex-I," *Leafl. West. Bot.* IV: 206-208. November 1945.

——"Studies in Carex-II," *Leafl. West. Bot.* V: 36-40, April 1947.

——"Notes on some Sierran Sedges," *Leafl. West. Bot.* VI: 107-111, July 1951.

Hulten, Eric. "Flora of Alaska and Yukon," Gleerup, C. W. K., Lund, Sweden, Vol. II, pp. 131-412.

Mackenzie, Kenneth K., "Cyperaceae," *North American Flora*, 18:1-478 1931-1935.

——"North American Cariceae," *New York Botanical Garden*, 1940, Vol. I and II.

Maguire, "Great Basin Plants - VIII," *Brittonia* 5:199-201, 1944.

McMillan, Calvin. "A Taxonomic and Ecological Study of the Deep Creek Mountains of Central Western Utah." An unpublished Master's thesis, University of Utah, 1948.

Van Eseltine, G. P. "Cyperaceae," in Tidestrom, Iran, *Flora of Utah and Nevada*, Contrib. *U. S. Nat. Herb.*, 25: pp. 102-110, 1925.

GLOSSARY

Achene—Small, dry hard indehiscent fruit, enclosed by the perigynium in species of *Carex*.
Acuminate—Tapering to a point.
Acute—Sharp-pointed but not tapering.
Aggregated—Crowded together as the spikes in a head.
Androgynous—Bearing the staminate flowers above in the spike.
Anther—The pollen-containing portion of the stamen.
Aphyllopodic—Blades of basal leaves rudimentary or lacking.
Appressed—Lying in close contact with another structure such as the main axis.
Approximate—Close but distinct, as the spikes of some species of *Carex*.
Arcuate—Curved like a bow.
Ascending—Directed upward at an angle, not erect.
Auricle—Appendages at junction of blade and sheath.
Beak—The narrowed projection above the main body of the perigynium.
Biconvex—Convex on both sides.
Bidentate—Two-toothed.
Bidenticulate—Lightly two-toothed.
Bract—Modified leaf projecting from the base of the spikes or inflorescence in the genus *Carex*.
Callous spot—Thickening, behind ligule in some species of *Carex*.
Canaliculate—With deep longitudinal groove, or deeply channelled.
Capitate—Inflorescence congested into a head.
Caudate—Tailed.
Cespitose—Forming tufts or tussocks.
Ciliate—With marginal hairs.
Clavate—Club-shaped or enlarged towards the apex.
Concavo-convex—Bowed inward on one face and outward on the other.
Convex—With surfaces bowed outward.
Coriaceous—Thick, leathery.
Cross-rugulose—With transverse wrinkles.
Culm—Stem
Cuspidate—With a short, sharp-pointed apex.
Dioecious—Bearing staminate and pistillate flowers on different individual plants.
Dorsal—Back, or side away from the axis.
Dorsal-suture—A seam on the dorsal side of the perigynium beak.
Emarginate—Shallowly notched at apex.
Erose—Irregular as if broken or gnawed.
Fasciculate—Forming bundles or closely clustered. Used in our case to describe the bundles of old culm and leaf sheaths remaining after aerial portions have been broken off which is common to certain species of *Carex*.
Filament—The stalk of the stamen terminating in the anther.
Flexuose—Bent in zig-zag fashion.
Glabrous—Hairless.
Glaucous—Whitened with a bloom of waxy material.
Gynaecandrous—Staminate flowers below and pistillate flowers above in a spike.
Head—A dense, rounded inflorescence.
Hyaline—Thin and translucent.
Imbricate—Overlapping like shingles.
Involute—With edges rolled inward.
Lacerate—With margins appearing to have been torn.
Ligule—Membranous projection between the leaf and culm at top of sheath.
Membranaceous—Thin.
Moniliform—Like a string of beads.
Monoecious—With the different sexes in separate flowers but on the same individual plant.
Mucronate—With a short abrupt tip.
Node—The place on the culm where the leaf is borne.
Nodulose—Small transverse knots.
Obliquely cleft—Slantingly cut.
Obtuse—Rounded or blunt.
Obovate—Outline of an egg but with the widest part above the middle.
Obovoid—Egg-shaped with the widest end pointing upward.
Ovary—The part of the pistil containing the seeds.
Ovate—The outline of an egg with the broadest end below the middle.
Ovoid—Egg-shaped with the narrow end pointing upward.
Papillate—Soft nipple-like projections.
Peduncle—The stalk of the spike in *Carex*.
Perigynia—The sacs that enclose the achenes in *Carex*.
Phyllopodic—The leaves of the basal sheaths well developed.
Pistil—Central female parts of the flower, consisting of stigma, style, and ovary.
Pistillate—Flowers containing pistils only.
Plano-convex—Flat on one side and rounding on the other.
Puberulent—Minutely pubescent.
Pubescent—Hairy, usually with fine, soft hairs.
Pulverlunt—With a dusty or powdery covering.
Puncticulate—With minute dots, pits or translucent glands.
Rachilla—In some species of Carex, the little organ that extends from the base of the achene and within the perigynium.
Revolute—Rolled back or under from margin of tip.
Rhizome—A horizontal underground stem, rooting at nodes.
Rootstock—Underground stem, often short.
Scabrous—Rough, harsh to the touch.
Scale—The expanded outgrowth at the base of each flower of the spike.
Scarious—Thin, dry and membranous.
Septate—A partition, transverse in the leaves and stems of some species of *Carex*.
Serrate—Saw-edged.
Serrulate—Minutely saw-edged.
Sessile—Stalkless.
Setaceous—With bristles.
Setiform—Bristle-like.
Setulose—With small bristles.
Sheath—The tube-like structure at base of leaf and enclosing the culm.
Spike—A flower cluster in which the flowers are sessile; the unit of several flowers in *Carex*.
Squamiform—Scale-like.
Squarrose—Widely spreading as the scales and perigynia in some species of *Carex*.
Stamen—The pollen-producing organ, consisting of anthers and filaments.
Staminate—With male flowers only.
Stigma—The apex of the pistil which is receptive to pollen.
Stipe—The stalk-like organ at the base of some perigynia and achenes.
Stipitate—Having a stalk or stipe.
Striate—With slender longitudinal grooves or veins.
Style—The stalk connecting the stigma with the ovary.
Suborbicular—Nearly circular in outline.
Subulate—Awl-shaped.
Terete—Round in cross-section, often tapering.
Tubercle—A small knob-like projection.
Trigorous—Three-angled, with plane faces.
Truncate—Cut off flat or at a right angle.
Unisexual—Of one sex.
Ventral—Front or side facing axis.
Ventrally—Pertaining to the front side.
Wing—A membranous projection common on the margins of some perigynia and culms.

INDEX

Species	Uinta Mts	Bear River	Raft River	Deep Creek Mts	Wasatch Mts	Sheep Rk Stansby	Tavaputs Plateau	Wasatch Plateau	Pavant Plateau	Fishlake Plateau	Aquarius Plateau	Sevier Plateau	Tushar Plateau	Paunsagunt Plat	Markagunt Plat	Pine Valley Mts	Henry Mts	La Sal Mts	Abajo Mts	Zones	Habitat	Affinity *	Abundance
Carex																							
hepburnii	X				X								X					X		Alpine	Open meadows	8 RM Alas.	L. abund
capitata	X																			Alpine	Open slopes	12 Arctic	L. abund
subnigricans	X																			ES Apline	Open slopes, meadows	7 RM Par	Rare
engelmannii		X											X							Alpine	Open slopes, summits	7 RM Pac	Occas
pyrenaica	X																			Alpine sl	Alpine sl	5-RM	L. abund
nigricans	X	X			X															ES Alpine	Well drained meadows	8 RM Alas	Frequent
vernacula	X												X		X					ES Alpine	Open meadows	7-RM Pac.	L. abund
var. hobsonii		X																		ES	Marshes, mead	1 Endemic	Rare
perglobosa																		X		Alpine	Peaks, slopes	2 SRM	L. abund
douglasii	X	X		X	X		X	X			X				X					PI-Aspen	Dry meadows	9-G Pl	Abundant
eleocharis	X				X		X	X		X								X	X	Val ES	Open grassland	9 G Pl	L. abund
simulata		X			X			X		X			X		X					PP ES	Wet meadow	7 RM Pac	Frequent
praegracilis	X	X			X		X	X			X	X						X		Val Asp	Open, moist site	9 G Pl	Abundant
foenea		X			X			X			X				X			X	X	Val ES	Dry, open site	10 Trans NA	Frequent
vallicola	X	X			X		X	X	X		X	X						X		Val Asp	Sage Grass	7 RM Pac	Frequent
hoodii	X	X			X		X	X	X				X					X		Mt Br ES	Open woodland	7 RM Pac	Abundant
occidentalis	X	X		X	X								X							Val ES	Open woodland	5 RM	Occas
cusickii																				Valleys	Wet Meadow	7 RM Pac	Rare
stipata					N															Val Pl	Wet meadow	10 Trans NA	Occas
disperma	X			X	X					X			X					X		Asp Alp	Swamps, mead	11 Bor NA	Frequent
bipartita	X				X															ES Alpine	Bogs, swamps	12-Arctic	Occas
praeceptorum	X																			ES	Grass sedge meadows	7 RM Pac	L. frequent
brunnescens	X												X							ES	Boggy lake shore	11 Bor NA	Rare
canescens	X				X								X					X		PP ES	Wet mead., bogs	10 Trans NA	Frequent
gynocrates				X				X												ES Alpine	Wet, calc. sites	11 Bor NA	Rare
interior	X	X			X									X	X					Val ES	Wet sites	10 Trans NA	L. abund
augustior	X							X												PP ES	Wet meadows	10 Trans NA	L. frequent
deweyana				X	X															Mt Br Asp	Moist sites	11 Bor NA	Rare
bolanderi																				Mt Br Asp	Woodland	7 RM Pac	
festivella	X	X		X	X	X	X	X		X	X	X	X		X	X	X	X	X	Mt Br ES	Meadows, parks	7 RM Pac	Common
microptera	X	X			X	X		X			X	X				X		X	X	Mt Br Asp	Meadows, slopes	7 RM Pac	Abundant
ebenea	X												X					X	X	ES-Alpine	Wet dry mead	3 M S RM	Frequent
haydeniana	X			X	X			X			X		X				X	X		PJ Alpine	Meadows	7 RM Pac	Frequent
illota	X																			ES	Flooded mead	7 RM Pac	L. abund
subfusca										X										ES	Dry meadows	7 RM Pac	Rare
pachystachya					X															Mt Br LPP	Wet dry sites	11 Bor NA	Rare
phaeocephala	X	X		X	X					X	X		X		X			X		ES Alpine	Slopes, parks	7 RM Pac	Frequent
leporinella	X																			ES Alpine	Sedge grass meadows	7 RM Pac	Occas
praticola	X																			Mt Br Alp	Meadows, slopes	11 Bor NA	Rare
eastwoodiana						X											X	X		Mt Br ES	Meadows, slopes	6 RM Basin	Occas
petasata	X	X		X	X		X		X	X	X		X	X	X		X	X		Mt Br ES	Meadows, slopes	6 RM Basin	Abundant
stramineiformis					X			X												Aspen ES	Parks	7 RM Pac	Rare
egglestonii	X	X			X		X	X		X			X		X			X		Aspen ES	Mt. grassland	3 M S RM	Abundant
xerantica	X				X						X									Val Asp	Parks, grassland	9 G Plains	L. freq
athrostachya	X	X			X					X	X		X		X	X				PP ES	Slopes, parks	8 RM Alas	Frequent
saximontana					X															Val-Asp	Dry woods	11 Bor NA	Rare
filifolia								N												Val., plains	Dry slopes	9 G Plains	Rare
elynoides	X			X						X			X		X			X		ES Alpine	Dry slopes	6 RM Basin	Abundant
obtusata	X				O			X		O	X	X								Mt Br ES	Grasslands, woods	8-RM-Alas	L. abund
rossii	X	X		X	X		X		X	X	X		X		X			X		Mt Br ES	Grasslands, woods	8 RM Alas	Abundant
pityophila																		X		Mt Br PP	PP Oakwood lands	2-SRM	Rare
pseudoscirpoidea	X	X																X		ES Alpine	Mead dry slopes	6 RM Basin	Abundant
drummondiana	X																			Alpine	Mead slopes	5 RM	Abundant
geyeri	X	X			X	X		X		O			X					X		Mt Br ES	Woodlands	7 RM Pac	Abundant
hassei	X				N														N	Val ES	Met, calc. sites	7 RM Pac	Occas
garberi																		N		Valley	Seeps	10 Trans NA	Rare
aurea	X	X		X	X			X					X	X				X		Val ES	Marsh, wet meadows	11 Bor NA	Frequent
crawei														X						Mt Br	Marl bogs	10 Trans-NA	Occas
capillaris	X	X		X											X					Alpine	Rocky tundra	11 Bor NA	Occas
viridula					X									X	X					Mt Br ES	Calc. bogs, seeps	11 Bor NA	Frequent
misandra	X				X															Alpine	Parks, meadows	12 Arctic	Occas
ablata	X																			ES Alp	Bogs, meadows	6 RM Basin	Rare
fissuricola													X							Asp Alp	Wet meadows	7 RM Pac	Rare
lanuginosa	X	X			X			X					X		X			X		Val ES	Meadows	10 Trans NA	Abundant
limosa	X																			ES	Wet meadows	11 Bor NA	Rare
paupercula	X																			PP ES	Wet meadows (acid)	11 Bor NA	Occas
tolmiei	X																			Alpine	Grassy tundra	8 RM Alas	Occas
raynoldsii	X				X		X	X					X							Asp Alp	Parks, open grassland	7 RM Pac	Frequent
aboriginum		X																		Valley	Meadows	7 RM Pac	Frequent
media var. stevenii	X				X								X		X					LPP Alpine	Wet meadows	8 RM Alas	Frequent
nelsonii	X																			Alp Es	Parks, tundra	3 M S RM	Frequent
albo-nigra	X			X									X					X		Alpine	Ridges, slopes	7 RM Pac	Frequent
pelocarpa	X																			Alpine	Tundra, slopes	4 M N RM	Occas
nova	X	X			X								X					X		ES Alpine	Mead., damp site	5 RM	Frequent
bella	X			X	X					X	X		X		X			X	X	ES-Alpine	Moist hillsides	5 RM	Frequent
epapillosa	X				X						X		X			X		X		Asp Alp	Swamps, mead	7 RM Pac	Frequent
chalciolepis	X			X	X					X			X					X		ES Alpine	Grassy slopes	3 M S RM	Frequent
atrata	X				X								X					X		ES Alpine	Wet meadows	12 Arctic	Frequent
buxbaumii																					Sunny swamps	10 Trans NA	
bigelowii	X				X															LPP ES	Bogs, lake edge	12 Arctic	Occas
scopulorum				X																ES Alp	Willow bogs	7 RM Pac	Rare
campylocarpa ssp. affinis				X																Aspen ES	Moist woodland	1 Endemic	Frequent
kelloggii	X	X			X						X									Mt Br ES	Mead., marsh	8 RM Alas	Abundant
nebrascensis	X	X	X	X	X		X	X	O	X	X		X	X	X			X		Val Asp	Marshes, mead	9 G Plains	Common
aquatilis	X	X		X	X			X			X	X	X		X			X		Asp ES	Wet mead., calc	12 Arctic	Abundant
hystricina																		N	N	Colo. Riv	Meadows	10 Trans NA	Occas
atherodes		X			X					X										Val PP	Calc. marshes	11 Bor NA	L. abund
sheldonii																				Valleys	Marshes	7 RM Pac.	Rare
physocarpa	X										X				X					LPP ES	Water edge	8 RM Alas	Abundant
vesicaria	X	X													X			X		Mt Br ES	Swamps, marshes	10 Trans NA	Occas
exsiccata															X					PP ES	Wet meadows	8 RM Alas	L. abund
rostrata	X	X			X			X		X	X		X	X	X			X	X	Val ES	Water edge	11 Bor NA	Common
retrorsa					X															Val Mt Br	Weber River	10 Trans NA	Rare

X Collected   N = Near   O = Observed

* Affinity

1 Endemic
2 Southern Rocky Mountains
3 Middle to Southern Rocky Mountains
4 - Middle to Northern Rocky Mountains
5 Rocky Mountains
6 Rocky Mountains - Great Basin
7 Rocky Mountains to Pacific Ocean
8 Rocky Mountains to Alaska
9 Great Plains
10 Trans United States and Southern Canada
11 Boreal America
12 Arctic Alpine

Brigham Young University

Science Bulletin

BIOLOGICAL SERIES — VOLUME I, NUMBER 3

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ZOOLOGY

OF THE UPPER COLORADO RIVER BASIN

I. The Biotic Communities

by

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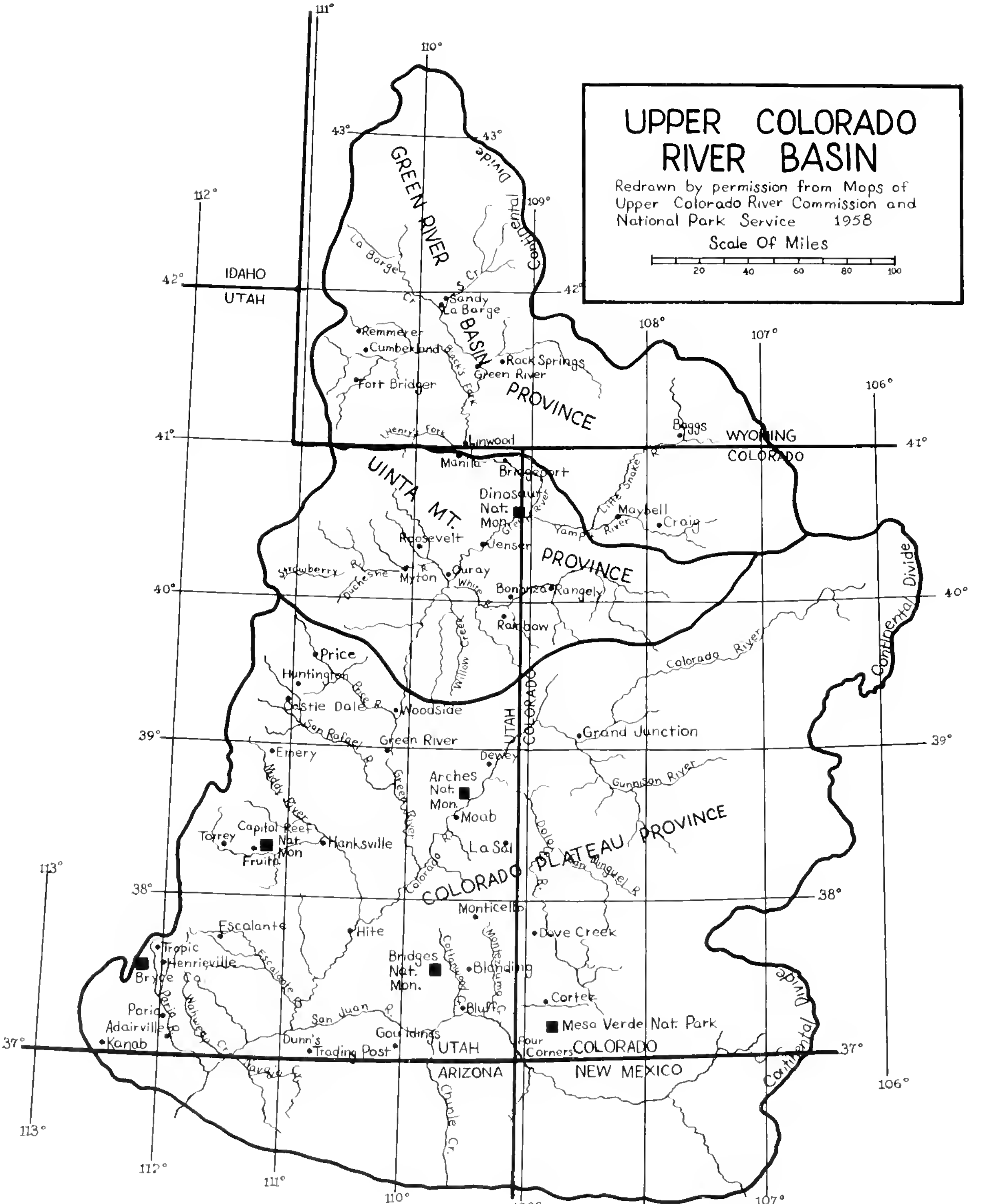

UPPER COLORADO RIVER BASIN
Redrawn by permission from Maps of Upper Colorado River Commission and National Park Service 1958
Scale Of Miles
20 40 60 80 100
GREEN RIVER BASIN PROVINCE
UINTA MT. PROVINCE
COLORADO PLATEAU PROVINCE
Continental Divide
IDAHO
UTAH
WYOMING
COLORADO
ARIZONA
NEW MEXICO
Sandy
La Barge
Remmerer
Cumberland
Rock Springs
Green River
Fort Bridger
Linwood
Manila
Bridgeport
Dinosaur Nat. Mon.
Maybell
Craig
Baggs
Roosevelt
Jensen
Myton
Ouray
Bonanza
Rangely
Rainbow
Price
Huntington
Castle Dale
Woodside
Green River
Grand Junction
Emery
Dewey
Arches Nat. Mon.
Moab
La Sal
Torrey
Capitol Reef Nat. Mon
Fruita
Hanksville
Monticello
Escalante
Hite
Dove Creek
Tropic
Henrieville
Bryce Ca.
Bridges Nat. Mon.
Blanding
Cortez
Paria
Adairville
Kanab
Bluff
Mesa Verde Nat. Park
Dunn's Trading Post
Gouldings
Four Corners
Colorado River
Gunnison River
Yampa River
White R.
Strawberry R.
Duchesne R.
San Rafael R.
Price R.
Muddy River
San Juan R.
Chinle Cr.

Fig. 1.

ZOOLOGY OF THE UPPER COLORADO RIVER BASIN

I. The Biotic Communities

by

C. Lynn Hayward, D Elden Beck and Wilmer W. Tanner

I. EXTENT AND GENERAL DESCRIPTION OF THE UPPER COLORADO RIVER BASIN

The Colorado River Basin includes a vast area which gathers its waters from most of the intermountain areas west of the Continental Divide. Portions of the states of California, Nevada, Utah, Wyoming, Colorado, and New Mexico, and nearly all of Arizona are involved. Extending from west central Wyoming to slightly beyond the Mexican border at the Gulf of California, the basin is over 800 miles in length and has a width at one point of about 500 miles. In elevation it ranges from over 14,000 feet at its rim in some of the lofty mountain ranges of Colorado and Wyoming to 348 feet below sea level at the Salton Sea of Southern California.

The northern portion of this extensive area, which is the subject of this report, is known as the Upper Colorado River Basin and occupies that part of the entire basin which lies mostly north of the Utah-Arizona and New Mexico-Colorado borders (Fig. 1). In recent years this portion of the Colorado River Basin has attracted widespread attention owing to the proposals to build a number of flood control, irrigation and power dams along the Colorado River and its tributaries, and to the discovery of extensive deposits of uranium ore, natural gas, oil, and gilsonite in certain sections. Furthermore, many portions of the Upper Basin, as it shall henceforth be called, possess areas of magnificent scenery which are becoming increasingly attractive to a large number of visitors. That portion of the Upper Basin which is located in the southwestern corner of Utah in Washington County, namely the Virgin River drainage basin, is not a part of this presentation, but will be considered as a separate study at a later date.

The increasing interest in the natural resources of this area has resulted in the construction of more and better roads, and while many sections can still be reached only on foot or horseback, much of it is available by jeep or truck and can now be studied by naturalists with much less expense and discomfort than was possible a few years ago. However, the excessive dryness of the area makes it difficult at times to obtain suitable drinking water, and in mid-summer maximum temperatures above 100°F. are not uncommon. Cold storms are frequent in early spring and may extend into June, while in late summer and early autumn, sudden thunder showers may result in flash floods that sweep without warning down the barren washes endangering the property and even the lives of those who are not prepared for them.

Accumulation of the data to be presented in this and subsequent reports has taken place over a period of nearly thirty years with many individuals taking part either as staff members or students of the Department of Zoology at Brigham Young University. The work has been discontinuous and at first was done in the main to add to the general natural history knowledge of Utah. During the last two decades, however, there has been a determined effort to bring together faunistic information pertaining to the Upper Basin area in particular.

Detailed descriptions of the field expeditions conducted in the Upper Basin over the years will be given in another section of this report, but it may be said at this time that the writers have at one time or another traversed almost all of the territory here considered. Furthermore, many workers from other institutions have done field work in this area and have published reports on various phases of the fauna and flora of the Upper Basin. One of the most recent is the "Preliminary Report on Biological Resources of the Glen Canyon Reservoir" by Woodbury, et. al. (1958). This gives an extensive listing of the biota for the Glen Canyon region. However, to our knowledge, ours is the first attempt to accumulate and publish information pertaining to the vertebrate fauna of the Upper Basin as a unit. It is planned in a series of papers to include eventually most of the living animals that are native to the area.

As field work by us continued in this complex area it became increasingly evident that many years' effort would be necessary before a complete picture of the fauna could be attained. Work in new areas invariably aroused fresh problems. Nevertheless the writers now feel that the time is appropriate to print the data that are now at hand and that enough of these are available to present a fairly reliable account of some of the faunal aspects of the area as they now exist.

While the writers have traveled in almost every section of the Upper Basin and in the states adjoining Utah, the most intensive field work has been done in the latter state. The major part of the discussion to follow deals, therefore, with the Utah section of the Upper Basin, extending from the Manila-Daggett region on the north to and including the Glen Canyon damsite on the south at the Utah-Arizona border. References made herein to the Upper Basin in adjacent states, are, therefore, of a more general nature.

II. PROCEDURES

In preparing this report the authors have divided the responsibilities somewhat as follows: Hayward has been responsible for most of the general descriptions and has collaborated with Beck and Tanner in the preparation of the section pertaining to the biotic communities. The lists of mammals and birds were prepared by Hayward and Beck, with Tanner preparing the lists of amphibians and reptiles. However, each of the authors has read the entire manuscript critically and has offered suggestions throughout the preparation of the entire study. The maps and diagrams were prepared by Wayne Killpack under the direction of Hayward, and the photographs are, in the main, from the files of D E. Beck.

In referring to the names of plants and animals the practice has been to use both scientific and common names. In the body of the text the scientific name is given only once when the plant or animal is first mentioned. Subsequently only common names are used. Technical names of mammals are taken from Miller and Kellog: *List of North American Recent Mammals*, U.S. Nat. Mus., Bull. 205, 1955; their common names are derived from Hall, et. al.: *Vernacular Names of North American Mammals North of Mexico*, University of Kansas Museum of Natural History, Misc. Publications. No. 14, 1957. Both scientific and common names of birds are taken from the American Ornithologists' Union: *Check-list of North American Birds*, 1957. In naming the amphibians and reptiles the scientific names are from Schmidt: *Check-list of North Amercan Amphibians and Reptiles*, University of Chicago Press, 1953. Common names were taken from American Society of Ichthyologists and Herpetologists: *Common Names for North American Amphibians and Reptiles*, Copeia, 1956.

III EXPLORATIONS AND REPORTS ON THE UPPER COLORADO BASIN

In several major works published on the Upper Basin, excellent accounts of the early explorations of the area are already in print, and it is not the intention of the writers to recount them in detail. Graham (1937) in his paper on the Botany of the Uinta Basin gives a thorough account of early visits to that part of the area. Woodbury (1945) has given a brief statement of some of the early surveys in the Navajo country of southern Utah and northern Arizona.

The earlier explorations into the Upper Basin by white men were those of the Spanish padres who visited some parts of the area as early as 1761 (Freeman, 1923:31). Escalante, the best known of these, crossed the Green River near the present townsite of Jensen, September 13, 1776, and explored parts of the Uinta Basin on his way to the Great Basin.

Between 1825 and 1835, a number of white trappers and fur traders were active especially in the Green River Valley of Wyoming and the Uinta Basin. Jedediah S. Smith, William H. Ashley, Etienne Provost, Jim Bridger, and Antoine Robidoux were among the better known of these early travelers (Dale, 1918). From the journals of some of these men we have certain information on the fur-bearing and larger game animals particularly.

Several early expeditions were carried out in the Upper Basin and numerous papers have been published relative to the biota of the area. Most of these will be dealt with later in the course of this paper, but some of the major and especially the earlier studies will be briefly considered at this time. Aside from the early exploration surveys of various governmental agencies including such prominent figures as Fremont (Abert, 1945, Fremont 1846, Warren 1859) and Powell 1875, who recorded some data on plants and animals, there have been a number of surveys that have dealt more specifically with the biota. In 1853 a party led by Captain J. W. Gunnison crossed the Grand River Valley of the Upper Basin in Utah and continued on westward to the Great Basin. Baird (1857, 1959) later published on the birds and mammals of this expedition. J. A. Allen, as a representative of the Museum of Comparative Zoology at Harvard University, visited a portion of the Upper Basin in 1871 and published an account of the birds (1872). There were at least two early expeditions of the American Museum of Natural History into the Upper Basin. Charles P. Rowley collected in the San Juan River area in 1892 and Allen (1893) published on the mammals of this expedition. Walter W. Granger worked in the eastern part of the Uinta Basin and at Brown's Park in 1895-96. Allen (1896) published on the mammals collected by this expedition. Cary (1911) worked in parts of the Upper Basin from 1905 to 1907. In 1905 he descended the Bear River (now known as the Yampa in Colorado) as far as Axial Basin and then traveled southward over the White River Plateau to Grand River (Colorado River) Valley. In 1907 he covered much of the same territory including a trip down the Little Snake River (tributary to the Yampa), with visits to Brown's Park on the Green River. During the same year he was in southwestern Colorado and included a trip to the LaSal Mountains in Utah. In a later paper (1917) Cary published an account of his studies in Wyoming which included work in the Green River Basin of southwestern Wyoming.

Bailey (1913) in his paper on the life zones and crop zones of New Mexico described the Lower Sonoran Zone of the San Juan Valley and other valleys of northwestern New Mexico.

Gregory (1917, 1948, 1950), Gregory and Moore (1931), Gregory and Thorpe (1938), Gregory and Anderson (1939) wrote a number of papers on the geology of the Upper Colorado River Basin. In addition to discussions of a strictly geological nature, there are also included descriptions of the biotic features, climate, agriculture and socio-historic data. In some of these monographic studies the biotic features are discussed in some detail. Hunt, Averitt, and Miller (1953) have described the overall vegetation of the Henry Mountains area in their geologic and geographic study of that region.

From 1931 to 1937 the Carnegie Institute of Pittsburg, Pennsylvania, sponsored a series of expeditions into the Uinta Basin. Graham of that institution published (1937) an extensive report on the botany of that area, and Twomey (1942) published on the birds. A collection of the mammals was made by Kenneth Doutt, but an account of these has not been published by him. Durrant (1952), however, worked over Doutt's material and included it in his "Mammals of Utah."

From 1933 to 1938 the National Park Service sponsored a series of expeditions into the Rainbow Bridge-Monument Valley part of the Upper Basin under the direction of Ansel F. Hall and Charles D. Winning. A general report was published by Hall (1934) and an account of the birds by Woodbury and Russell (1945).

In 1941 the Secretary of the Interior approved a survey of the Colorado River Basin with a view to ascertaining its recreational and water resources. The work was done by the National Park Service under the direction of Conrad L. Wirth. Several other agencies of the government assisted with the work, and a comprehensive report was published in 1950.

In recent years staff members and students of the educational institutions in Utah and Arizona have conducted field studies in several parts of the Upper Basin. The University of Utah has made extensive studies of the mammals, birds, and reptiles under the leadership of Stephen D. Durrant, William H. Behle and Angus M. Woodbury.

Since 1926 the Department of Zoology, Brigham Young University, has actively engaged in field work throughout much of the Upper Basin, and it is upon this work that the present study is largely based. Staff members who have participated in these studies are Vasco M. Tanner, C. Lynn Hayward, D Elden Beck, Wilmer W. Tanner, Dorald M. Allred, and Clarence Cottam. Many former students have also assisted in the surveys. These include Claudeous Brown, Anson Call, James Kartchner, Selar Hutchings, Irvin Rasmussen, Harold Hutchings, James Bee, Harry Chandler, George Cannon and Merlin L. Killpack.

A chronologic account of the Brigham Young University expeditions into the Upper Basin follows:

June and July 1926. A party of four worked at Fossil and Fort Bridger, Wyoming, and then entered the Uinta Basin by way of the Manila-Vernal road. Studies were made at several stations in the Uinta Basin where birds, reptiles, amphibians, and invertebrates were collected.

June and July, 1927. A party of seven entered the Upper Basin by way of Price. Collections were made at Wellington, Woodside, Green River, Moab, La Sal and other areas in the La Sal Mountains in Utah. Stops were made at Dove Creek, Mesa Verde, and Ute Mountains in Colorado and Shiprock, New Mexico, Elk Ridge, and the Natural Bridges area, Blanding, Bluff, Monument Valley, Lee's Ferry, House Rock Valley, Kanab, Bryce Canyon in Utah and Grand Canyon in Arizona. Collections of plants, invertebrates, reptiles, amphibians and birds were made during this expedition.

July and August, 1934. A party of four worked in the Upper Basin during the month of July and part of August in 1934. Overnight stops were made at Woodside and Moab, but the major part of the time was spent at high elevations in the La Sal Mountains. An account of part of the work done in the La Sal Mountains was published by V. M. Tanner and C. L. Hayward (1934).

June, 1936. A survey trip into Carbon and Emery Counties was made by a party of six staff members and students. From Spring Canyon the following collecting areas were visited: Price, Wellington, Huntington, and Castle Dale. Insects, amphibians, and reptiles were collected

Summers of 1938, 1939, 1940. During these years several parties conducted extensive field studies in Wayne, Garfield and Kane Counties, Utah. During that period many stations were established and collections of mammals, birds, reptiles, amphibians, and invertebrates were made. Some papers resulting from these studies have been published (Tanner, 1940; Chandler, 1941; Beck, 1954).

Summer, 1946. As a continuation of the above surveys another expedition was organized to revisit established stations and locate new ones in Wayne, Garfield and Kane Counties. Extensive collections of ants, spiders, centipedes, aquatic insects, reptiles, and amphibia were made. Occurrence of kinds and numbers of birds was also noted. All previously established stations in Wayne, Garfield, and Kane Counties were revisited. Six days were spent in surveying the newly established stations in Kane County.

April 25-27, 1947. A general survey party was organized to make a preliminary study of the Arches National Monument in Grand County. In this survey a few specimens of mammals, birds, reptiles and other animals were collected.

September 8-15, 1948. A party visited the Wayne and San Juan County regions in order to establish additional stations. Visits to the old stations at Price, Woodside, LaSal Junction and Monticello were made. Some work was done at Dead Horse Point in Garfield County, Blanding, Bluff, Mexican Hat, Monument Valley and the Natural Bridges National Monument in San Juan County. New stations in Wayne County were located at Hanksville and Cainville. Stations at Fruita and Torrey were revisited. Collections of reptiles, amphibians and spiders were made.

May 8-14, 1949. Field work was done at Arches National Monument, Grand County, Utah. An overnight visit was also made to Dead Horse Point. Birds, mammals, reptiles and invertebrates were studied and collected.

May 7-13, 1950. Arches National Monument, Grand County, Utah, was revisited. A one day's side trip was taken to Castle Valley and the area known as the Fisher Towers east of the Colorado River.

May 20-23, 1950. A trip was made to Uintah County, north and east of Vernal. Collections of amphibians, reptiles and insects were made near Dinosaur National Monument, Jensen, and the mouth of Split Mountain gorge.

May 3-9, 1951. Several areas in San Juan County were visited. Principal study areas were Bluff and a camp near the highway, twenty-two miles south of Moab.

August 9-12, 1951. Studies were made in an area seven miles northwest of Roosevelt, Duchesne County, Utah. Particular attention was given to the mammals and birds of the station.

June 30-*July* 3, 1952. Brief studies were made in the LaSal Mountains and Castle Valley, Grand County, Utah. Special attention was given to the mammals and birds.

Summers, 1950-1953. During this period, D. Elden Beck was in charge of a National Institute of Health Project (U. S. Public Health Service), dealing with the distribution of parasitic arthropods that may be vectors of Rocky Mountain spotted fever and plague. In the course of this study, visits were made to a number of localities in the Upper Basin. Extensive mammal collections were made and many specimens were preserved. In addition, reptiles, amphibians and selected groups of arthropods other than parasites were collected. A report of this study was published (Beck, 1955). Localities visited within the Upper Basin are indicated on maps found on pages 33 and 34 of that report. These localities include Pink Dunes, Three Lakes, Kanab Canyon, and Adairville in Kane County; Dead Horse Point, San Juan; Manila, Brown's Park, Bridgeport, and other locatities in Daggett County; Fruita and Torrey as well as other places in Wayne County; the entire Escalante Basin included in Kane and Garfield Counties; and Roosevelt in Duchesne County.

August 26-28, 1953. A visit was made to Four-Corners, Red Mesa, and Monument Valley south of the San Juan River. A new station was established at the eastern end of Monument Valley.

June 6-15, 1954. Field work was done in Uintah County east of Green River with concentrated work at Rainbow and Bonanza.

July 6-15, 1954. Additional field work was done in Uintah and Daggett Counties with stations at the South Base of Blue Mountains Plateau, Bridgeport (Brown's Park), Clay Basin, and Manila.

April 30-*May* 5, 1955. A trip was made to the Navajo Mountain area in Utah, and northern Arizona. Collections were made fourteen miles north of Tonolea, Arizona; and at Tuba City in Arizona; Navajo Mountain Trading Post, San Juan County; Kanab and Pink Dunes in Kane County, Utah. Mammals, reptiles and invertebrates were collected.

June 3-13, 1955. An expedition was conducted into Grand, Garfield and San Juan Counties with study stations at Castle Valley, Grand County; ten miles south of Cisco, Grand County; Montezuma Trading Post, San Juan County; and twenty miles northwest of Hite, Garfield County.

August 22-24, 1955. A short trip to Cumberland, Lincoln County, Wyoming, was made for the purpose of collecting mammals in that area.

May 19-23, 1956. A trip was made to the Glen Canyon Area, Kane County, with stations at Wahweap Creek and Catstairs Canyon. Special attention was given to the collection of mammals, birds and reptiles.

September 4-8, 1956. White Canyon and Cottonwood Wash, San Juan County; Dead Horse Point and Grand View area, San Juan County were revisited and studies were made of reptiles, birds, and mammals.

June 3-5, 1957. A station was established at the junction of the San Rafael and Green Rivers, Emery County.

June 19-20, 1957. Studies and collections of birds and mammals were made on Strawberry River, Duchesne County.

December 29-31, 1957. Glen Canyon Area, Kane County, Utah, and Coconino County, Arizona, were revisited and collections of wintering birds were made.

In addition to the above-mentioned expeditions, several trips were conducted independently under the direction of Wilmer W. Tanner, principally for the purpose of collecting and studying reptiles and amphibians. They were as follows:

May 7-10, 1952. Kane County east of Kanab was visited where collecting was done at Navajo Wells, Paria (a ghost town), north end of House Rock Valley, Catstairs Canyon and Adairville. Although the major attention was placed on amphibians and reptiles, a few mammals were taken at Catstairs Canyon and Navajo Wells.

May 21-25, 1953. Another trip east of Kanab, Kane County, included the following collecting stations: Johnson Creek at the base of the escarpment of the Vermillion Cliffs, Navajo Wells, House Rock Valley, Wahweap Spring and Lone Rock. (The latter locality is only a few miles west of Glen Canyon).

May 14-18, 1954. A survey trip was conducted into Wayne, Garfield and San Juan Counties for the purpose of establishing new stations and for collecting amphibians and reptiles. The basin was entered by way of Loa and included studies at Fruita, Notom, King's Ranch, Water Pocket Canyon, Bullfrog Creek, Star Spring, Trachite Creek, Hite, White Canyon, Natural Bridges, Maverick Spring, and Cottonwood Wash near Blanding.

June 8-10, 1954. Several localities were studied along North Wash, Garfield County, Utah.

May 18-21, 1955. North Wash, Junction of North Wash and Colorado River and Trachite Creek were visited on these dates and again on June 10.

June 21-27, 1955. Two days were spent on Elk Ridge, southwestern Colorado from Cortez east to Pagosa Springs and south into the San Juan Basin of northwestern New Mexico.

May 17-18, 1956. Studies were again made in eastern Garfield County including North Wash, Trachite Creek, and Star Spring. On this trip emphasis was placed on the collection of *Sceloporus magister* and *Xantusia.*

May 12-14, 1956. Another visit was made to Star Spring, Garfield County, Utah. Reptiles, mammals and birds were collected.

In June, 1957 observations and some reptile collections were made a few miles north of Duchesne at Blue Bench, Duchesne County, Utah.

From June 16-18, 1958, observations and collections were made from the head of House Rock Valley east to Glen Canyon. During June 22-26 a general survey was conducted in Uinta and Daggett Counties. Another survey was conducted from July 10-15, to Dead Horse Point and Monument Valley in San Juan County and the Pink Dunes in Kane County. Birds and mammals were the main interests of investigation in these places. (Table 1.)

Table 1. Principal Field Stations, Brigham Young University

Studies in the Upper Colorado River Basin

Locality	County and State	Elevation	North Latitude		West Longitude	
Adairville	Kane, Utah	5,375	37	07	111	54
Arches National Monument	Grand, Utah	5,100	38	50	109	30
Big Bend	Kane, Utah	3,800	37	15	111	00
Big Indian	San Juan, Utah		38	10	109	20
Blanding	San Juan, Utah	6,103	37	37	109	29
Bluff	San Juan, Utah	4,320	37	17	109	33
Bonanza	Uintah, Utah	5,456	40	03	109	09
Boulder	Garfield, Utah	6,675	37	54	111	24
Bridgeport	Daggett, Utah	5,439	40	54	109	09
Bridges National Monument	San Juan, Utah	6,022	37	38	110	02
Brush Creek	Uintah, Utah	4,726	40	25	109	20
Bryce Canyon	Garfield, Utah	7,970	37	37	112	07
Buckhorn Reservoir	Emery, Utah	5,750	39	15	110	48
Calf Creek Crossing	Garfield, Utah	5,200	38	32	111	30
Castle Dale	Emery, Utah	5,771	39	13	111	01
Castle Valley	Grand, Utah	4,200	38	40	109	07
Catstairs Canyon	Kane, Utah	4,800	37	10	111	58
Circle Cliffs	Garfield, Utah	6,000	37	50	111	10
Clay Basin	Daggett, Utah	7,000	41	00	109	38
Collett Wash	Garfield, Utah	5,000	38	05	111	10
Cottonwood Creek	Kane, Utah	5,500	37	45	111	54
Cottonwood Wash (upper)	San Juan, Utah	5,700	37	45	109	30
Cottonwood Wash (lower)	San Juan, Utah	5,300	37	15	109	30
Coyote Gulch, Head	Kane, Utah	5,000	37	51	111	10
Coyote Gulch, Mouth	Kane, Utah	3,800	37	50	111	00

Locality	County and State	Elevation	North Latitude		West Longitude	
Cumberland	Lincoln, Wyoming	6,900	41	32	110	30
Dead Horse Point	Garfield, Utah	6,300	38	25	109	51
Dewey Bridge	Grand, Utah	4,090	38	49	109	17
Dinosaur National Monument	Uintah, Utah	4,900	40	25	109	15
Dove Creek	Dolores, Colorado		37	45	108	52
Dunn's Trading Post	San Juan, Utah	6,000	37	02	110	47
Dutton Bridge	Kane, Utah	4,500	37	50	111	05
East Rim Mounment Valley	San Juan, Utah	5,000	37	04	109	52
Emery	Emery, Utah	6,228	38	56	111	14
Escalante	Garfield. Utah	5,303	37	46	111	36
Escalante Canyon	Kane, Utah	3,305-5,300	37:15-37:45		110:58-111:35	
Fifteen Mile Point	Garfield, Utah	5,000	38	10	111	20
Fifty Mile Point	Kane, Utah	4,314	37	15	110	57
Fisher Towers	Grand, Utah	4,200	38	40	109	07
Flaming Gorge	Daggett, Utah	6,000	40	57	109	35
Fort Bridger	Uinta, Wyoming	6,657	41	12	110	30
Fourcorners	San Juan, Utah		37	00	109	05
Fruita	Wayne, Utah	5,418	38	17	111	15
Grand View Point	San Juan, Utah	6,300	38	26	109	53
Glen Canyon	Coconino, Arizona	3,200	36	52	111	03
Green River	Emery, Utah	4,087	38	59	110	09
Green River Desert	Emery, Utah	5,000	38	30	110	15
Hanging Arch	Kane, Utah	4,500	37	50	111	05
Hanksville	Wayne, Utah	4,125	38	22	110	41
Henrieville	Garfield, Utah	6,000	37	34	112	00
Hite	Garfield, Utah	3,542	37	48	110	27
Head of Wahweap	Kane, Utah	5,500	37	23	111	46
Hole-in-the-Rock	Kane, Utah	3,265	37	16	110	56
Hole-in-the-Rock (upper)	Kane, Utah	4,329	37	16	110	56
House Rock Valley	Kane, Utah	5,000	37	16	111	54
Huntington	Emery, Utah	5,791	39	20	110	58
Indian Gulch, Mouth	Kane, Utah	3,500	37	30	110	58
Jensen	Uintah, Utah	4,738	40	23	109	19
Johnson Creek	Kane, Utah	5,000	37	03	112	23
Junct. N. Wash and Colo. River	Garfield, Utah	3,455	37	52	110	24
Junct. San Rafael and Green R.	Emery, Utah	3,985	38	46	110	07
Junct. Strawberry R. and Timber Canyon	Duchesne, Utah	6,700	40	07	110	49
Kanab	Kane, Utah	4,925				
Kanab Canyon	Kane, Utah	5,300	37	08	112	32
Kemmerer, 39 mile East	Sweetwater, Wyoming	6,900	41	52	110	30
Linwood	Daggett, Utah	6,024	41	00	109	38
La Sal Junction	San Juan, Utah		38	15	109	20
La Sal	San Juan, Utah		38	15	109	10
Lone Rock (Wahweap Creek)	Kane, Utah	4,034	37	01	111	23
Manila	Daggett, Utah	6,376	40	59	109	42
Mesa Verde National Park	Montezuma, Colorado	8,500	37	15	108	30
Mexican Hat	San Juan, Utah	4,244	37	09	109	53
Mexican Water	Apache, Arizona		36	59	109	43
Moab	Grand, Utah	4,042	38	35	109	32
Moab, 20 miles South	San Juan, Utah	5,900	38	33	109	32
Montezuma Creek	San Juan, Utah	4,750	37	27	109	12
Monticello	San Juan, Utah	7,066	37	52	109	20
Monument Valley (Gouldings)	San Juan, Utah	5,225	37	02	110	03
Myton	Duchesne, Utah	5,082	40	11	110	03
Natural Bridges Nat. Monument	San Juan, Utah	6,022	37	38	110	02
Navajo Mountain (Dunn's)	San Juan, Utah	6,000	37	02	110	47
Navajo Wells	Kane, Utah	5,000	37	04	112	15

Locality	County and State	Elevation	North Latitude		West Longitude	
North Wash	Garfield, Utah	3,600	37	53	110	25
Notom	Wayne, Utah	5,250	38	14	111	07
Ouray	Uintah, Utah	4,654	40	05	109	41
Paria	Kane, Utah	4,625	37	13	111	58
Pink Sand Dunes	Kane, Utah	5,200	37	03	112	43
Price	Carbon, Utah	5,566	39	36	110	12
Rainbow	Uintah, Utah	5,350	39	51	109	12
Red Creek	Daggett, Utah	5,500	40	54	109	13
Red Mesa	San Juan, Utah		37	00	109	25
Roosevelt	Duchesne, Utah	5,100	40	18	109	59
San Rafael Swell	Emery, Utah	5,000	39	01	110	38
Sheep Creek	Daggett, Utah	5,900	40	55	109	40
Sheffield Ranch	Garfield, Utah	4,800	37	45	111	57
Short Creek	Mohave, Arizona		36	59	112	57
Sixty Mile	Kane, Utah	5,000	37	25	111	02
Soda Springs	Kane, Utah	5,000	37	25	111	02
Split Mt.	Uintah, Utah	4,780	40	30	109	03
Star Spring	Garfield, Utah	5,000	37	49	110	32
Temple of the Sun	Garfield, Utah	4,200	38	05	111	05
The Hall	Kane, Utah	5,000	37	31	111	08
Three Lakes	Kane, Utah	5,300	37	08	112	35
Tonalea	Navajo, Arizona		36	25	110	55
Torrey	Wayne, Utah	7,000	38	18	111	26
Trachyte Creek	Garfield, Utah	3,445	37	48	110	27
Tropic	Garfield, Utah	6,298	37	37	112	06
Tuba City	Coconino, Arizona		36	08	111	15
Twenty Mile	Garfield, Utah	5,000	37	32	111	15
Wahweap Creek	Kane, Utah	4,300	37	03	111	37
Wellington	Carbon, Utah	5,415	39	33	110	44
White Canyon	San Juan, Utah	5,600	37	37	110	02
Willow Creek	Daggett, Utah	5,365	40	51	109	06
Willow Tank Spring	Kane, Utah	4,800	37	32	111	08
Woodside	Emery, Utah	4,627	39	16	110	21
Yellowstone Creek	Duchesne, Utah	8,200	40	30	110	18

In addition to specimens and field notes available from the above-mentioned expeditions conducted by the authors, several persons have contributed valuable information and specimens from various parts of the Upper Basin. From 1948 to 1958, Merlin L. Killpack contributed many specimens of mammals, birds, reptiles and amphibians from the Uinta Basin Area. Karl Lemon also contributed some reptile collections from Ioka, Duchesne County, and Andrew Barnum has contributed a small collection of reptiles from Grand Junction, Colorado.

IV. GEOLOGICAL AND TOPOGRAPHICAL FEATURES

From the writings of Powell (1875) and other early geologists to the present day, many papers on the geology and topography of the Upper Colorado Basin have been published. A comprehensive list of these publications is found in "A Survey of the Recreational Resources of the Colorado River Basin" (1950). In this publication (pp. 22-54) an excellent summary of the geology of the area is given by Gregory and McKee. Only a very brief statement covering the area considered in this paper will be included in this report. (Fig. 2)

The region which is the subject of the present report is divided into three principal geographic provinces (Fig. 1): namely, the Green River Basin Province, the Uinta Mountain Province, and the Colorado Plateau Province. Green River Basin occupies an area of approximately 30,000 square miles. It lies chiefly in the southwestern corner of Wyoming, but a narrow strip of it is found along the northeastern border of Utah and a considerable area of northwestern Colorado belongs to this Province. The general aspect of the province is one of rolling hills or flat to gentle sloping country, trenched by broad river valleys. The rocks are mainly sedimentary, Tertiary in age, and many ledges are exposed along the borders of the stream valleys. Green River Basin is bounded on the north by the high Wind River and Wyoming Mountain Ranges, on the east by the continental divide, on the west by the Bear River divide and on the south by the Uinta Mountains and Yampa Plateau. The Green River, having its origin in the Wind River and

Wyoming Ranges, passes approximately down the center of the province. Its principal tributaries include La Barge Creek, Sandy Creek, Bitter Creek, Black's Fork, the Yampa River and its chief tributary, the Little Snake River. The general direction of flow of the Green River is directly southward until it reaches the Uinta Mountains. It then turns abruptly eastward into Colorado, cuts across the east end of the mountains through deep gorges and then enters the Uinta Basin through Split Mountain Canyon.

The Uinta Mountain Province includes the Uinta Range itself and the Uinta Basin which lies directly southward of it. This basin, which is the chief area of the province considered in this report, covers a relatively small area of about 14,000 square miles in Utah and Colorado. It is bounded on the north by the Uinta Mountains, on the east by the Roan and White River Plateaus, on the west by the Wasatch Mountains, and is terminated by the escarpment of the Tavaputs Plateau on the south.

In structure it represents a long syncline. Its lowest elevation along the Green River is 4700 feet, from whence it ascends northward toward the base of the Uinta Mountains to 7,000 feet. Southward it slopes gradually upward to the rim of the Tavaputs Plateau to an elevation of 8,000 to 9,000 feet. The latter then breaks off abruptly along the Roan and Book Cliffs, to the Price and Grand River Valleys. Rocks which form the floor of the basin and are exposed in many places are of Tertiary age. The Green River takes a diagonal course across the basin, bisecting the Tavaputs Plateau, and then enters the Colorado River Plateau near the town of Green River, Utah. Two main tributaries join Green River in the Uinta Basin; namely, White River coming from the east and Duchesne River from the west. The latter stream receives the Uintah River from the Uinta Mountains and the Strawberry River from the Wasatch Mountains besides several smaller streams.

The Colorado Plateau Province is by all odds the greatest in size and the most spectacular part of the Upper Basin (Figs. 1, 2, 21). The geological history of this vast area of approximately 130,000 square miles includes two long periods of deposition, two periods of great uplift, and two periods of erosion. During Paleozoic and Mesozoic times, sandstone, limestone and shale were deposited to great depths in water and on land. This mass of sedimentary rock was uplifted near the close of the Cretaceous Period in a nearly horizontal position but with much folding and warping in certain areas. A period of erosion then followed during which a general leveling took place. This was followed by a second period of deposition during Tertiary times and another period of uplift which brought the plateau to an elevation where precipitation was increased and the forces of stream erosion became immensely intensified. Thus during the past 20,000,000 years the great maze of precipitous canyons, cliffs, mesas, and terraces, as well as the many wierd formations which characterize this province, was sculptured.

As stated above, the uplifting of this immense plateau area generally left the rocks in their original horizontal position of deposition. However, several forces acting in local areas have broken the even continuity of the strata. One of these forces was an upwarping and downwarping of the strata in large areas which brought about such conspicuous structures as the Kaibab Plateau, the Uncompagre, and Kiaparowits Plateaus, the Water Pocket Fold, the San Rafael Swell and the Tavaputs Plateau. A second force was the intrusion of igneous material which tilted and broke the overlying sedimentary strata and produced high isolated mountain ranges such as the Navajo, Henry, Abajo, La Sal and Ute Mountains. (Fig. 3). In most cases the sedimentary rocks have been eroded away from these laccolithic mountains, leaving the igneous cores exposed. A final important force in the dynamic geology of the area has been the formation of extensive faults such as the Hurricane, Paunsaugunt, Sevier, and Grand Wash.

The northern part of the Colorado Plateau as it is found immediately south of the Book and Roan Cliffs consists of the broad valleys of Price River, which arises from the Wasatch Mountains, and the Grand River, which flows southwestward from the Colorado Rockies and is joined by its large tributary, the Gunnison River, which also has its origin high in the Rockies.

Soon after entering the canyon country to the south of the Grand River Valley, the Green and Colorado Rivers join, thus bringing together the waters from the water sheds of Utah, Wyoming and Colorado. Before joining the Green River the Colorado receives the Dolores River from the east, and farther in its course, near the Utah-Arizona border, the San Juan River also enters the Colorado from the east. From the westward high plateaus of Central Utah come a number of lesser streams including the San Rafael, Fremont, Escalante, and Paria Rivers and Kanab Creek. (Fig. 21)

V. GENERAL CLIMATIC CONDITIONS OF THE UPPER COLORADO RIVER BASIN

Most of the desert lands of the Upper Colorado River Basin lie between 4,000 and 7,000 feet in elevation. The winters, though comparatively dry, are cold and windy, and the summers are characterized by hot days and cool

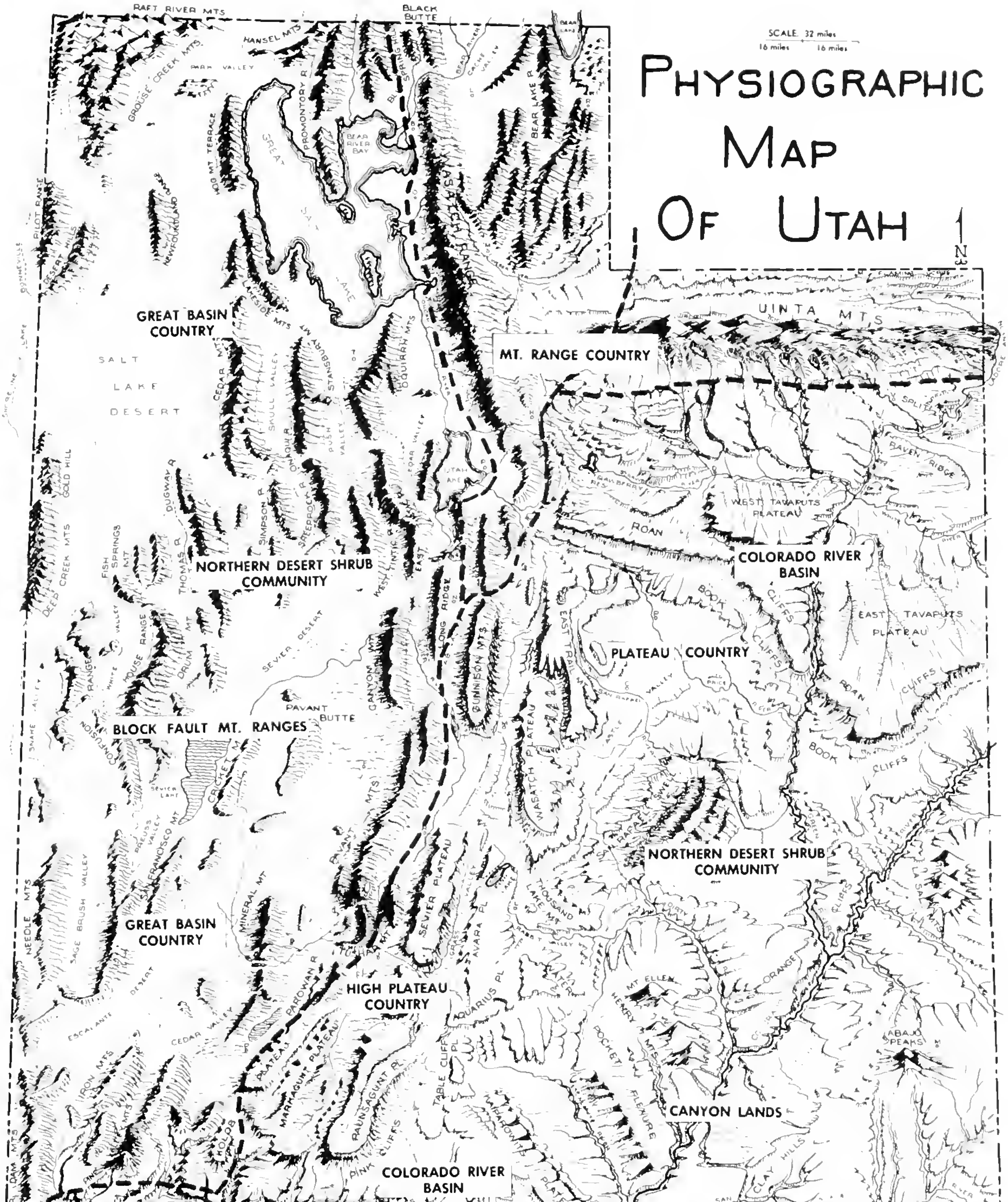


Fig. 2. Physiographic map of Utah.

nights. Most of the moisture in the form of snow usually falls between January 1 and May 1. June and early July are usually dry periods but in late July, August and early September there may be frequent thunder showers in local areas. Often the precipitation from these summer storms falls over the mountains and high plateaus rather than the desert, collects in the canyons and washes and forms raging torrents for a few hours. The desert itself actually benefits very little from most of these storms since there is a high rate of runoff, even of that precipitation which actually falls on the desert lands. In fact, such storms may do considerable harm through sheet erosion. Precipitation coming in the form of snow or gentle rain in late winter and spring is of greatest importance to the desert lands since more of it can be absorbed and utilized by the vegetation Desert areas close to mountains or high plateaus usually receive slightly more moisture than do those far removed.

A detailed climatic summary of Eastern Utah up to 1930 may be found in a publication of the United States Weather Bureau (Climatic Summary of the United States, Section 21). A summary of information pertaining to several localities within the Upper Basin is presented in Table 2.

Excluding the conditions at Hite, fourteen stations taken at random over the Utah portion of the Upper Basin and ranging between 4,000 and 7,000 feet in elevation show that the annual mean temperatures vary within a range of about 12 degrees, between 42 degrees F., and 54 degrees F., or about 4 degrees per thousand feet of elevation. Almost all are subject to temperatures above 100 degrees F. at times during the summer, and all may suffer subzero temperatures in winter. Annual precipitation varies a great deal more, owing in part, at least, to more or less favorable conditions with respect to mountain ranges and elevation. For example, Monticello, located between the LaSal and Abajo Mountains at a relatively high elevation, receives about three times more precipitation than Cisco located in the Grand River Valley. The last-named station has an elevation of about 4,300 feet and is farther removed from high mountains. In general there is somewhat less correlation between precipitation and altitude than there is between temperature and altitude. For example, Kanab, which has an elevation about 600 feet higher than Bluff, re-

Table 2. Weather Data from Selected Stations in the Utah Portion of the Upper Colorado River Basin from Summary Reports of U.S. Weather Bureau. Temperature in °F. Precipitation in Inches.

	Elevation	Av. Annual Temperature	Highest Temp. to 1930	Lowest Temp. to 1930	Av. Annual Precipitation	Av. Snowfall
Bluff, San Juan County	4,320	54.7	109	-20	7.12	10.3
Castle Dale, Emery County	5,771	45.5	104	-35	9.07	14.5
Cisco, Grand County	4,352	51.9	109	-26	6.50	17.3
Escalante, Garfield County	5,303	47.8	101	-20	11.76	23.1
Fort Duchesne, Duchesne County	5,990	44.2	104	-36	6.97	19.0
Green River, Emery County	4,087	52.2	112	-31	6.24	9.2
Hanksville, Wayne County	4,125	51.4	112	-35	5.41	13.3
Hite, Garfield County	3,480	59.7	115	- 1	7.28	0.0
Kanab, Kane County	4,973	52.1	105	-15	12.63	20.3
Manila, Daggett County	6,376	42.8	99	-32	10.63	47.8
Moab, Grand County	4,042	54.1	111	-24	9.52	16.5
Monticello, San Juan County	7,066	45.3	98	-14	18.12	65.1
Price, Carbon County	5,566	47.8	108	-31	10.66	21.9
Vernal, Uintah County	5,315	45.0	106	-29	9.11	23.1
Watson, Uintah County	5,346	46.2	99	-23	11.87	41.2

ceives on the average over five inches more annual precipitation.

From the point of view of survival of desert organisms, the Upper Basin climate is subject to extreme variations with the season and the years. At Bluff, Utah, for example, extreme temperatures of 109 degrees F. and -20 degrees F. may be felt within a year, a range of 129 degrees. In precipitation the area about Escalante had an annual variation over a thirty-year period from a low of 6.9 inches in 1924 to a high of 21.7 in 1927.

VI. BIOTIC COMMUNITIES

As is the case everywhere, the presence or absence of a given kind of animal depends upon a complex variety of physical and biotic forces that impinge upon it. In the previous section of this study we have shown that the desert area under consideration is subject to a generally dry climate, with only a narrow border along the waterways and about the scattered springs having available a fairly constant and dependable source of water. By far the greater part of the land surface depends upon a few inches of precipitation, variable in amount from year to year, that falls mostly during late winter and early spring. Deserts of the Upper Basin are sometimes considered to be "cold" deserts in contrast to the "hot" deserts of the Southern Basin. Many of the animals are actually subjected to great extremes of temperatures both hot and cold, and their responses to these factors in terms of their habits and distribution are of great importance.

Soils of the area are generally of poor quality owing to the slow formation of organic matter, the tendency for it to be washed away by sheet erosion, and the proclivity for salts to accumulate in poorly drained areas. In texture, too, the soils vary from heavy clays in lower basins and valleys to almost pure sands in other places. In topography the Upper Basin desert lands range from extensive plains to the most rugged kind of terrain.

It is the *details* of physical factors operating in an area that are of greatest importance in a localized study such as we are presenting here; therefore, broad systems of community classifications such as geographical regions, provinces, and life zones have only a very general application to our situation.

As we attempt to define and describe the biotic communities of the Upper Basin, the vegetation of the area probably affords the best basis for comparison, since the nature of the plant cover gives us a clue to those physical forces that are also important to the animal life. The role of plants, or more particularly vegetation as such, in the occurrence and habits of animals is difficult to evaluate although we sometimes see a close correlation between the distribution of the two. Of the several environmental factors that are of importance to the general well being of the animals, cover is of paramount importance, and vegetation is only one factor, along with the physical nature of the terrain and the condition of the soil, that plays a part in the shelter of the animal inhabitants of the area.

Figs. 15, 16, 18, and 19 show the distribution of amphibians, reptiles, birds, and mammals from selected localities in the Upper Basin.

The Life Zone Concept proposed by Merriam many years ago (1890, 1892, 1894, 1898) was an attempt to define biotic communities on the basis of both plants and animals as well as to arrive at the factors of the climate, particularly temperature, that control the distribution of organisms. While this concept has a certain value in a broad sense when applied to areas of great differences in altitude or latitude, it is of little use in the present study because almost all of the Upper Basin desert communities would fall within a single life zone; namely, the Upper Sonoran. What is needed is a more detailed analysis of the subdivision of the major communities and a picture of the more precise ways in which the animals fit into them. Several studies in the Upper Basin and adjacent areas have thrown some light upon this matter.

V. M. Tanner (1940) published a report on the Kaiparowits region, based principally upon data collected by several expeditions made by the Brigham Young University Department of Zoology. He recognized a Desert-Prairie Community and a Pinyon-Juniper Community as desert types. While he presents a considerable list of plants and animals which had been collected, there is some confusion in his use of ecological terms, and the reader is left without a clear concept of the details of community organization. Futhermore, his report covers only a small part of the Upper Basin area

Fautin (1946) made a careful study of the desert communities of a part of the Great Basin of western Utah in which he recognized about four major communities. He placed these communities in the Northern Desert Shrub Biome. However, the Upper Basin is so different topographically from the Great Basin that it is difficult to apply some of his terms to the Upper Basin area even though many species of plants and animals are common to both and climatic conditions are also similar.

Whereas the Great Basin consists mainly of broad valleys of relatively even contour and great expanses of uniform vegetation, the Upper Basin is, for the most part, a land of many deep canyons, sheer cliffs, badland formations, plateaus, mesas, and country that is also broken and warped by the upthrusting of great mountain masses. The vegetation, therefore, presents a picture of great complexity, less uniform in continuity, and it is more difficult to define and describe. Ecologically speaking, the desert communities of the Upper Basin are less stabilized into extensive climaxes. While the Great Basin has few large streams running for long distances and none that connect it with outside areas, the Colorado Basin has numerous sizeable waterways coming from all directions and affording natural passages for egress and ingress from a vast area of country. This has resulted in a fauna and flora of unusual diversity and interest. (Fig. 2)

Several floristic studies have been made that apply directly or indirectly to the Upper Basin. Most of these, however, have been broad and general or else have been limited to small areas. Shantz (Tidestrom, 1925) has described the general plant communities of Utah and Nevada. His Pinyon-Juniper Woodland, Northern Desert Shrub, and to a limited extent his Salt Desert Shurb formations occur in the Upper Basin, but some of his subdivisions of these formations (associations and associes) are less easily distinguished in the Colorado River Basin than they are in the Great Basin. Hunt (1953) has followed the system of Shantz in a brief description of the vegetation of the Henry Mountains area and has published a rather extensive list of the plants of that area based on the collections of the late W. D. Stanton of Brigham Young University.

Graham (1937) defined the plant communities in the Uinta Basin and recognized a Juniper-Pinyon zone and a Mixed Desert Shrub Zone. The latter zone was divided by him into a number of subcommunities, some of which were called associations. These included the Cottonwood River Floodplain, marshlands (Scirpus-Typha Swamp), Salt Grass Meadow, Badlands, Desert Gulch, Greasewood (*Sarcobatus*) Association, Mat Shadscale (*Atriplex*) Association, *Kochia-Hilaria* Association (Gray Molly and Galleta Grass), Rabbitbrush Association (*Chrysothamnus*), *Atriplex-Tetradymia* Association (Shadscale and Saltbrush), Low Altitude *Artemisia* Asociation (Sagebrush), *Eurotia* Association (Winter Fat) and the Mid-Altitude *Artemisia* Association (Sagebrush).

Dixon (1935) has described the vegetation of the high plateaus of Central Utah. She calls attention to the Southern Desert element in the canyon floras and also recognizes a Pinyon Zone, an Alkali Association, a Northern Desert Climax (sagebrush), and a Northern Semidesert (juniper-mountain mahogany climax), all of which would be included in the Upper Basin deserts as herein considered.

Costello (1944) in describing the semideserts of western Colorado and part of Wyoming lying in the Upper Basin describes saltbrush, sagebrush, and greasewood types. His sagebrush type includes a number of important grasses: namely, *Agropyron dasystachyum*, *Oryzopis hymenoides*, *Sitanion hystrix*, and *Agropyron smithi*. His saltbrush type (in which he recognizes southwestern and northwestern subtypes) is characterized by several species of Atriplex and other salt tolerant plants and the grasses *Hilaria jamesii* and *Oryzopsis hymenoides*. Costello's greasewood type is distinctive through the predominance of *Sarcobatus vermiculatus*, *Kochia americana*, and several species of *Atriplex* as well as a few grasses.

Kelson (1951) and Durrant (1952) in dealing with the mammals of the Upper Basin of Utah and other areas have utilized a system of faunal areas which they have subdivided into provinces and subcenters. They recognize about nine such units within the Utah portion of the Upper Basin alone. Their divisions are based solely upon the coincidence of the distribution of mammals and the major physiographic regions, and they do not pretend to take into account other groups of animals and the types of plant communities. Both of these authors recognize the shortcomings of such broad concepts as Merriam's Life Zones and the Biotic Provinces of Dice (1943) in attempting to describe the ecology and distribution of animals in local and complex situations such as prevail in the Upper Basin. The works of Kelson and Durrant (*loc. cit.*) are of special importance in dealing with problems of the origin of the mammal fauna of the Upper Basin.

The examples given above are enough to indicate the diversity of criteria and terminology that have been employed in an attempt to describe the biota of the Upper Basin. In general, however, we feel that it is feasible to base a community classification on the types of predominant vegetation with due consideration for the principal variations within each major type that result from the impact of differences in topography, soil, and climate. It is proposed that four principal vegetation types in the Upper Basin deserts be considered as follows for the Green River Basin, Uinta Mountain and the Colorado Plateau Provinces:

1. Cottonwood-Willow-Tamerisk Floodplain, characteristically bordering the waterways. (Figs. 3, 4, 5, 6)
2. Northern Desert Shrub occupying the broad valleys, slopes, and low hills are typified by such plants as several species of sagebrush, shadscale, rabbitbrush, yucca, cacti, blackbrush, greasewood, joint fir, and others. (Figs. 7 and 8)
3. Pinyon-Juniper Woodland varying from extensive and continuous forests to scattered growths interspaced with desert shrubs occupying low mesas or ravines where the soil is rocky or sandy. (Figs. 9 and 10)

4. Hanging Gardens, a fourth, though somewhat localized vegetation type, which is of some significance and is characteristic of the canyon country. Seep seams along the steep canyon walls allow the accumulation of travertine which supports a rich variety and luxuriant growth of plants adapted to hydric conditions. (Fig. 17)

In general, the floodplain community occupies the lowest elevations, pinyon-juniper the highest, and the desert shrub the intermediate. However, there are frequent instances of inversion, and evidences that such things as edaphic conditions, overgrazing or historical factors may be more important than mere elevation under certain localized conditions.

Of the four types the floodplain is the most uniform throughout the Upper Basin as to the general ecological conditions of cover and the availability of water. However, there are considerable differences in climate from one end of the Upper Colorado drainage to the other which are reflected in the species of predominant plants and animals that live in the floodplain habitat.

The desert and semi-desert shrub type receives the greatest impact from the variations in topographic features and from the differences in the physical and, to a lesser degree, the chemical conditions of the soil. Climatic differences within the Upper Basin desert shrub community are also evident as a result of altitudinal and latitudinal variations.

The Pinyon-Juniper Woodland is more uniform than the desert shrub type although it too shows much variation, particularly with respect to basal area cover (density) within its range. Furthermore, this community is not well developed in the Green River Basin Province.

While the botanist, and particularly the plant sociologist, would find it necessary to subdivide the Upper Basin deserts into many vegetation units in order to adequately deal with the complex ecology of the area, the zoologist finds it impractical to employ such a system in describing the distribution and ecology of the animals that live there. The vertebrate land animals in particular are often less dependent upon the vegetation *per se* than upon the physical factors of climate, soil, and topography, and rarely do they respect the boundaries or conditions prescribed by the botanist for his plant communities.

Among the land vertebrates certain general conditions of distribution and habitat requirements prevail in desert areas. Some reptiles and small mammals tend to be closely confined to peculiar habitats. Most of them are true desert animals depending for their water supply primarily upon that which they can obtain from their food either directly or as metabolic water, and secondarily upon the infrequent and temporary supply from rain or snow. Larger predatory and ungulate animals are less confined to peculiar and limited habitats and may wander far out into the deserts, but they must be able to visit more or less frequently a dependable and constant source of water from a stream or spring.

Where constant and extensive waterways pass through desert country as they do in the Upper Basin, most of the bird species concentrate along these waterways partly because of a more favorable cover and food supply afforded by the more luxuriant vegetation, and partly because of the close and dependable supply of water. It is doubtful if there is any kind of bird living in the Upper Basin that is truly desert as are some of the reptiles and small mammals, but a limited number of species are no doubt better adapted to longer periods without drinking water than others and are consistently found many miles from the nearest permanent water source. Woodbury (1954: p. 99) states that Say's phoebe is able to live without drinking water. Wing (1956: p. 92) states that while most birds require drinking water almost every day, certain desert birds "have no opportunity to drink." Zoologists are prone to make their field camps near streams or springs and thus fail to gain a true picture of desert life, and a distorted concept of populations of birds in particular would result from such a practice. To gain a realistic idea of true deseret conditions it is necessary for the student to carry his water with him and subject himself as much as possible to the ecological circumstances under which true desert animals live.

Since the overall picture of the Upper Basin desert habitats is so variable from place to place it is thought most desirable at this time to review the patterns of distribution, and insofar as possible, the ecology of the land vertebrates as we have observed them in certain typical localities throughout the three major physiographic provinces of the Upper Basin in which we have done field work.

For convenience in presentation each of the provinces (Green River Basin, Uinta Mountains, and Colorado River Provinces) is divided into a number of "areas." These areas do not necessarily represent distinct biotic units and no attempt is made to show their boundaries on a map. They are designated for the purpose of giving the reader a clearer picture of the more specific topographical and geological features of the areas as a basis for understanding the occurrence and distribution of the more common plants and vertebrate animals. Certain ones of these areas are described in general, while in other areas specific stations, typical of different parts of the area, are

Fig. 3. La Sal Mountains in Grand and San Juan counties, Utah, are a typical intrusive laccolithic range in the Upper Basin. Some of these peaks have an elevation above 13,000 feet. This range is surrounded by desert country having an average elevation of about 5,000 feet, isolating it from other mountain ranges. In the foreground is a typical broad and shallow desert wash subject to seasonal floods, but normally carrying very little if any water.

Fig. 4. Desert country in the Uinta Basin, Uintah County, Utah. The Green River with typical willow-cottonwood floodplain is shown in the middle distance. The principal vegetation in the river valley is three-toothed sage. The distant benchlands are vegetated principally with shadscale, while the higher elevations shown in the right foreground of the picture support a typical pinyon-juniper woodland.

Fig. 5. Narrow canyon floodplain at Fruita, Wayne County, Utah. At the right is a typical, precipitous reef formation with rocky talus at the base. Tamarisk and cottonwoods are the predominant plants on the floodplain of the Fremont River at this point. In the distance is Miner's Mountain which is the northern extension of the Water Pocket Fold. It is vegetated with a sparse growth of pinyon-juniper woodland.

Fig. 6. Kanab Canyon about 7 miles north of Kanab, Kane County, Utah. This is an open type canyon in which the stream is bordered by a narrow marshland. The canyon slopes are clothed with a mixture of pinyon-juniper woodland, three-toothed sage, and other shrubs.

Fig. 7. Plains area southwest of Green River, Emery County, Utah. The vegetation is predominantly shadscale, rabbitbrush and matchbrush. In the distance are the upturned rock formations forming the eastern edge of the San Rafael Swell.

Fig. 8. Broad plain near Navajo Wells east of Kanab, Kane County, Utah. The vegetation is an almost pure stand of three-toothed sage. The Vermillion Cliffs are in the background with the slopes at their bases vegetated with a pinyon-juniper woodland. The road in the foreground connects Kanab with the Glen Canyon damsite at the Utah-Arizona border.

Fig. 9. Pink Dunes area near Kanab, Kane County, Utah, at the southwest corner of the Upper Basin. The vegetation on the sand dunes is principally *Yucca*, scurf-pea and *Wyethia*. The vegetation on the highlands in the background represents the upper limits of the pinyon-juniper woodland predominated by western yellow pine.

Fig. 10. Typical pinyon-juniper woodland looking west from Elk Ridge toward the Bridges National Monument, San Juan County, Utah. The long mesas, slopes and valleys are all covered with pinyons and junipers. In the distance are the Henry Mountains across the Colorado River in eastern Garfield County, Utah.

Fig. 11. Pinyon-juniper woodland near Flaming Gorge, Daggett County, Utah. Scattered western yellow pines are also present. This is also typical of much of the highland desert country along the north and west borders of the Uinta Basin. The open areas are clothed with a variety of grasses.

Fig. 12. Pinyon-juniper-blackbrush community in Arches National Monument. Here the pinyon-juniper occupies the more rocky draws and ridges. The open sandy flats are vegetated predominantly with blackbrush and joint-fir. (See also Fig. 16).

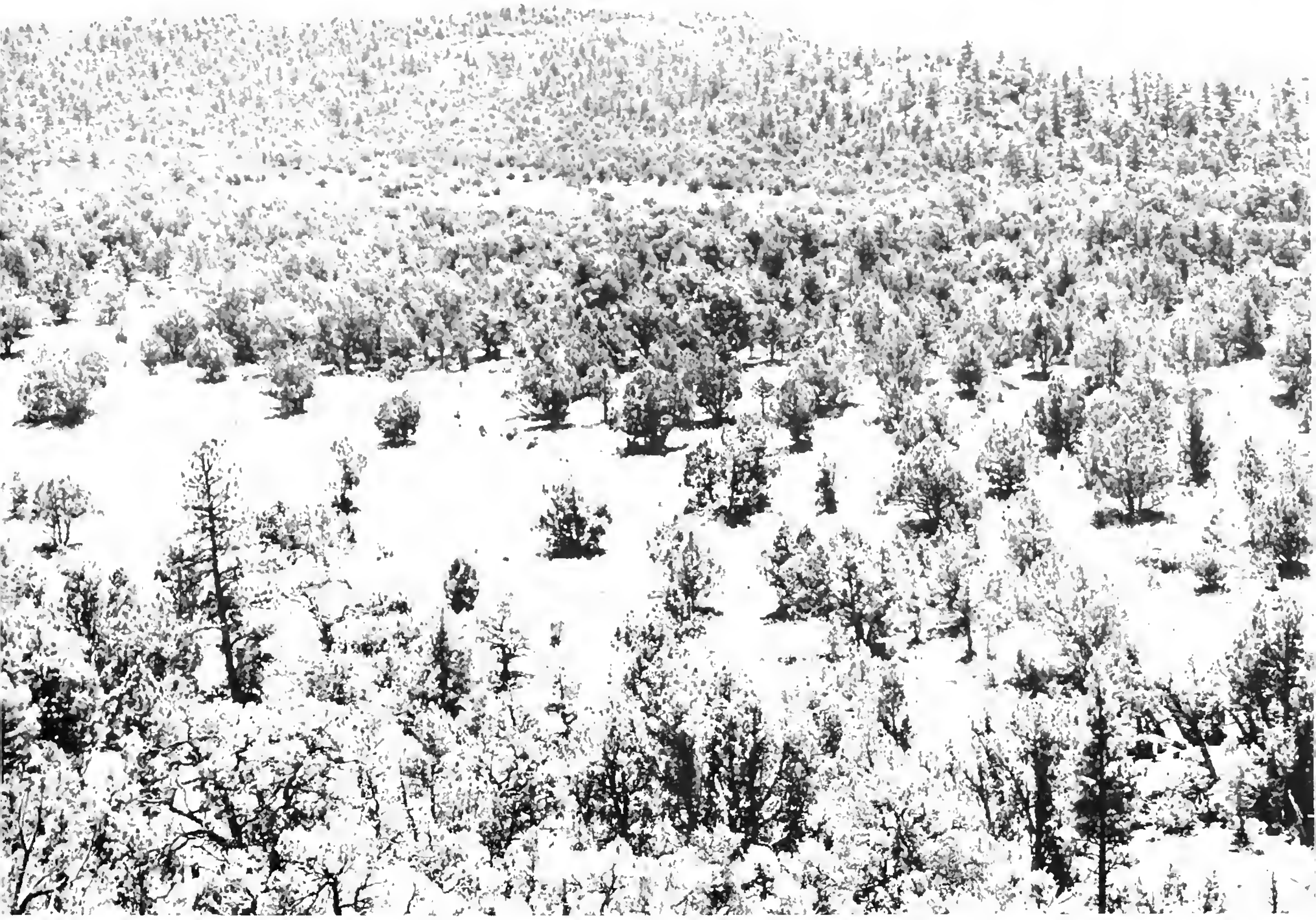


Fig. 13. Castle Valley northeast of Moab, Grand County, Utah. This is a broad river valley dominated by pinyon-juniper on the hillsides, and a mixture of three-toothed sage, greasewood, shadscale and rabbitbrush in the valley. The tall light colored plant in the foreground is Princess Plume. In the distance is one of the high peaks of the La Sal Mountains.

Fig. 14. Clark's Bench, Paria Plateau, Kane County, Utah. In the foreground is a grassland vegetated principally with Indian rice grass and galleta grass. There are also a few hummocks of joint-fir and *Yucca*. The hills in the distance are the southern extension of the Kaiparowits Plateau.

considered in more or less detail. Although this means of presentation results in some repetition, the writers feel that it will serve to give the reader a more detailed account of the Upper Basin than would otherwise be possible.

The Colorado Plateau Province

The general physiographic features of the Colorado Plateau have been described elsewhere in this report. In area it occupies about two-thirds of the Upper Basin and affords a complex of topographic, edaphic and climatic conditions that are reflected in the ecology and distribution of its fauna. In describing this province the areas east of the Colorado and Green Rivers and those west of these rivers will be considered in turn.

The Navajo Mountain Area

Navajo Mountain is a conspicuous rounded laccolith that rises in the desert south and east of the junction of the San Juan and Colorado Rivers. A biological reconnaissance of the area was made and the results published by Benson and others (1935), and the birds were reported upon by Woodbury and Russell (1945). The area may be reached by traveling northward from Tonolea, Arizona, over a rather poor desert road to the Navajo Trading Post which is situated near the east side of the mountain. In the approach from Tonolea one passes over many miles of rolling country where the soil is very sandy. There are alternating low sand hills, showing some signs of drifting, and shallow valleys where the soil is more stabilized. The sand hills are vegetated with *Ephedra*, *Yucca*, Indian rice grass (*Oryzopsis hymenoides*) and a few scattered junipers, while the flats and valleys are clothed principally with three-toothed sagebrush (*Artemisia tridentata*). As one approaches nearer to the mountain the elevation increases, gradually forming extensive mesas with elevations of from 5,000 to 6,000 feet. These mesas are vegetated with a well developed pinyon-juniper forest, but their even continuity is interrupted by many deep, rugged and tortuous gorges that drain into the San Juan and Colorado Rivers. Navajo Canyon and Piute Canyon with their many tributaries are typical of such gorges lying south and east of Navajo Mountain itself.

The biotic communities of this area are complex and varied and have not been sufficiently studied. However, certain generalizations may be drawn from our studies and from the literature. The area adjacent to the Navajo Mountain Trading Post near the east base of the mountain possesses most of the habitats typical of the country in general. They are as follows: (1) Broad canyon bottoms or valleys surrounding low mesas where the soil is composed of deep, often unstable sand and where the principle vegetation is joint fir (*Ephedra*), rabbitbrush (*Chrysothamnus*), yucca, and a few scattered junipers, and three-toothed sagebrush (*Artemisia tridentata*) where the soil is more stabilized; (2) walls of canyons and mesas formed of sandstone ledges and tumbled masses of boulders; (3) flat-topped mesas supporting either pinyon-juniper forests or open patches of sagebrush where the soil is sandy, or blackbrush (*Coleogyne ramosissima*) where the soil is gravelly or rocky.

In the first-named community the deer mouse (*Peromyscus maniculatus*) and Ord's kangaroo rat (*Dipodomys ordii*) are most abundant. Signs of the latter species are everywhere and the evidence of their burrows about the basis of the clumps of vegetation are commonplace. Found in lesser numbers in this sandy habitat are the western harvest mouse (*Reithrodontomys megalotis*), the northern grasshopper mouse (*Onychomys leucogaster*) and the white-throated woodrat (*Neotoma albigula*). Benson (1935) found this woodrat inhabiting rocky habitats, but we took it fourteen miles north of Tonolea in a typical sandy area and in a similar situation at Navajo Trading Post.

The sandstone ledges and loose piles of boulders support a distinctly different mammalian fauna than does the sandy habitat described above. The piñon mouse (*Peromyscus truei*) is very common and Stephens' woodrat (*Neotoma stephensi*), Colorado chipmunk (*Eutamias quadrivittatus*) and rock pocket mouse (*Perognathus intermedius*) are very characteristic although less abundant. Benson (1935) found the canyon mouse (*Peromyscus crinitus*) to be very abundant in the deeper canyons near Rainbow Bridge, but we found it to be rare at Navajo Mountain Trading Post. Both the white-tailed antelope squirrel (*Citellus leucurus*) and the rock squirrel (*Citellus variegatus*) were seen in the rocky ledges, but they were very uncommon, owing in part, no doubt, to the fact that they are constantly hunted by Indians and their dogs. A few desert cottontails (*Sylvilagus auduboni*) inhabit the rocky areas, but they, too, are scarce and wild.

In our work we did not sample the dense stands of Pinyon-Juniper Woodland of the higher mesas, but we did study the open stands of sagebrush and blackbrush. In both we found the populations of small mammals to be very low. The silky pocket mouse (*Perognathus flavus*) was found in the blackbrush community on gravelly soil. In addition, Benson (1935) also found the Apache pocket mouse (*Perognathus apache*) on the plain, south of Navajo Mountain where sagebrush is predominant. Botta's pocket gopher (*Thomomys bottae*) is fairly common on these plains, and we also took the deer mouse in this same habitat. We saw a few black-tailed jack rabbits (*Lepus cal-*

ifornicus) in the pinyon-juniper woodlands and desert shrubs.

Our observations would agree with those of Benson (*loc. cit.*) that there is a general scarcity of mammal life throughout the Navajo Mountain area. It differs from all other parts of the Upper Basin in that there are apparently no deer or other large game animals (Benson, *loc. cit.*) Either these have been exterminated by the Indians or else they have never existed there. Jack rabbits, cottontails and the larger squirrels have undoubtedly been utilized extensively by the Indians as food which may account in part for their scarcity and wildness. The area is heavily grazed by sheep and goat herds as well as the horses of the Indians. The Indians' dogs also roam widely over the area. Many of these are semi-wild. Of the native carnivors the grey fox (*Urocyon cinereoargenteus*) is apparently the most widespread and common.

Most of our information concerning the birds of the Navajo Mountain area comes from the observations of Benson (*loc. cit.*) and Woodbury and Russell (*loc. cit.*) In our own field work in the area we were able to make only casual observations. Benson found that the bird populations were relatively low in desert communities. In the open blackbrush, sagebrush or sandy Ephedra-Yucca type of community the black-throated sparrow (*Amphispiza bilineata*) and Brewer's sparrow (*Spizella breweri*) are probably the most abundant and characteristic species. In the pinyon-juniper woodland the pinon jay (*Gymnorhinus cyanocephala*), plain titmouse (*Parus inornatus*) and blue-gray gnatcatcher (*Polioptila caeulea*) are common.

Our limited information concerning the amphibians and reptiles of the Navajo Mountain area is based primarily on the survey trip made by C. Lynn Hayward, D Elden Beck, and LaVell King in April 1955. In the temporary ponds and along the few intermittent streams of the broad valleys the Great Basin spadefoot (*Scaphiopus h. intermontanus*) and the Rocky Mountain toad (*Bufo woodhousei*) were found. The brushy flats and low mesas are inhabited by the leopard lizard (*Crotaphytus w. wislizeni*), northern side-blotched lizard (*Uta s. stansburiana*) and the Great Basin sagebrush lizard (*Sceloporus g. graciosus*). Along the rocky slopes and among the tumbled masses of rock we found three species of lizard to be rather common: Utah spiny lizard (*Sceloporus magister cephaloflavus*), northern plateau lizard (*Sceloporus u. elongatus*) and northern cliff uta (*Uta ornata wrighti*).

The distribution of the snakes in this area is not well known. Two of the more common species, the Great Basin gopher snake (*Pituophis catenifer deserticola*) and the Hopi rattlesnake (*Crotalus v. nuntius*), seemingly occur in the several biotic communities listed above.

Bluff-Four Corners-Monument Valley Area

The Bluff-Four Corners-Monument Valley area in the Utah portion of the Upper Basin extends eastward from the Colorado River to the western edge of Colorado, southward to Arizona, and northward to the higher country in the vicinity of Elk Ridge and the Abajo Mountains. A similar type of country is to be found in northeastern Arizona, southwestern Colorado, and northwestern New Mexico as far as the continental divide. Two principal deep canyons formed by the San Juan River and White Canyon flow westward across the area and are joined by the many lesser, more shallow washes, characterized by Cottonwood Wash, Comb Wash, and Montezuma Creek which flow southward into the San Juan River.

In general, this area is topographically characterized by broad valleys exemplified by Monument Valley lying south of the San Juan River and the extensive flats south and east of Blanding. The soil in these areas is mostly sandy and is vegetated with mixtures of the various low shrubs and grasses characteristic of the Northern Desert Shrub community. These include three-toothed sagebrush, blackbrush, rabbitbrush, several kinds of shadscale (*Atriplex*), joint-fir and Indian rice grass. Low mesas, rocky ridges and spire-like rock formations rise above the more even contour of the country. The rocky ridges are often domelike structures composed of "slick-rock" that are barren of vegetation except in small intervening valleys where mixtures of desert shrubs and a few scattered junipers occur.

The San Juan River, after reaching the Utah border, runs for the most part through narrow and precipitous walled canyons where the floodplain is very narrow and its vegetation is limited to a few small patches of tamarisk (*Tamarix gallica*) and willows (*Salix*). The more permanent washes that are tributary to the San Juan usually run in shallow canyons with wide floodplains and more gently sloping walls.

South and west of the town of Blanding along the route followed by state highway 95 one crosses over a series of extensive flats, washes, and rocky ridges. The predominant vegetation here is pinyon-juniper woodland which in places forms a vast and unbroken forest. The area known as Grand Flat is typical of such a forest.

Three typical stations within the Bluff-Four Corners area will now be considered in more detail.

Montezuma Creek Station (Fig 15). This area is reached by traveling about sixteen miles south of Blanding along state highway 47

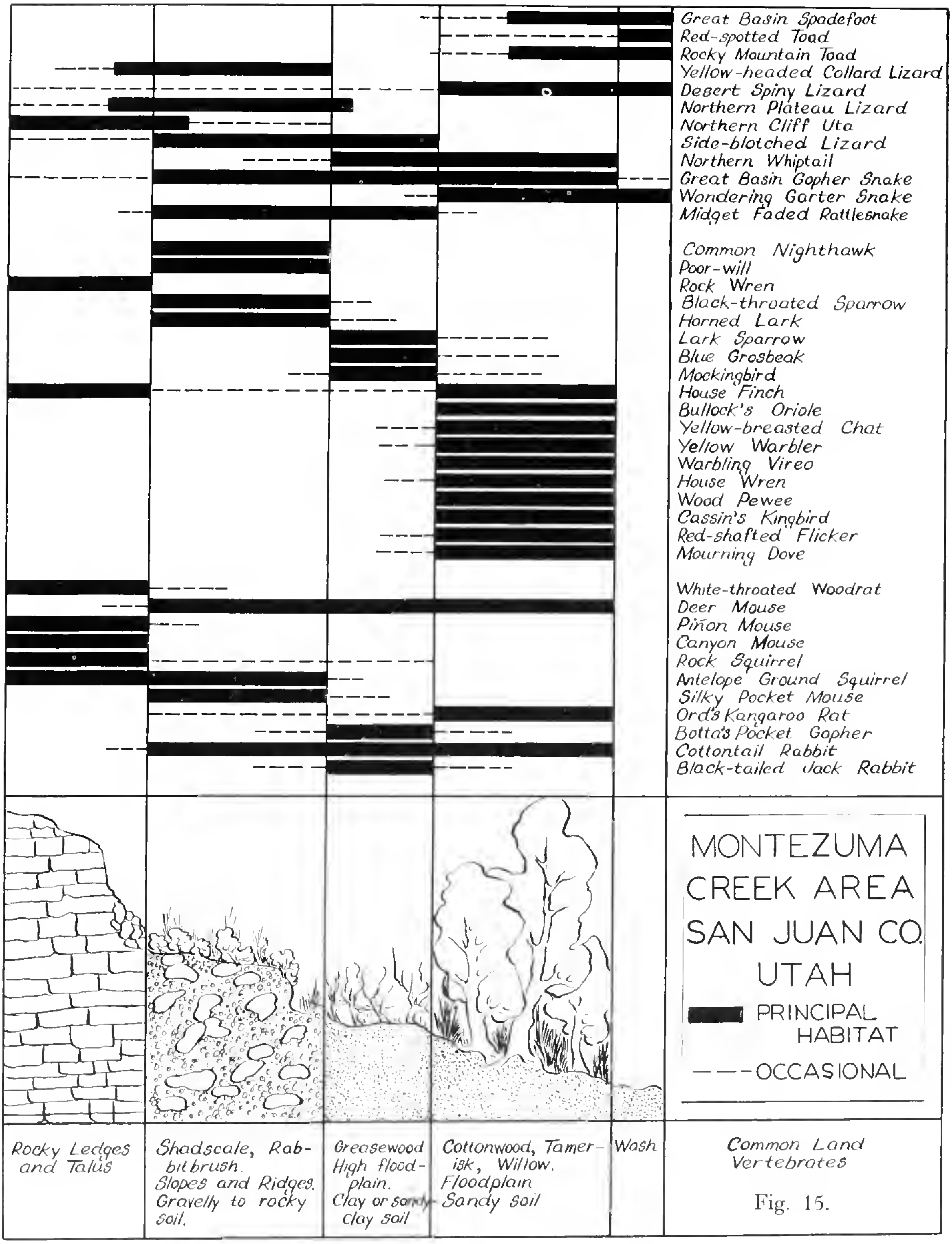

Great Basin Spadefoot
Red-spotted Toad
Rocky Mountain Toad
Yellow-headed Collard Lizard
Desert Spiny Lizard
Northern Plateau Lizard
Northern Cliff Uta
Side-blotched Lizard
Northern Whiptail
Great Basin Gopher Snake
Wondering Garter Snake
Midget Faded Rattlesnake
Common Nighthawk
Poor-will
Rock Wren
Black-throated Sparrow
Horned Lark
Lark Sparrow
Blue Grosbeak
Mockingbird
House Finch
Bullock's Oriole
Yellow-breasted Chat
Yellow Warbler
Warbling Vireo
House Wren
Wood Pewee
Cassin's Kingbird
Red-shafted Flicker
Mourning Dove
White-throated Woodrat
Deer Mouse
Piñon Mouse
Canyon Mouse
Rock Squirrel
Antelope Ground Squirrel
Silky Pocket Mouse
Ord's Kangaroo Rat
Botta's Pocket Gopher
Cottontail Rabbit
Black-tailed Jack Rabbit
MONTEZUMA CREEK AREA SAN JUAN CO. UTAH
PRINCIPAL HABITAT
OCCASIONAL
Rocky Ledges and Talus
Shadscale, Rabbitbrush. Slopes and Ridges. Gravelly to rocky soil.
Greasewood High floodplain. Clay or sandy-Clay soil
Cottonwood, Tamerisk, Willow. Floodplain Sandy soil
Wash
Common Land Vertebrates

Fig. 15.

thence eastward about fifteen miles to Montezuma Creek. Enroute to this locality one crosses several shallow but rocky canyons and an extensive flat of red sand covered with a rich growth of the three-toothed sagebrush. Montezuma Creek and its many tributaries occupy wide and shallow floodplain valleys which have eroded fifteen or more feet below the general level of the country. The lower portions of the washes are sandy and clothed with a scanty growth of tamarisk, tall rabbitbrush, and willows. Groves of young Fremont cottonwoods (*Populus fremonti*) occur in places, and small clumps of old trees may be found on higher ground where more stable conditions prevail. A little sagebrush grows on higher ground next to the perpendicular clay banks that rise fifteen or more feet above the bottom of the wash.

On higher ground above the washes is the relatively flat floor of the original valley level. These flats, varying in width, are covered with nearly pure stands of greasewood (*Sarcobatus vermiculatus*), some of which grow higher than a man's head. Above the level of this greasewood are a series of low hills or flat-topped mesas supporting a sparse growth of shadscale, rabbitbrush, and other shrubs and a very few junipers. The soil on these ridges and mesas is rocky or gravelly. There are many low ledges of exposed rock and loose boulders. This entire area presents an aspect of barrenness with none of the colorful formations that are so characteristic of other parts of the Colorado Plateau Province.

With respect to the small mammals of this area, there are two strikingly different biotic communities. The tamarisk-greasewood type of community growing on sandy or sandy-clay soils of the floodsplain and valley supports a relatively low animal population. Ord's kangaroo rat is confined almost entirely to this habitat as is also Botta's pocket gopher. Of the larger mammals, the black-tailed jack rabbit seems to live almost exclusively in the tall greasewood where it can secure ample cover.

In spite of their barrenness the low rocky hills and ledges support the greatest variety and population of mammals. The most uncommon species is the silky pocket-mouse. These little animals are active both night and day. The white-tailed antelope ground squirrel is also very abundant in rocky areas, and a few are found in the greasewood community. The piñon mouse and the canyon mouse are found abundantly in the rocky ledges, and there are a few rock squirrels in this same habitat. The white-throated woodrat also lives in considerable numbers in the ledges.

Desert cottontails are very common in both the floodplain and on the rocky hills, and the deer mouse is also fairly common in both types of communities.

A characteristic mammal of the plains extending northward from the San Juan River to the boundary of Grand County is Gunnison's prairie dog (*Cynomys gunnisoni*). This species does not range west of the Colorado River.

The bird populations of the Montezuma Creek Station are concentrated along and immediately adjacent to the washes, especially in the cottonwood and tamarisk communities. The mourning dove (*Zenaidura macroura*) is probably the most conspicuous if not the most common resident. Other common species in this community are Cassin's kingbird (*Tyrannus vociferans*), ash-throated flycatcher (*Myiarchus cinerascens*), western wood pewee (*Contopus sordidulus*), house wren (*Troglodytes aedon*), mocking bird (*Mimus polyglottos*), yellow warbler (*Dendroica petechia*), yellow-breasted chat (*Icteria virens*), and Bullock's oriole (*Icterus bullockii*). The blue grosbeak (*Guiraca caerulea*), and lark sparrow (*Chondestes grammacus*) live at the edge of the floodplain community adjacent to the desert shrubs The black-throated sparrow, horned lark (*Eremophila alpestris*), poorwill (*Phalaenoptilus nuttallii*), and common nighthawk (*Chordeiles minor*) inhabit the open desert shrub communities, while the rock wren (*Salpinctes obsoletus*) is a common species about the rocky ledges.

Along the small streams and particularly in the ponds made by irrigation water near Indian villages are heard nightly choruses of three species of toads. In the ponds the more common is the Great Basin spadefoot, whereas the red spotted toad (*Bufo punctatus*) and the Rocky Mountain toad are widely distributed along the streams as well as in the ponds. We did not observe frogs in this area.

In the greasewood bottom lands we found several species of lizards, the most common of which are the leopard lizard, northern side-blotched Uta, and the northern whiptail (*Cnemidophorus t. septentrionalis*). The leopard lizard is confined almost entirely to this habitat, with the side-blotched uta and the northern whiptail ranging into the edges of the low rocky hills.

By far the greatest population of reptiles is found in the low rocky ledges. On the large boulders strewn along the base of rocky hill is the yellow-headed collard lizard (*Crotaphytus c. auriceps*). From these boulders to the rocky areas and ledges of the steeper slopes are the northern plateau lizard, the northern cliff uta, plateau whiptail, and in the brushy area, the spiny lizard (*Sceloporus magister*). The later was also found in the scattered groves of cottonwoods along the creek.

Only a few snakes were seen, and these were in the rocks and brush along the edge of the rocky hill habitat. The Great Basin gopher snake and the desert striped whipsnake (*Masticophis t. taeniatus*) are perhaps the most common at this station.

Bluff Station. The town of Bluff is located on the San Juan River at a point where the valley is relatively wide and considerable land has been brought under cultivation. Approaching the San Juan River Valley from the north, one crosses an extensive sandy plain before dropping suddenly down into the river valley itself. High cliffs of red sandstone rise on either side of the valley with tumbled masses of boulders lying at their bases. In the area of Bluff the following types of communities are found: (1) Floodplain community where Fremont cottonwood, willow, and tamarisk are predominant; (2) low desert shrub occupying sand-clay soils where greasewood is characteristic; (3) higher rocky or gravelly ridges where shadscale and three-toothed sagebrush predominate; (4) sandy benchlands next to the high cliffs that border the valley where joint-fir and blackbrush are the most abundant plants; (5) cliffs and tumbled boulders rising above the river valley. Beyond the tops of the cliffs the sandy plain extends northward as a continuation of Number 4 above. North of the town of Bluff the wide valley of Cottonwood Wash joins the San Juan Valley.

On the floodplain communities and in the desert shrubs of the river valley floor we found the population of mammals to be very low. Ord's kangaroo rat, deer mouse, and western harvest mouse were most characteristic. A few Botta's pocket gophers were found, especially on the farmlands. The silky pocket mouse was found on the more rocky or gravelly soils of the low hills or ridges where shadscale was predominant.

Close to the bases of the cliffs that rise above the valley, the canyon mouse is the most abundant species. The pinon mouse, Colorado chipmunk, rock squirrel, and white-tailed antelope ground squirrel, the Mexican wood rat (*Neotoma mexicana*), and the white-throated woodrat are also present. Desert cottontails are very common both in the floodplain and in rocky areas along the bases of the cliffs.

As is typical in other areas described, the bird life in the Bluff area is concentrated along the floodplains where cottonwood groves and willows afford ample cover and where water is available. The great blue heron (*Ardea herodias*), snowy egret (*Leucophoyx thula*), and killdeer (*Charadrius vociferus*) occur commonly along the San Juan River itself. The red-winged blackbird (*Agelaius phoeniceus*), Brewer's blackbird (*Euphagus cyanocephalus*), robin (*Turdus migratorius*), house finch, Bullock's oriole, rufous-sided towhee (*Pipilo erythrophthalmus*), and mockingbird are the most conspicuous species associated with the floodplain vegetation. In the several types of desert shrubs of the river valley the horned lark, Say's phoebe (*Sayornis saya*), vesper sparrow (*Pooecetes gramineus*), and black-throated sparrow are commonly found. Associated with the cliff habitats are the common raven (*Corvus corax*), canon wren (*Catherpes mexicanus*), turkey vulture (*Cathartes aura*), white-throated swift (*Aeronautes saxatalis*), and ferruginous hawk (*Buteo regalis*).

On the valley floor near the river and in the irrigation ditches and run-off ponds are found the Great Basin spadefoot, the red-spotted toad, and the Rocky Mountain toad. Near the river and along the more permanent ditches the western leopard frog (*Rana pipiens*) is seen.

The desert shrub habitat of the valley floor supports a moderate population of lizards, the most common ones being the leopard lizard, Northern side-blotched uta, and the Northern whiptail. The latter is also common on the brushy slopes along the edge of the valley floor. The spiny lizard is also present along the valley floor.

Near and in the streams two species of garter snake occur; namely, the more widely distributed wandering garter snake (*Thamnophis e. vagrans*) and the more aquatic black-necked garter snake (*Thamnophis c. cyrtopsis*).

Close to the cliffs and on the more rocky portions of the slope surrounding the valleys, the northern plateau lizard and the northern cliff uta are commonly seen.

At the base of the rocky hills and cliffs and along slopes where there is a greater abundance and variety of food, are found the desert striped whipsnake and the Great Basin gopher snake.

Bridges Monument - White Canyon Station. This station is in an area of extensive pinyon-juniper woodland broken by high cliffs, many exposed low ledges, and the deep gulch of White Canyon. In the more open areas among the pinyons and junipers there are patches of three-toothed sagebrush, shadscale, yucca and rabbitbrush. The soils on the flats are usually sandy, but in most areas tend to be hard-packed and subjected to much surface washing during sudden summer showers.

Our field work in this area has not been as extensive as would be desired, especially with respect to the birds and mammals, but the reptiles and amphibians are well known. There is every indication that populations of small mammals are very low. Probably the most common species is the piñon mouse, which lives particularly in the low, more broken ledges where pinyons and junipers are close by or about the bases of the higher cliffs. Woodrats build their houses in the ledges and at the bases of junipers and pinyons, and there are a few desert cottontails wherever there is a loose rockpile for cover. In much of the area the soil is too hard for the extensive burrowing of kangaroo rats and pocket mice.

Among the birds the piñon jay and Brewer's sparrow seem to be the most abundant. The latter species is especially abundant in autumn along the roadways and in more open desert shrub areas.

The pothole ponds along White Canyon and particularly those visited at the Natural Bridge Monument supported the three common toads of this general desert area — the Great Basin spadefoot, the red-spotted toad, and the Rocky Mountain toad. We saw no *Rana* at the Natural Bridges. However, at the headwaters of White River a few miles east at Elk Ridge both the Utah tiger salamander (*Ambystoma t. utahensis*) and the western leopard frog were collected.

In the pinyon-juniper woodlands the most common lizards are Great Basin sagebrush lizard, Northern side-blotched uta, and the Northern whiptail. Rocky and ledge habitats along the canyon rim and near the buttes of the area support large numbers of the Northern plateau lizard, the Northern cliff uta, a few spiny lizards, and the plateau whiptail (*Cnemidophorus velox*). Among the yucca of the area the Utah night lizard (*Xantusia vigilis utahensis*) is seen occasionally.

In the Natural Bridges area we have seen the desert striped whipsnake and the Great Basin gopher snake. Rattlesnakes were not seen by us, but are known to be present. Along White River above the Natural Bridges and near Elk Ridge were found the wandering garter snake and the western smooth green snake (*Opheodrys v. blanchardi*).

Moab-Arches Monument Area

The Moab-Arches Monument area includes a large part of the Colorado Plateau Province lying west of the La Sal Mountains, east of the canyon of the Green River, south of the Grand River Valley and north of the Abajo Mountains and the highlands that extend eastward from them. This is, in general, an area of deep canyons, washes, spectacular rock formation and intervening valleys and flats of sandy soils. The physical forces of this area that are most evident are the Colorado and Green Rivers, which are confined for the most part in deep gorges with narrow floodplains and sheer walls of rock on either side. Tributary to these streams are innumerable smaller canyons and washes that contribute to the general ruggedness of the country.

Arches National Monument Station (Fig. 16). This area, which is one of spectacular natural beauty, has been studied by us as thoroughly as any other part of this section of the Upper Basin. It lies a few miles north and west of the town of Moab and west of the Colorado River. Within the confines of the monument, the following types of habitats may be recognized: (1) low floodplains and open valleys bordering the shallow washes; (2) sandy flats and gentle slopes where blackbrush, joint fir, and Indian rice grass predominate; (3) higher ridges and ravines where the soil is rocky or gravelly and where pinyon-juniper and a variety of taller shrubs occur; (4) solid rock formations and ledges with tumbled rock masses lying at their bases; and (5) localized hydric situations, especailly where there is seepage between the strata of the sandstone ledges.

The floodplains of the wide washes, such as Salt Wash for example, are characterized by clay soils where tamarisk and greasewood are the predominant plants. Mammal populations are relatively low with comparatively few species represented. The black-tailed jack rabbit reaches its greatest abundance in this community, where there is ample tall cover, and Ord's kangaroo rat, the western harvest mouse, and the deer mouse are also present. Within the monument area there are very few springs, but one such spring and small stream known as Freshwater is accompanied by a thicket of willows, Gamble's oak (*Quercus gambellii*) and other tall shrubs, and there is a variety of sedges and grasses in the boggy areas. Seepage of water along higher rock ledges permits the development of hanging gardens characterized by ferns, horsetail, common reed (*Phragmites communis*) and other aquatic or semi-aquatic plants.

In the above-mentioned types of hydric and semi-hydric communities we have not been able to establish any peculiar mammal fauna such as *Microtus* or *Sorex*, but the floodplains of the washes and stream or springside thickets support the greatest variety and highest populations of birds. Along the washes the great blue heron and killdeer are fairly common. In the heavier thickets near springs or seeps, Virginia's warbler (*Vermivora virginiae*), green-tailed townee (*Chlorura chlorura*), common bushtit (*Psaltriparus minimus*), and rufous-sided towhee (*Pipilo erythrophthalmus*) are characteristic and common. Along the wide washes where tamarisk and greasewood are predominant the house finch, Say's phoebe, vesper sparrow, Brewer's blackbird, Brewer's sparrow, and lark sparrow are the most common species.

The open sandy flats and slopes that rise above the shallow canyons of the washes and lie between many of the rocky formations afford a habitat suitable for many burrowing mammals, and it is in such situations that we find the highest populations of small rodents.

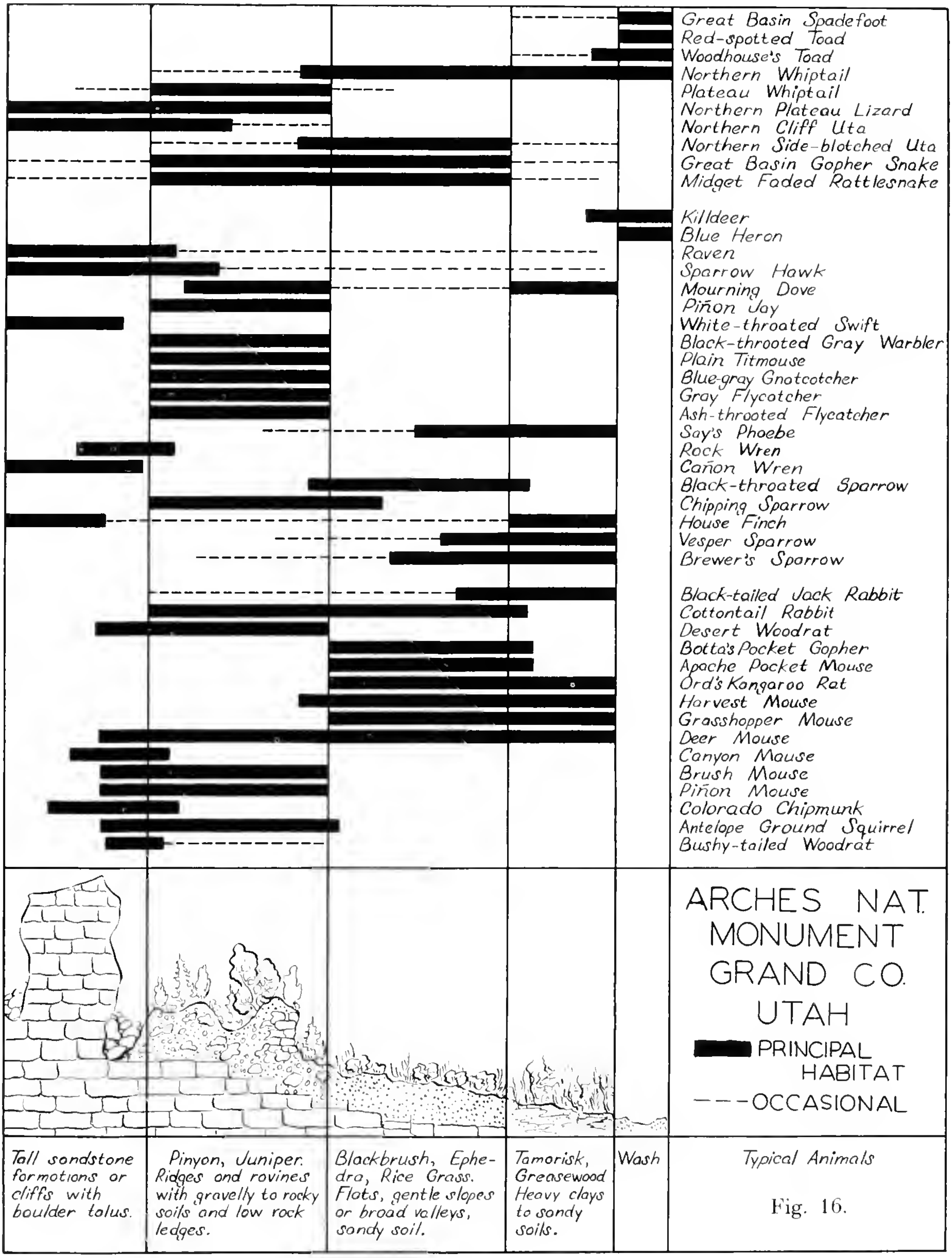

Great Basin Spadefoot
Red-spotted Toad
Woodhouse's Toad
Northern Whiptail
Plateau Whiptail
Northern Plateau Lizard
Northern Cliff Uta
Northern Side-blotched Uta
Great Basin Gopher Snake
Midget Faded Rattlesnake
Killdeer
Blue Heron
Raven
Sparrow Hawk
Mourning Dove
Piñon Jay
White-throated Swift
Black-throated Gray Warbler
Plain Titmouse
Blue-gray Gnatcatcher
Gray Flycatcher
Ash-throated Flycatcher
Say's Phoebe
Rock Wren
Cañon Wren
Black-throated Sparrow
Chipping Sparrow
House Finch
Vesper Sparrow
Brewer's Sparrow
Black-tailed Jack Rabbit
Cottontail Rabbit
Desert Woodrat
Botta's Pocket Gopher
Apache Pocket Mouse
Ord's Kangaroo Rat
Harvest Mouse
Grasshopper Mouse
Deer Mouse
Canyon Mouse
Brush Mouse
Piñon Mouse
Colorado Chipmunk
Antelope Ground Squirrel
Bushy-tailed Woodrat
ARCHES NAT. MONUMENT GRAND CO. UTAH
PRINCIPAL HABITAT
OCCASIONAL
Tall sandstone formations or cliffs with boulder talus.
Pinyon, Juniper. Ridges and ravines with gravelly to rocky soils and low rock ledges.
Blackbrush, Ephedra, Rice Grass. Flats, gentle slopes or broad valleys, sandy soil.
Tamarisk, Greasewood Heavy clays to sandy soils.
Wash
Typical Animals

Fig. 16.

In this habitat Ord's kangaroo rat attains its greatest numbers. The Apache pocket mouse is also abundant as well as the grasshopper mouse, deer mouse, western harvest mouse, and Botta's pocket gopher. Bird life in these sandy areas is very scarce, but the black-throated sparrow seems to prefer the low shrub type of habitat provided by blackbrush and other short shrubs that are characteristic of such areas. (Figs. 3, 12, and 16.)

Scattered pinyon-juniper woodlands that occupy higher ridges and shallow ravines are a distinctive type of community. Soils are usually rocky or gravelly but may be sandy and rather unstable in places. In addition to the junipers and pinyons taller shrubs such as cliff rose (*Cowania stansburiana*), wavey leaf oak (*Quercus undulata*) and single leaf ash (*Fraxinus anomala*) are common plants. Mammal populations in this community tend to be low. The desert cottontail reaches its greatest abundance here, and the white-tailed antelope squirrel and deer mouse are also very common and characteristic. The bird life of the pinyon-juniper woodland is very distinctive. The bluegray gnatcatcher, plain titmouse, black-throated gray warbler (*Dendroica nigrescens*), ash-throated flycatcher, gray flycatcher (*Empidonax wrightii*), piñon jay, and chipping sparrow (*Spizella passerina*) are all very common.

The spectacular rock formations of the Arches National Monument are sculptured into a great variety of forms. There are sheer cliffs, low ledges, spires, arches and innumerable shapes that lend to the scenic interest of the area. They also provide habitats for a unique and interesting fauna. Crevices and holes, as well as the tumbled masses of loose rocks, offer nesting sites, roosting sites, and cover for a number of species. The canyon mouse is perhaps the most abundant and characteristic species of such situations. Both the bushy-tailed woodrat (*Neotoma cinerea*) and the desert woodrat (*Neotoma lepida*) are found, particularly in the low ledges. The piñon mouse and the brush mouse (*Peromyscus boylii*) are confined to rocky situations but appear to be less common in the Arches area than in many other parts of the Upper Basin. The colorful Colorado chipmunk is the most common mammal seen at the bases of the rock formations and is able to climb their sheer faces without difficulty.

Several kinds of birds utilize the rock formations as nesting and perching sites. These include the red-tailed hawk (*Buteo jamaicensis*), prairie falcon (*Falco mexicanus*), ferruginous hawk, sparrow hawk (*Falco sparverius*), and raven. The white-throated swift, rock wren, cañon wren (particularly in the deeper canyons) and house finch are characteristic of the small species utilizing this habitat.

The open sandy desert shrub flats and the gentle slopes leading up from the washes is a habitat suited to the northern side-blotched uta and the leopard lizard. Where the sandy flats abut the abruptly elevated areas and along the rocky canyon walls, we find the sagebrush lizard and the northern whiptail. The northern side-blotched uta is also found in this habitat. In the rocky ledge areas one finds the northern plateau lizard and the northern cliff uta.

Snake populations in the Arches area are apparently low, appearing to be greatest in the rocky and ledge areas where there is some vegetation and a higher population of other vertebrates for food. We have seen the desert striped whipsnake, Great Basin gopher snake and the midget faded rattlesnake (*Crotalus v. concolor*) in this type of habitat. We have found the gopher snake to be the most common of the three.

A lack of water, particularly during the greater part of the hot dry summer and fall, provides little opportunity for amphibians or garter snakes to inhabit this area.

Castle Valley Station. After the Colorado River receives the waters of the Dolores River in the vicinity of Dewey Bridge, it passes southward for the most part through precipitous walled canyons for the entire extent of its passage through the lower part of the Upper Basin. Exceptions to this are to be found in the vicinity of the town of Moab where there is a wide valley occupied by considerable farming land. About fifteen miles north of Moab is another similar area known as Castle Valley. The latter area is typical of the river floodplain in this section of the stream. The valley itself contains some ranches but relatively little cultivated land. The natural beauty of its spectacular rock formations is attested by its name and by the fact that it is frequently used as a location for the motion picture industry.

The floor of Castle Valley consists of a rolling country where the soils are mostly sandy or gravelly. The entire area shows the effects of heavy grazing by livestock. The present predominant vegetation consists of two principal types growing in a complicated patchwork. In the better sandy-loam soils, three-toothed sagebrush occurs in dense stands. On low hills where the soil is rocky or gravelly there is a very sparse growth of vegetation consisting of shadscale, small rabbit brush and other low-growing shrubs. Arising from all sides of the valley and in the midst of the valley itself are sheer walls of rock terminating above in flat-topped mesas or pinnacle-like formations. The spectacular formations on the east side of the valley known as Fisher Towers are typical examples. (Fig. 13)

Several studies that we have made in the

Castle Valley area have indicated that the mammal population is extremely low in contrast to the abundance of rodents that occur in the Arches area directly across on the west side of the Colorado River. The white-throated woodrat was found by Durrant (1934, p. 65) to be very common in the sagebrush-covered areas of the valley where its houses were built at the bases of the shrubs. The deer mouse also occurs sparingly in this habitat. In the more sandy, gravelly or rocky soils where the vegetation is sparse conditions appear ideal for pocket mice and kangaroo rats, but we have found the populations of these as well as other small rodents to be very sparse. A few Apache pocket mice and a very limited number of deer mice may be found here. In the sandy soil Ord's kangaroo rat occurs in small numbers. The desent cottontail and black-tailed jackrabbit are both present but uncommon throughout all the shrubby types of communities.

In the tumbled masses of rocks that lie at the base of the precipitous walls of the valley the more characteristic mammals are the rock squirrel and white-tailed antelope squirrel.

The Castle Valley area is one of the most favorable places in the Upper Basin for a variety of land birds. The ample water supply, floodplain groves and thickets and open surrounding country afford the most acceptable kind of habitat, much more so than the precipitous and narrow canyons that are common to much of the Colorado River and its tributaries in this area.

Along the borders of the river itself, the great blue heron, spotted sandpiper (*Actitis macularia*), and killdeer are commonly seen. Cottonwood groves and thickets formed by young trees, tamarisk and willows offer a suitable habitat for a variety of passerine birds. The mourning dove, western kingbird (*Tyrannus verticalis*), ash-throated flycatcher, western wood pewee (*Cantopus sordidulus*), black-billed magpie (*Pica pica*), warbling vireo, yellow-breasted chat, and Bullock's oriole are the most common and characteristic species. In the heavier desert shrub growths of greasewood and sagebrush, Magillivray's warbler (*Operornis tolmiei*), blue grosbeak, lark sparrow, and mockingbird are characteristic species, while in the areas of low and sparse shrubs the horned lark and black-throated sparrow are found in small numbers. The precipitous rock formations within the area are utilized as perching and nesting sites by the golden eagle (*Aquila chrysaetos*), red-tailed hawk, sparrow hawk, turkey vulture, rock wren, canon wren, and white-throated swift.

From the Dewey Bridge and Castle Valley southwestward along the Colorado River to Moab and from Moab to the western base of the La Sal Mountains is a terrain rich in numbers and kinds of amphibians and reptiles. Along the river and in the meadows west of Moab, the western leopard frog and the Rocky Moutain toad are common. On May 10, 1957, we heard the calls of the western chorus frog (*Pseudacris n. triseriata*) in these same meadows.

In the brushy habitat between the river and the canyon walls the northern side-blotched uta, the sagebrush lizard, and the northern whiptail are common. On the tumbled boulders along the edge of the canyon walls the ornate yellow-headed collared lizard is seen, and the northern plateau lizard occurs. In areas of rocky ledges the northern cliff uta is present.

Besides the common snake species of this general area, (the striped whipsnake, gopher snake, and midget faded rattlesnake) there are two garter snakes—the black-necked and the wandering garter snakes. A population of the Great Plains rat snake (*Elaphe guttata emoryi*) is also present. Although we have taken only a few specimens of the Colorado plateau night snake (*Hypsiglena t. loreala*), it should be common in the rocky, boulder-strewn areas.

The Grand Valley Area

The Grand Valley area is an extensive and relatively flat valley lying immediately south of the Tavaputs Plateau (Roan Cliffs) and extending from the Green River eastward to the Colorado Rocky Mountains. Unlike the colorful canyon country to the south of it, this is an area of gray, comparatively heavy soils and barren badland formations of monotonous appearance. The vegetation is predominantly shadscale of several species with some mixture of grasses in certain areas, greasewood in low places, and three-toothed sagebrush and juniper on higher slopes and ridges.

Despite the fact that U. S. Highway 50 crosses this area, making it easily accessible for study, we know comparatively little at this writing about its fauna. Perhaps the most characteristic and one of the most common mammals is the white-tailed prairie dog (*Cynomys leucurus*). Several colonies of this mammal are known to live in this area, and the animals are frequently seen along the roadside. The black-tailed jack rabbit is another common species in this wide, open country. Of the smaller mammals Ord's kangaroo rat is common wherever there is sandy soil. The Apache pocket mouse as well as the deer mouse and the western harvest mouse are likewise common throughout this area. We have no record of the Apache mouse west of the Green River.

Birds of the floodplain woodlands that traverse these broad valleys seem to be similar in kind and abundance to those described elsewhere for similar habitats. In the open desert the horned lark is very common and the sage thrasher and western mockingbird occur, particularly in greasewood communities. In the vicinity of prairie dog colonies the burrowing owl is a characteristic species.

Throughout the greater part of this area the amphibian and reptile populations are low when contrasted to some of the peripheral habitats. The broad central area supports sparse reptile populations, with more of these occurring along the edges of washes and near the streams. A few side-blotched uta, sagebrush lizards and northern whiptail lizards are to be seen throughout the entire area.

Amphibians are almost completely restricted to the permanent streams and the associated irrigation areas along them. In these areas the leopard frog, Rocky Mountain toad, and red-spotted toad occur. The latter is found only in the lower, more southern parts of this area. Although an occasional desert striped whipsnake, Great Basin gopher snake and midget faded rattlesnake are seen throughout the area, these are more abundant near the base of the Tavaputs Plateau.

We are not well informed on the amphibians and reptiles in the eastern section of this area. However, the reports given us by Andrew Barnum, who spent several years at Grand Junction, Colorado, suggest that the species occuring there are similar to those known to occur in the Moab-LaSal area. Specimens of the plateau whiptail and of the Utah milk snake in the collection of Mr. Barnum add to the less common species of the eastern area.

That portion of the Colorado Plateau Province lying west of the Colorado and Green Rivers, south of the Book Cliffs and east of the high plateaus of central Utah will be considered next. The southwestern corner of this area is located at Pink Dunes a few miles west of Kanab, Kane County. The northwest corner is in the vicinity of Castle Gate, Carbon County.

Drainage from the high plateau country toward the Colorado River has created a number of canyons, basins, and locally differentiated geological features pecular to the various areas. These erosional forces of the past have resulted in a complexity of habitats which are partly responsible for the present-day distribution of the biota.

Proceeding from Pink Dunes to Castle Gate we describe the following areas:

1. Pink Dunes — Central Kane County Area. (Fig. 9)
2. Paria Basin—Paria Plateau Area. (Fig. 14)
3. Kaiparowits Plateau—Escalante Basin Area (Fig. 17)
4. Escalante Canyon—Water Pocket Fold —Circle Cliffs Area. (Figs. 2 and 17)
5. Torrey—Capitol Reef Area. (Fig. 5)
6. Henry Mountains—Green River Desert Area. (Fig. 7)
7. San Rafael Swell—Castle Valley—Price River Valley Area. (Fig. 7)

Pink Dunes and Central Kane County Area

The eastern border of the Pink Dunes and Central Kane County area is bounded by the Coxcomb Ridge and the southern portion by the Kaibab and Kanab Plateaus; the northern limit is at the base of the Vermillion Cliffs as far as Kanab Canyon. North and west of Kanab Canyon the boundary is at the base of the White Cliffs, extending to the edge of the Sevier Fault on the west. The southern boundary of the area is the Pink Dunes located on the Unikaret Plateau. (Fig. 9)

Gregory (1948 and 1950) described the geology and geography in great detail for both of the above locations. The Pink Dunes are a part of the Zion Park Region report (1950), and Central Kane County is a separate report (1948).

Pink Dunes Station. The Pink Dunes station is approached from U. S. Highway 89. The turnoff is about five miles south of Carmel Junction in Kane County, and the dunes are located about eleven miles south of the highway. (For details on geological formations see Gregory, 1950, p. 5.)

The downthrow side of the Sevier fault drains to the west and eventually the waters reach the Virgin River. The upthrow side drains to Kanab Creek and thence to the Colorado River. Prevailing winds from the west transport fine erosional material from the Unikaret Plateau across Moccasin Terrace, and over the eons of time have created the vast sandy area which now covers the Wygaret Terrace. This terrace lies between the base of the White Cliffs on the north (Carmel Sandstone Formation) and the top of the southern edge of the Vermillion Cliffs on the south.

Locally, the Pink Dunes station, with elevations ranging from 5,700 to 6,000 feet, has a complex of vegetational types. Castle (1954) made a study of the vegetation of the central dune station. For the purposes of this study, the following classification will suffice:

The region west of the dunes is bordered at the dunes' edge by Gamble's oak and three-toothed sage which in turn merges with a pinyon-juniper woodland extending westward to and over the Block Mesas. Other less common plants are antelope brush (*Purshia tridentata*), groundsel (*Senecio spartioides*), dogtown grass (*Aristida longiseta*) and sand reedgrass (*Calamovilfa gigantea*).

A very unique plant type is found at the northern end of the station. There is a small aspen (*Populus tremuloides*) woodland which is surrounded by a mixture of Gamble's oak, willow (*Salix lutea*), three-toothed sage, and scattered junipers.

Owing to a continuous movement of the

central part of the dunes area, plant life is greatly reduced and in places totally absent on the dunes themselves. However, at the perimeters and in more stabilized habitats, the composite, *Wyethia scabra*, grows in abundance. Also present are the scurfpea (*Psoralea stenostachys*), Indian rice grass, yucca, rabbitbrush, and a variety of other grasses and forbes.

The faunal picture for the dunes station is seasonally incomplete, but collections so far show the following condition. In the sage, juniper, yellow pine, and aspen habitats, the black-tailed jack rabbit is common. Ord's kangaroo rat, deer mouse, and the Great Basin pocket mouse are representative of the smaller rodents. Botta's pocket gopher and the northern grasshopper mouse are found in more open areas adjacent to the dunes, and the desert wood rat constructs its houses at the base of trees in the pinyon-juniper woodlands, where the rock squirrel is also found.

Our knowledge of the birds of this area is very incomplete. A large colony of the western bluebird (*Sialia mexicana*) nests in the aspen grove near the dunes, and the hairy woodpecker (*Dendrocopos villosus*) and downy woodpecker (*Dendrocopos pubescens*) also inhabit this community. The more characteristic birds of the desert shrub types in the vicinity of the dunes include vesper sparrow, chipping sparrow, horned lark, and rufous-sided towhee. In the pinyon-juniper community both the scrub jay and piñon jay are common.

The most common species of lizards include Great Basin sagebrush lizard, northern side-blotched lizard—and in the ledge habitats—the northern cliff uta, northern whiptail, and the great basin skink (*Eumeces skiltonianus utahensis*). Two species of snakes commonly seen are the Great Basin gopher snake and the Great Basin rattlesnake.

Three Lakes Station. This is a roadside station at the head of a canyon on U.S. 89 approximately twelve miles north of Kanab and three miles north of Kanab Creek junction. The canyon at Three Lakes and the immediate environs which include Kanab Creek Canyon show several topographic features. They range from narrow canyons with very little floor to fairly broad valleys and from steep-sided canyon walls to gently inclined slopes or canyon slopes made up of masses of fallen rocks and mounds of loose sand.

Along the canyons are cliff caves of various sizes and kinds that have originated through water erosion and have resulted in interesting hydric conditions. Some of these are of an open type in which the erosional products partly impound the seeping water to form pools of varying size and depth. The open types are represented by those at Three Lakes station itself. Other cave lakes in the area are actual underground bodies of water, some of which are as much as 100 feet long and 12 to 15 feet deep.

The major plant cover in the canyon is a pinyon-juniper woodland with the juniper being the more abundant. Antelope brush, squawbush, and service berry (*Amelanchier pallida*) occur in scattered clumps along the canyon. In the canyon bottoms and floodplains where side canyons issue, are found rank stands of three-toothed sage and localized patches of rabbitbrush (*Chysothamnus* sp.). Along sheltered areas of the canyon where underground water is more likely to occur, or is retained from seasonal precipitation, Gamble's oak groves are found. These groves are abundant near rock caves where seep water issues or where the cave has been dammed off and the accumulated water forced underground. In open caves where seep water is sufficient the maiden hair fern (*Adiantum pedatum aleuticum*), false solomon seal (*Vagnera* sp.), columbine (*Aquilegia* sp.), and *Penstemon* sp. are found. Either from underground cave lakes, open lakes, or as direct runoff from seep seams along cliff faces there occur meadow-like habitats of varying size. In these places, dependent on the amount of water flow, there may occur large groves exemplified by those at Three Lakes where cottonwood (*Populus fremonti*) and Gamble's oak occur. Willow clumps (*Salix* sp.), Gamble's oak, and squaw-bush grow rank in and around the marshy habitats. Cattails (*Typha* sp.), rushes (*Juncus*), and sedges (*Carex*) are predominant in the more aquatic habitats. In the meadows and floodplains along the stream side at the bottom of the canyon an occasional grove or single tree of cottonwoods may be seen, but for the most part the plant life is made up of various species of rushes and sedges (*Juncus* and *Carex*) as well as tamarisk and some grasses. (Fig. 6)

Mammals of the Three Lakes station are similar in kind to those of the Pink Dunes. Black-tailed jack rabbits and dessert cottontails are common in the desert shrubs, and on the more rocky slopes the cliff chipmunk (*Eutamias dorsalis*) and rock squirrel are common. Houses of the desert wood rat (*Neotoma lepida*) are frequently encountered around the rocky ledges. In the sandy meadows the mounds of Botta's pocket gopher are very abundant.

The availability of water and the ample cover attract a high population of birds. The more common of these include the piñon jay, robin, broad-tailed hummingbird (*Selaphorus platycercus*), great blue heron, yellow-breasted chat, yellow warbler, black-headed grosbeak (*Pheucticus melanocephalus*), yellow-bellied sapsucker (*Sphyrapicus varius*), red-shafted flicker, white-throated swift, house finch, western kingbird, mourning dove, western meadowlark (*Sturnella neglecta*), sparrow hawk, and Cooper's hawk (*Accipiter cooperii*).

We have found the Rocky Mountain toad

and western leopard frog at this station. The reptiles do not appear to differ from those found at the preceding station except for the occurrence of the wandering garter snake near the streams and the night snake on the rocky slopes.

Navajo Wells Station. That part of Central Kane County included in this area extends from Kanab eastward to and including the northern part of House Rock Valley. The road eastward from Kanab follows a route about two miles south of the Vermillion Cliffs to Navajo Wells. The highway continues in a northeasterly direction across an extensive plain on which the vegetation is almost a pure stand of three-toothed sage. Northwestward near the base of the Vermillion Cliffs the sage plain merges into a pinyon-juniper woodland. This extensive sagebrush plain continues for many miles eastward to the Coxcomb (Kaibab monocline). (Fig. 8)

Mammals in the above-described region appear to be uniformly distributed, as would be expected from the almost uniform type of habitat. Ord's kangaroo rat is very common in the pinyon-juniper and in sandy habitats northeast of Navajo Wells. The northern grasshopper mouse has been collected in sandy habitats north of Navajo Wells, and the white-tailed antelope squirrel is found in the rocky ledges of the same locality. Desert wood rats are found in these same ledges, along with the piñon mouse. The deer mouse is present throughout the entire region regardless of habitat. The black-tailed jack rabbit and the desert cottontail are also widely distributed.

The open sagebrush plains support a rather sparse population of birds. The black-throated sparrow, sage thrasher, raven, horned lark, and mockingbird are the most common species.

In this area we have found a rich reptile fauna but few amphibians. Perhaps the most common of the latter is the Great Basin spadefoot. Only a few Rocky Mountain toads and western leopard frogs have been seen.

The more common lizards of this area include the Great Basin sagebrush lizard, leopard lizard, side-blotched lizard, southern desert horned lizard, and northern whiptail, seen throughout the sage-covered valleys and along the edge of the rocky slopes. On the rocky slopes and nearby ledges the following lizards occur: western collared lizard (*Crotaphytus c. baileyi*), Utah spiny lizard, northern cliff uta, and Great Basin sagebrush lizard.

Snakes common to this area include the desert striped whipsnake, Great Basin gopher snake and the Great Basin rattlesnake. On the rocky slopes the spotted night and the Utah black-headed (*tautilla* utahensis) snakes occur commonly.

Paria Basin — Paria Plateau Area

Paria Basin is a vast, U-shaped geological formation, flanked on the west by the Paunsaugunt Plateau. The colorful formations of Bryce Canyon National Park are found along the east rim of this plateau. The north end of the basin is bounded by the general region of the Escalante Mountains, of which the Table Cliff Plateau is the southernmost extension. The southern part of the basin merges into the White and Vermillion Cliffs mentioned previously in the Central Kane County discussions. The eastern boundary is distinctively marked by the upturned rocks of the Coxcomb, creating a landscape so rugged that east-west travel is almost impossible, and any such traverse must follow a north-south route between the upturned rocks. The small villages of Tropic, Cannonville, and Henriville are located in the upper part of the basin. Drainage is from north to southeast, cutting across several thousand feet of varied geological formations from the rim at Bryce Canyon to the place where the accumulated drainage cuts southeast across the Coxcomb. The combined waters draining into the basin form the Paria River. Many of the streams have local names. However, there is one principal channel known as Cottonwood Creek which runs along the east flank of the basin along the Kaibab Monocline. It unites with all the other drainage channels in the basin at the point where the united streams traverse the Coxcomb at the southeast corner.

According to Gregory (1948), the land now known as the Paria Basin was originally higher than the Paunsaugunt Plateau. As a result of north-south faulting, the Escalante Mountains, including the Table Cliff Plateau, became a portion of the upthrow block, while the east rim of the Paunsaugunt Plateau (Bryce Canyon rim) became a remnant of the downthrow. In some places the displacement amounts to at least 1,500 feet.

The Paria Plateau is bounded on the west by the Coxcomb Ridge. The old abandoned townsite of Adairville is found at the northwest corner of the plateau. On the northern boundary are the low cliffs of the Kaiparowits Plateau. The Wahweap Creek runs at the base of this plateau as it courses southeastward to the Colorado River. Shortly after Paria River breaches the Coxcomb it runs for some distance in a broad river valley, but soon after passing the town of Adairville it progressively deepens into a narrow, meandering gorge eventually uniting with the Colorado River a few miles south of the Glen Canyon damsite. East of the Paria River near Adairville the landscape becomes an extensive flatland known as Clark's Bench. This benchland terminates about halfway between Adairville and the Glen Canyon. At this point the bench drops gradually over the Echo Monocline and spreads out south and eastward as a relatively flat tableland terminating at the Colorado River.

In the Paria Basin the three-tooth sage predominates the valley flora with rabbitbrush being more abundant along stream courses. Foothills and bluffs have typical pinyon-juniper woodlands varying from scattered clumps to a continuous forest.

In the upland sage and pinyon-juniper habitats are found such mammals as Botta's pocket gopher, deer mouse, piñon mouse, Great Basin pocket mouse, desert wood rat, Ord's kangaroo rat, desert cottontail, and black-tailed jack rabbit. In the deeply incised canyons are the desert wood rat, cliff chipmunk, white-tailed antelope squirrel, deer mouse, and canyon mouse. The Cottonwood Wash (Canyon), which is at the eastern boundary of the basin, is a fantastically formed geological structure, and in it are found complex, locally differentiated ecological environments due to varied edaphic, structural, and hydrographic conditions. The several kinds of biotic communities certainly would bear extensive and careful study.

At the western portion of the Paria Plateau in the vicinity of the Coxcomb the vegetation picture is of two general types. In the more rocky areas pinyon-juniper woodland predominates, with mixture of service berry, cliff rose, silver buffalo berry (*Lepargyrea argentea*), and holly oak (*Quercus wilcoxi*). In sandy habitats are the narrow and broad-leaved yucca, old man sage, Indian rice grass, desert beauty (*Dalea johnsoni*) and occasional clumps of joint fir.

Mammals characteristic of the rugged Coxcomb Ridge are the piñon mouse, desert wood rat, and cliff chipmunk. The long-tailed pocket mouse (*Perognathus formosus*) is also present but uncommon.

Birds common to the area are the house finch and the mourning dove. Characteristic pinyon-juniper birds are also present and inmlude the ash-throated flycatcher, scrub jay, piñon jay, and black-throated gray warbler.

Eastward beyond the Paria River is Clark's Bench of the Paria Plateau. The western portion is an extensive grassland, with Indian rice grass and galleta grass (*Hilaria jamesi*) predominating. In the sandy habitats small hummocks of joint fir and narrow-leaved yucca are the dominant plants. A few junipers grow on the higher elevations of Clark's Bench all along the route from Adairville to the Glen Canyon damsite. Generally speaking, predominant vegetation of Clark's Bench is grassland to the Echo Monocline and blackbrush (*Coleogyne ramosissima*) from there to Glen Canyon damsite. (Fig. 14)

Mammal life is similar throughout the Paria Plateau. The desert wood rat is restricted to rocky situations or more heavily wooded areas, and the canyon mouse, piñon mouse, and white-tailed antelope squirrel occur in similar habitats. On the extensive sandy flats, the most common mammal is the little pocket mouse (*Perognathus longimembris*). Ord's kangaroo rat is also abundant and the northern grasshopper mouse occurs in small numbers. We have found the deer mouse to be relatively uncommon throughout the Paria Plateau. The black-tailed jack rabbit and desert cottontail have their greatest populations along the stream courses where there is cover, but limited numbers of these are also found on higher ridges, especially where there are junipers and taller shrubs.

In the Paria Basin and Paria Plateau area we have found the richest fauna of amphibians and reptiles in the Upper Basin. The low elevation near and at Glen Canyon and the influence of the southern slopes presumably has provided habitats suited to some of the species which commonly occur in the Lower Colorado River Basin. Such species as the canyon tree frog (*Hyla arenicolor*) along the Glen Canyon, the chuckwalla (*Sauromalus obesus obesus*) from the Glen Canyon up the Wahweap Creek and as far west as the Coxcomb Ridge, and the Mojave patch-nosed snake (*Salvadora hexalepis mojavensis*) are examples of the southern element.

Because of the gradual decrease in elevation as one moves from the Paria Basin to the Paria Plateau and the Glen Canyon rim, one encounters an increasing number of species for the area. In the basin near Tropic and Cannonville, the Utah tiger salamander, Rocky Mountain toad, leopard frog, Great Basin sagebrush lizard, plateau lizard, northern side-blotched lizard, mountain short-horned lizard, northern whiptail, plateau whiptail, Great Basin skink, wandering garter snake, Great Basin gopher snake, night snake, and midget faded rattlesnake are apparently common.

In the lower part of the basin near the old ghost town of Paria we find the same species except for the skink and the occurrence of the Great Basin rattlesnake instead of the midget faded rattlesnake. At this locale, the Great Basin spadefoot, red-spotted toad, Utah spiny lizard, and western collared lizard were also common. The presence of the Great Basin rattlesnake may indicate an ingress to this basin from the valleys on the west.

From the Coxcomb eastward across Clark's Bench to the Glen Canyon one encounters in the appropriate habitats approximately the same species as those found in the lower portion of the Paria Basin. As indicated above, the species of the southern element also occur here. We have also taken the southern desert horned lizard near Lone Rock and the Utah black-headed snake on the Coxcomb. The Great Basin rattlesnake has not been taken east of the Coxcomb.

Kaiparowits Plateau-Escalante Basin Area

The borders of the Kaiparowits Plateau as referred to in this study are Glen Canyon of the Colorado River on the southeast, the rim of the Straight Cliffs on the northeast, and the Aquarius and Table Cliff Plateaus on the north and northwest respectively, with the upturned rocks of the East Kaibab Fold on the west (Eastern Rim of Paria Basin). The southern boundary at its western half is marked by the escarpments which are at the northern edge of the Paria Plateau, and the eastern half by Wahweap Creek.

The region constituting the Kaiparowits Plateau has not been surveyed by us to any appreciable extent. At only a few places along the eastern rim is the summit accessible. The western approach is quite prohibitive due to the rugged canyon type of topography. The main access is by means of dirt roads leading southward from Escalante and keeping more or less to the rim area of the Straight Cliffs. The plateau is a massive upturned block sloping westward and southward with the northeastward facing escarpment standing high above the Escalante Basin.

The Escalante Basin, for the purpose of this study, includes Potato Valley, the foothills of the Aquarius Plateau west of the Escalante Monocline, and all of the region between the Escalante River and the Straight Cliffs southward to the Colorado River. With the exception of Harris' Wash, which originates on top of the northeast corner of the Kaiparowits Plateau, and Collett Creek, which likewise originates on the plateau, most of the streams running eastward to the Escalante River are basin borne. This is especially true of the region below Collett Creek. The streambeds have their origin at the base of the steep walled Straight Cliffs and are shallow and dry at their heads except following summer rains and the seasonal winter precipitation. As the streams flow eastward they rapidly descend and soon are found at the bottom of deep and meandering canyons (Fig. 17).

The land nearest the Straight Cliffs is more or less sandy, but the eastern half of the area for the most part is bare sandstone. In certain places this bare rock surface is abundantly provided with naturally eroded pockets of varying dimensions. Some are completely bare inside while others have a rank growth of plant life including large cottonwood trees. Some of the pockets are inaccessible while others may be easily entered. (Fig. 17)

In order to facilitate a general description of the faunistic picture of Escalante Basin, three stations have been selected which are characteristic for the basin as a whole. The selected stations are Escalante, Calf Creek Crossing, and Willow Tank Springs.

Escalante Station. This station includes an area in the vicinity of the town of Escalante. Pinyon-juniper woodland is the predominant vegetation, accompanied by local plant variants such as greasewood in the more alkaline habitats and the Fremont cottonwood, rabbitbrush, three-tooth sage, tamarisk, willow, and meadowlands which are found on the floodplains.

Mammals at this station include the yellow-bellied marmot found at the base of the Aquarius Plateau and Botta's pocket gopher found in the fields about the town of Escalante and along water courses. On the more rocky slopes at the head of Escalante Canyon, near the town of Escalante, the Colorado chipmunk and the white-tailed antelope squirrel are seen. The desert wood rat is found in the rocky areas, but its nests are also found in the pinyon-juniper woodlands. In the more open habitats along streams as well as in the desert and among the pinyon and junipers the black-tailed jack rabbit is a common species. The deer mouse is widely distributed throughout all habitats.

Birds found here are the rufous-sided towhee, Say's phoebe, blue-gray gnatcatcher, savannah sparrow (*Passerculus sandwichensis*), western wood pewee, lark sparrow, mountain bluebird, piñon jay and scrub jay. In the canyon the cliff swallow (*Petrochelidon pyrrhonota*) nests in great abundance, and the cañon wren and white-throated swift are typical inhabitants. In meadows near the river and in the irrigated fields about town are found Bullock's oriole, Brewer's blackbird, redwinged blackbird (*Agelaius phoeniceus*), and western meadowlark. The western kingbird, robin, red-shafted flicker, mockingbird, yellow warbler, sparrow hawk, and house finch are frequently seen along the streamsides.

This station does not support a large variety of amphibian and reptile species, the most common ones being the Rocky Mountain toad, leopard frog, Great Basin sagebrush lizard, northern side-blotched uta, Great Basin gopher snake, wandering garter snake and midget faded rattlesnake.

Calf Creek Crossing Station. (Fig. 18). This station is located about eight miles downstream from the town of Escalante. At this point the canyon floor is relatively wide in contrast with most of the Escalante Canyon which is steep walled and very difficult of access. The Calf Creek Crossing Station is an excellent example of open canyon type of habitat in which the canyon walls rise as a series of benchlands or shelves.

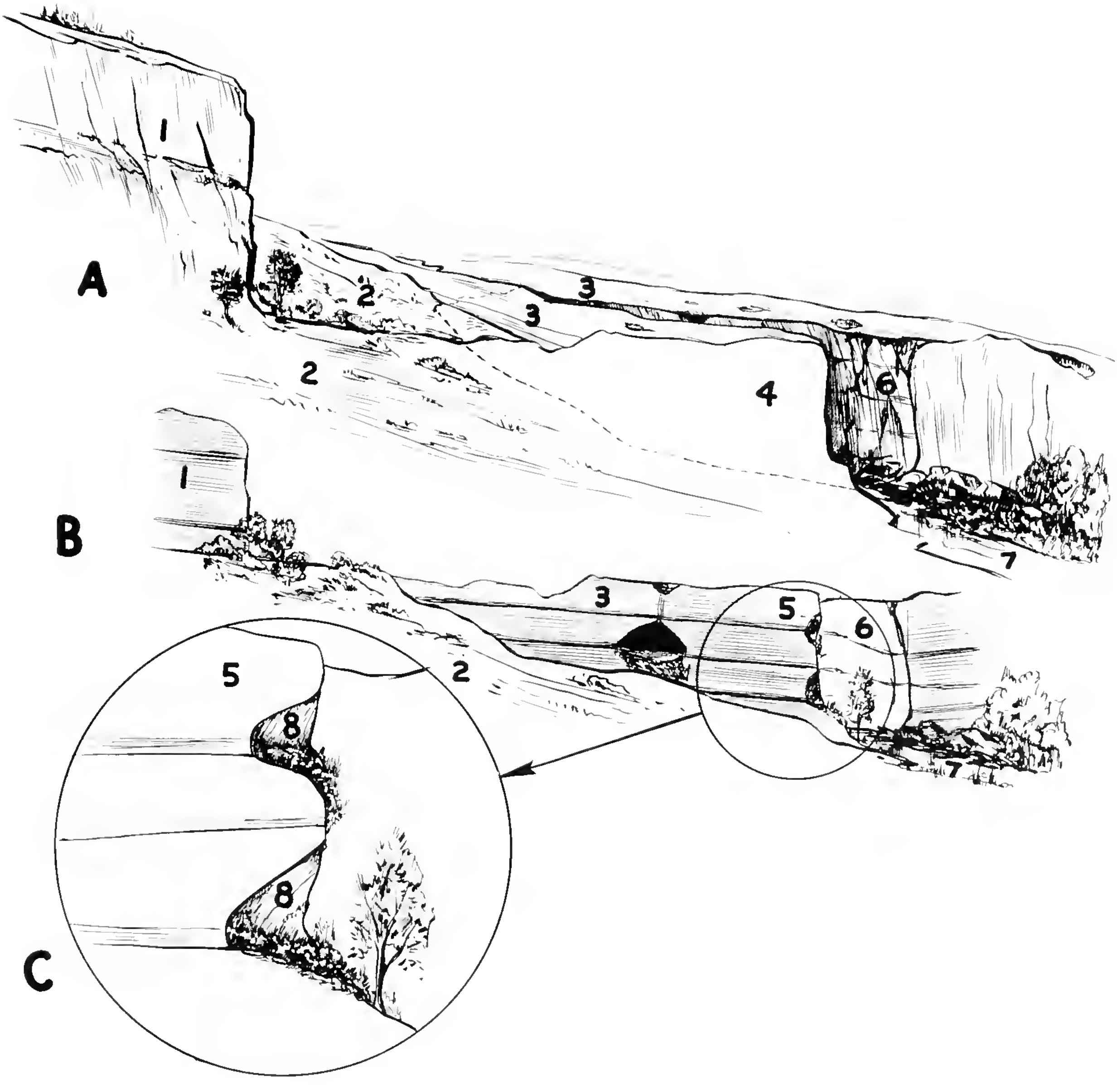
The pinyon-juniper woodlands extend down into the canyons. They are found in dense growths on canyon shelves, canyon benchlands, and even on nearly bare sandstone and rocky areas where protection affords some opportunity for growth. On the benchlands and at other places in the canyon varying amounts of sand deposits occur that have been blown down from the deserts above. Old man sage and joint fir

Fig. 17. Topographic and biotic features of the canyon country in the region of the Escalante Basin.

A. 1. Straight Cliffs formation with pinyon and juniper at the base. 2. Extending eastward is a sandy, relatively level country covered in the main by *Krameria* and black brush. 3. East of the sandy desert is a barren sandstone formation, dissected by many canyons represented in this drawing by the Escalante Canyon, 6. At the edge of the Escalante River, 7, are found rank growths of tamerisk and cottonwood. Dotted line enclosing 3 and 4 represents the block of land removed and as illustrated in B below.

B. This is a diagrammatic section of 1 and 3. Number 1 area has been sectioned to identify seep seams. Number 2 has been left intact; 3 is seen in section profile to show a generalized view of the steep canyon walls which is characteristic of most of the canyon lands of the Upper Basin. Note the seep seams. Drainage from the country above, plus the water from the seep seams, contributes to the formation of erosional features as potholes and deeply recessed alcoves as shown just below number 3, or at 5 which in this drawing is the Escalante Canyon. The alcove and pot holes in 3 is in Coyote Gulch.

C. This is an enlarged sketch of area 5 B. The amount of seep water will determine the biotic feature of the alcoves, 8. With sufficient water present the alcoves will support a luxurient, hanging garden composed both of hydrophytic and of mesophytic plants.



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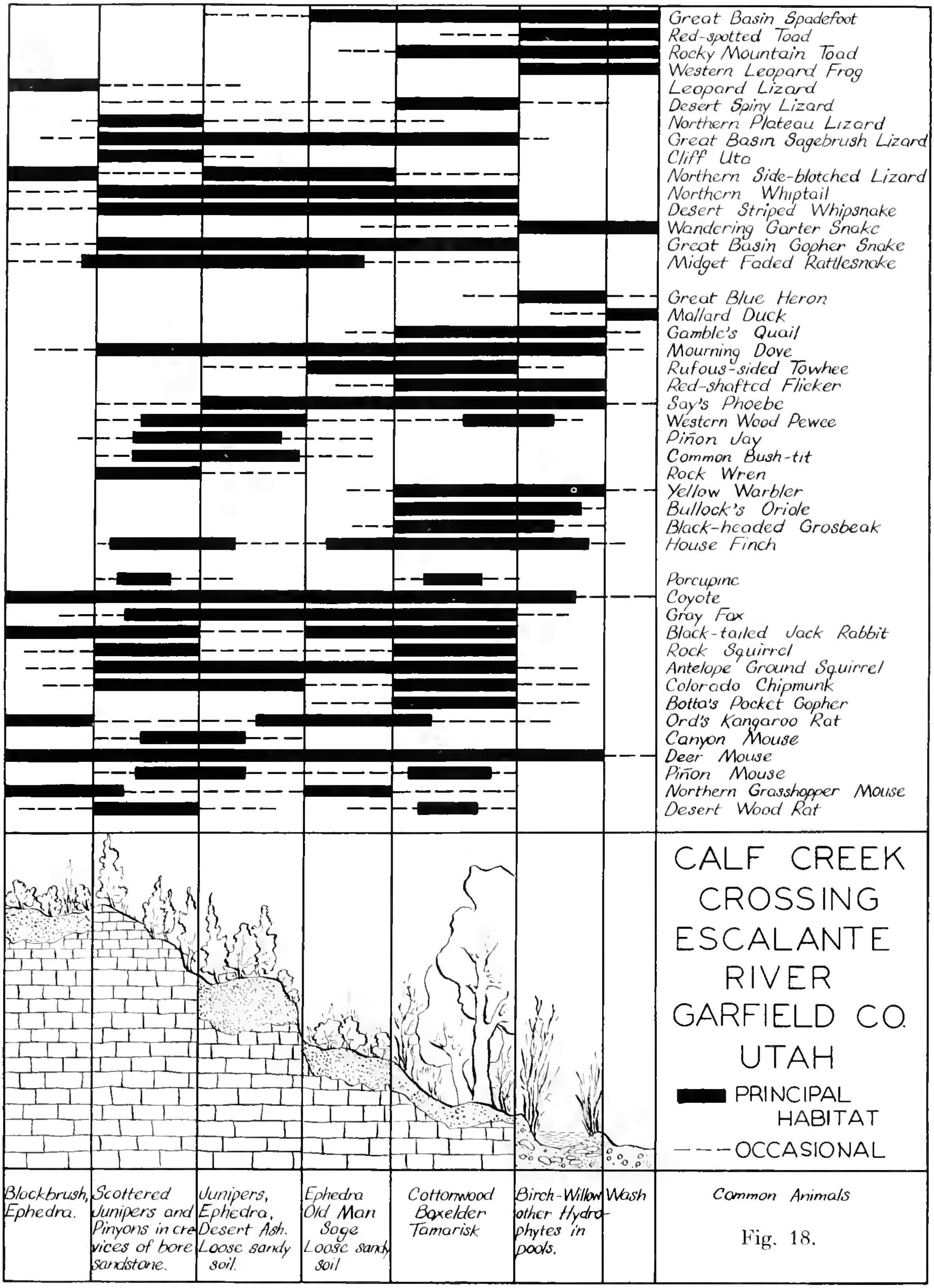

Great Basin Spadefoot
Red-spotted Toad
Rocky Mountain Toad
Western Leopard Frog
Leopard Lizard
Desert Spiny Lizard
Northern Plateau Lizard
Great Basin Sagebrush Lizard
Cliff Uta
Northern Side-blotched Lizard
Northern Whiptail
Desert Striped Whipsnake
Wandering Garter Snake
Great Basin Gopher Snake
Midget Faded Rattlesnake
Great Blue Heron
Mallard Duck
Gamble's Quail
Mourning Dove
Rufous-sided Towhee
Red-shafted Flicker
Say's Phoebe
Western Wood Pewee
Piñon Jay
Common Bush-tit
Rock Wren
Yellow Warbler
Bullock's Oriole
Black-headed Grosbeak
House Finch
Porcupine
Coyote
Gray Fox
Black-tailed Jack Rabbit
Rock Squirrel
Antelope Ground Squirrel
Colorado Chipmunk
Botta's Pocket Gopher
Ord's Kangaroo Rat
Canyon Mouse
Deer Mouse
Piñon Mouse
Northern Grasshopper Mouse
Desert Wood Rat
CALF CREEK CROSSING ESCALANTE RIVER GARFIELD CO. UTAH
PRINCIPAL HABITAT
OCCASIONAL
Blackbrush, Ephedra.
Scattered Junipers and Pinyons in crevices of bare sandstone.
Junipers, Ephedra, Desert Ash. Loose sandy soil.
Ephedra Old Man Sage Loose sandy soil
Cottonwood Boxelder Tamarisk
Birch-Willow other Hydrophytes in pools.
Wash
Common Animals

Fig. 18.

are the predominant plants in such habitats. In protected places such as at the base of cliffs, the desert ash, cliff rose, silver buffalo berry, Gamble's oak, and service berry are found. Where domestic stock cannot graze, these shelves support rank growths of grasses of several species. At the canyon floor level the Fremont cottonwood is the predominant plant. During certain seasons of the year, their seedlings provide a green carpet along the river's edge only to be washed away by summer floods. Three-toothed sage, rabbit brush, *Datura*, and tamarisk grow on slightly elevated river banks. In more protected areas are clumps of willow, squaw-bush, Gamble's oak, and boxelder Where side streams or seep seams issue, maple, birch and willows are found as well as sedges (*Carex concolor*, *C. kelloggii*, *C. rostrata*), bullrush (*Scirpus olneyi*), columbine (*Aquilegia micrantha*), penstemons, scouring rush, Indian paint brush (*Castilleja*), and *Smilicina*. At the river level may be found seasonal blanket growths of Russian thistle (*Salsola pestifer*) and bee flower (*Cleome lutea*).

Some of the mammals at Calf Creek Crossing station are not appreciably different from those inhabiting the desert flat lands that extend outward from the canyon rim. Typical of these are Ord's kangaroo rat and the northern grasshopper mouse, which have an extensive and more or less continuous horizontal distribution on the sandy flatlands above, while in the canyons their ranges are restricted to places of smaller dimension where sand deposits afford suitable places to live. These places are usually found on the canyon shelves. Mammals which are more or less restricted to the canyon are the Colorado chipmunk, cliff chipmunk rock squirrel, brush mouse and piñon mouse. The desert wood rat and deer mouse are also common inhabitants of the canyon. The coyote (*Canis latrans*) was at least formerly a common inhabitant of the canyon. Occasionally the black-tailed jack rabbit wanders from the desert land above into the more open canyon regions.

Several kinds of ducks and the great blue heron are found along the water courses. In those areas of the canyon where there is ample cover, the Gamble's quail (*Lophortyx gambelii*), rufous-sided towhee, Say's phoebe and mourning dove are found. Bullocks oriole, the house finch, yellow warbler, ash-throated flycatcher, black-headed grosbeak, broadtailed and black-chinned hummingbirds and western wood pewee are some of the birds frequenting the canyon bottoms. Scattered more or less in the canyon benchlands and especially where pinyons and junipers are located will be found the scrub jay, ash-throated flycatcher, and common bush tit. The white-throated swift, cañon wren and rock wren are also common inhabitants of the canyon.

Three toads are common at this station and are found in abundance along the river at evenings. On the evening of July 3, 1938, a count was made of the toads found along the river from the junction of Calf Creek for approximately one third of a mile downstream. All toads found were placed in cloth bags and after one hour were counted. We secured 110 individuals of which 93 were Rocky Mountain toads, 14 were red-spotted toads, and 3 were Great Basin spadefoots. Most were found in or along the stream and were rather evenly distributed. This represents a feeding population rather than a breeding one, for we found the newly metamorphosed toads of both *bufos* near a pond at the junction of the stream.

The most common lizards in the narrow river valley are the northern plateau, northern side-blotched uta, northern cliff uta, and northern whiptail. We did not find snakes to be common, perhaps because of the difficulty of finding them among the numerous rocks in this habitat. Our records indicate that the western striped racer, Great Basin gopher snake, and midget faded rattlesnake are present.

Willow Tank Spring Station. Typical of the desert flatlands in the Escalante Basin is the station at Willow Tank Springs. This is a government-developed watering place for range stock located at the head of Coyote Gulch. It is approximately forty-five miles southeast of Escalante and about three miles northeast of the base of the Straight Cliffs. At this point the Straight Cliffs rise about 2,000 feet above the desert floor. Willow Tank Springs is at the head of an arroyo known as Hurricane Gulch, a tributary of the main canyon of Coyote Gulch. The latter drops down from the desert floor level at Willow Tank Springs at 5,000 feet to 4,200 feet at the Escalante River, a descent of about 800 feet in ten miles. Black brush and *Kramaria* dominate the vegetational landscape on the desert flatlands with local patches of joint fir and old man sage in more sandy situations. Junipers are restricted more or less to the base of the Straight Cliffs and to the washes which drain into the main canyon. At Willow Tank Springs there is a mixture of desert floor vegetation and the canyon type with squaw-bush and desert ash predominating.

The northern grasshopper mouse, Ord's kangaroo rat, deer mouse, little pocket mouse and Botta's pocket gopher are the most characteristic mammals of the desert flats Grasshopper mice and kangaroo rats are especially abundant around hummocks of joint fir. The little pocket mouse ranges over a variety of habitats from pure sand to gravelly soil and even bare rocks. The white-tailed antelope squirrel occurs principally in the washes and over the gravelly or rocky hillsides. Desert wood rats are confined to rocky areas and brush situations which afford suitable habitats for their nest construction. The black-tailed jack rabbit ranges throughout the entire area. The western pipistrelle bat (*Pipistrellus hesperus*) is common in the evening over the water pockets and seep springs.

Birds most common to the area and widely distributed are the loggerhead shrike (*Lanius ludovicianus*), black-throated sparrow, horned lark, and common nighthawk. In the areas near water where squaw-bush thickets are found, Say's phoebe, the ash-throated flycatcher, mocking bird, mourning dove and house finch occur.

Our records suggest that there is little difference in the kinds of reptiles here and those taken at Calf Creek Crossing. However, as one descends into the deep gorges such as Coyote Gulch, the canyon tree frog is common in the pot holes. Along the lower Escalante River the western leopard frog is common and the chuckwalla occurs in the ledges of the canyon wall.

Approximately 15 miles northwest of the Willow Tank Springs we took a specimen of the California king snake. It was on the road in the desert shrub habitat.

Escalante Canyon-Water Pocket Fold-Circle Cliffs Area

The Water Pocket Fold and the Circle Cliffs are considered together as one geological unit, but they are actually two separate formations. The Water Pocket Fold is a monoclinal structure extending from Thousand Lake Mountain in Wayne County on the north to a point just south of the Colorado River, a distance of more than eighty miles. In and around the Circle Cliffs area the upturned limbs of the fold are remarkably exposed while in the southern portion the flexure is more or less continuous.

For the purpose of this report the boundaries of the area under immediate discussion are the Escalante River (Canyon) on the southwest, the Colorado River on the southeast, Hall's Creek on the east and the rim of the Circle Cliffs on the north.

Aside from the Circle Cliffs region and the outlying town of Boulder at the base of the Aquarius Plateau, very little natural history observation has been done by us in this area. The lower part of the Water Pocket Fold offers an unusual condition in natural history study with respect to the water pockets which occur in great numbers and variety of sizes. The western side of the flexure has a number of major canyons and many minor canyons which drain to the Escalante River. From the stand point of canyon structure and the overall biotic nature, all of these canyons are similar to those described for Calf Creek Crossing or Coyote Gulch.

In the summer of 1939 an expedition was conducted along the entire length of the Escalante Canyon, returning via Hole-in-the-Rock Crossing on the Colorado River and Escalante Basin to the town of Escalante. As a part of this survey the major canyons leading to the Water Pocket Fold were checked at their lower extremities. Since the 1939 survey several special surveys have been conducted to the canyons which drain the Escalante Basin and empty into the Escalante River. All of these canyons were found to have a similar geology and ecology. It therefore can be concluded that the lower part of the canyons draining the Water Pocket Fold are not dissimilar to the western drainage from the Escalante Basin. The upper reaches of these tributaries are, however, topographically and ecologically much different on each side of the Escalante River. The Escalante Basin previously described is relatively sandy, whereas the Water Pocket Fold is to a great extent barren sandstone.

The flora at the base of the Circle Cliffs is mainly a pinyon-juniper woodland with extensive intervening regions of three-toothed sage. Also present in restricted localities are Gamble's oak groves and patches of rabbitbrush. The pinyon-juniper woodlands seem to be relegated to the mesas and the benchlands. The sage occupies the floor of the Circle Cliff basin itself. In the washes and canyons are found joint fir, yucca, service berry, oak, Palmer's penstemon, and silver buffalo berry plus a host of other species of plants, mostly flowering annuals.

Mammals common to the Circle Cliffs are the black-tailed jack rabbit, desert cottontail, Colorado chipmunk, rock squirrel, white-tailed antelope squirrel, desert wood rat, Ord's kangaroo rat, deer mouse, and coyote.

Typical birds of the Circle Cliffs basin include the mourning dove, scrub jay, Say's phoebe, vesper sparrow, blue-gray gnatcatcher, ash-throated flycatcher, rock wren, house finch, green-tailed towhee, piñon jay, rufous-sided towhee, raven, black-throated gray warbler, plain titmouse, and common bush tit.

In the springs of Indian Gulch and at the Moki tanks we found the tadpoles of the Rocky Mountain toad and on the night of June 29, 1938, after a heavy rain, the Great Basin spadefoot was calling along the stream bed of Indian Gulch.

Such lizards as the northern plateau, Great Basin sagebrush, northern cliff uta, and northern whiptail were common at the Circle Cliffs. We do not have snake records from this immediate area; however, we do have records for the wandering garter snake and the Great Basin gopher snake at Boulder. A midget faded rattlesnake was taken on a sand dune along the Escalante River about 30 miles from the Colorado River.

Torrey-Capitol Reef Area

For the most part, this area is included in the Capitol Reef National Monument. The Water Pocket Fold extends in a northern direction beyond the Circle Cliffs region. At the town of Fremont where the Fremont River cuts through the fold, the monoclinal structure turns westward, disappearing under Thousand Lakes Plateau. Erosion of the tilted beds on the westward side has produced the reef-like formation from which the area gets it name. The eastward limb more or less gently folds downward and disappears under the Cretaceous formations of the Painted Desert surrounding the Henry Mountains. Actually the upturned beds produce several major structures on the westward side rather than a single wall.

Fremont River (also known as the Dirty Devil) drains from the Aquarius, Awapa and Thousand Lakes Plateaus, apparently outdating the present topographic features. Another principal stream of the area is Pleasant Creek which originates on the east face of the Aquarius Plateau. These two streams have actually cut their way through the monoclinal fold as it was slowly being raised. The folding, local faulting, and consummate stream erosion have created here as elsewhere in the canyon country a landscape which is commonly described as "terrifyingly beautiful." The kinds of erosional features, the water supply (or lack thereof), its kind, and elevational differences for the area also create a number of locally differentiated ecological environments. The uppermost elevation limiting the area included in this study is at Torrey which is 7,000 feet. The lowermost is at Notom at the mouth of Capitol Gorge with an elevation of 5,250 feet.

At the northeast flank of the Aquarius Plateau is the town of Torrey situated at the lower end of a long valley known as Rabbit Valley. To the south there is a gradual rise of the landscape leading to the Aquarius Plateau, and to the north the landscape rises more abruptly to the Thousand Lakes Plateau.

Torrey Station. In and around Torrey the drier habitats are dominated by pinyon-juniper forests plus localized patches of shadscale. Other plants common to the drier situations are princess plume, red false mallow (*Sphaeralcea coccinea*) and several species of primrose (*Anogra.*) Three-tooth sage predominates in the open valley, while cottonwoods and willows are found along the streams. Marshlands and meadows occur adjacent to the Fremont River as it meanders through the full length of the valley. Tules (*Scirpus validus*), Carex of several species (*Carex chalciolepis*, *C. lonuginosa* and *C. nebraskensis*), blue-eyed grass, and buttercups (*Ranunculus cymbalaria* and *R. sceleratus*) are characteristic here.

Black-tailed jack rabbits and desert cottontails range over most of the valley except the marshlands. The white-tailed antelope squirrel seems to prefer the pinyon-juniper woodland. In and around the marshlands are long-tailed voles and montane voles. Ord's kangaroo rat is restricted more or less to sandy arid situations. The deer mouse is generally distributed throughout the entire area. In the first years of the survey there was a white-tailed prairie dog town south of Torrey, but it was later abandoned.

Birds common to the area are the savannah sparrow, mountain blue bird (*Sialia currucoides*), yellow-headed blackbird (*Xanthocephalus xanthocephalus*), redwinged blackbird, Brewer's blackbird, red-shafted flicker, robin, rock wren, white-throated swift, sparrow hawk, and raven.

Amphibians occurring in the vicinity of Torrey reflect the higher elevation. The high plateaus to the west provide streams which drain from elevations where old glacial lakes are now nestled in conifer forests and seemingly influence the distribution of certain species. For example, the boreal toad (*Bufo boreas boreas*), has been taken along the Fremont river a few miles west of the Capitol Reef. The Rocky Mountian toad and the leopard frog are common in the meadows and along the stream.

Reptiles common to this station are the Great Basin sagebrush lizard, northern plateau lizard, Great Basin side-blotched uta, northern whiptail, wandering garter snake, Great Basin gopher snake, and midget faded rattlesnake. On the rocky hills the Colorado plateau night snake occurs in limited numbers.

Fruita Station. Immediately east of Torrey the valley drops away to the Capitol Reef formation, and the landscape assumes a definite desert-like character in aridity and sparseness of vegetation. The high reef on the north and the great swell of the Miners' Mountain crest on the south, the greatly eroded surface of the landscape in general plus the variety in the color of the rocks and the contrasting green of the pinyon-juniper woodlands create an unusually beautiful landscape. The central station selected for this area is Fruita, a town located on the Fremont River at the point where the river enters the gorge through the reef. Fruita has an elevation of about 5,400 feet, which is approximately 1,500 feet lower than Torrey.

The Fruita station is in most respects a broad desert canyon type, similar in a way to the situation described above for Calf Creek Crossing. Several distinct community types are found in this locality. The canyon floor, mainly identified with some permanent and intermittant streams which are tributary to the Fremont River, supports a growth of cottonwood, willow, rabbit brush, bee flower, shadscale, and tamarisk. Terraces, mesas and surfaces of the upturned folds constitute another community type vegetated predominantly with pinyon-juniper or in other places with *Yucca herrimaniae*, silver buffalo berry, joint fir, and princess plume Still another kind of environment is that found in the side canyons and other recesses where larger shrubs such as desert ash, service berry and squaw-bush occur. Other common plants are old man sage, Indian rice grass, squirrel-tail grass (*Sitanion hystrix*), needle and thread grass (*Stipa comata*), galleta grass (*Hilaria jamesii*) and alkali sacaton (*Sporobolus airoides*). Virgin's bower (*Clematis ligusticifolia*), joint fir, shadscale (*Atriplex canescens* and *A. confertifolia*), and daisies (*Erigeron argentatus*, *E. caespitosus*) are in lesser abundance.

The Colorado chipmunk is a most characteristic mammal of the canyons and is also commonly seen in the rocky areas where pinyon-juniper woodlands occur. The desert wood rat is found most often along much broken cliff faces and in talus. The white-tailed antelope squirrel is more abundant on the terraces and lowlands but may be observed high on the reef. On the other hand, the rock squirrel is distributed mainly along the talus slopes and the river floodplains. Desert cottontails are usually found along the stream courses, but a few may be seen in dry canyons, while the black-tailed jack rabbit roams over the landscape generally except the high mesas and narrow terraces. The western harvest mouse is found especially in and around the local ranches. The deer mouse is the most generally distributed mammal, being found from the top of the reef to the river bottom. (Fig. 5)

In and around the Fruita station there is found a large variety of birds. In the canyons and along the hillsides are the mourning dove, Say's phoebe, white-throated swift, cañon wren, green-tailed towhee, and rufous-sided towhee. On the terraces and benchlands, especially in the pinyon-juniper habitat, are the common nighthawk, solitary vireo, common bush tit, plain titmouse, black-headed grosbeak, blue-gray gnatchatcher, piñon jay, and lazuli bunting (*Passerina amoena*). Characteristic birds of the river floodplains include the house finch, American goldfinch (*Spinus tristis*), yellow warbler, robin, red-shafted flicker, song sparrow (*Melospiza melodia*), and Bullock's oriole

Amphibians such as the Rocky Mountain toad, red-spotted toad, and western leopard frog are common along the streams.

Reptiles are similar to those taken at the Torrey Station but with some species such as the northern cliff uta, northern plateau lizard, and northern whiptail becoming more abundant. The Utah spiny lizard is also commonly seen in the canyons and to the east of the Capitol Reef.

Henry Mountains-Southern Green River Desert Area

Water Pocket Fold and Capitol Reef on the west, San Rafael Swell on the north, and the Green and Colorado Rivers on the east and south mark the general boundaries of this area of the canyon lands under consideration. Perhaps the high Henry Mountains and the sand deserts which surround them are the most prominant features of this vast area, unique in two respects compared with other regions thus far described. The two southern peaks, Mt. Holmes and Mt. Ellsworth, have only a sparse vegetative cover and exhibit very clearly the effects of the instrusive magmas on the overlying sedimentary layers. Although most of this overburden has been eroded away exposing the jagged granite peaks, the sides of the old sedimentary dome are sharply defined against the black igneous rocks which now form the peaks. Between the Colorado River and Mt. Hillers the terrain is extremely rugged and crossed by deep narrow canyons. If not the most rugged area, this is one of the most rugged areas in the entire Upper Basin. From the eastern base of Mt. Hillers one can see its peak at approximately 10,550 feet and the Colorado River at 3,400 feet, yet these two points are only about 15 miles apart.

Most of the country to the northeast, south and west of the Henry Mountains is the sand desert and canyon type. Some of these areas are broad and open while others also have deep narrow canyons. Generally speaking, the latter are much like the desert canyons which have been described previously.

Northeast and east of Mt. Ellen the country is comparatively level and constitutes a sand desert type of habitat. Burr Desert, southwest of the Fremont River, and Green River Desert, northeast of the Fremont, are typical examples. Where washes and canyons occur, sand slopes may fill one side of the depression from bottom to rim.

These sand deserts support a typical variety and population of plants. In the upper reaches of sand deserts at the base of the mountains the three-toothed sage is predominant. Lower down, shadscale and greasewood are found either in extensive, almost pure stands or mixed together depending on the kind of soil and the drainage. In the more sandy and less saline situations are found old man sage, joint fir, yucca, matchbrush, blackbrush, various species of shrubby eriogonums and "little" rabbitbrush. Along stream courses are tamarisk, cottonwoods, greasewood, three-toothed sage, squawbush, willow (*Salix* sp.), box elder, and single leaf ash (*Fraxinus anomala*).

A typical canyon type of habitat in the Henry Mountains-Southern Green River Desert Area is exemplified by North Wash. This canyon joins the Colorado River approximately four miles north of Hite. From here it extends in a westerly direction through sandstone canyon walls to the bench land east of the Henry Mountains and then into a mountain canyon on the southeast face of Mount Ellen. There is considerable sand from the base of the mountains to the river, leaving few areas where stable soils occur.

A series of springs along North Wash provides for small intermittent streams during most of the year. Approximately fourteen miles from Hite is Hog Springs, which provides an abundance of water for a few miles. In most of the canyon floor there are scattered growths of cottonwood, willow, and tamarisk. Along the canyon walls is a series of low sandy benches which support a growth of mixed desert shrubs and yucca.

The canyon mouse, desert wood rat, white-tailed antelope squirrel, rock squirrel, and Colorado chipmunk are very characteristic mammals of the canyons. On the open sandy desert the most common mammal is the Great Basin pocket mouse. Ord's kangaroo rat also occurs in loose, sandy areas. Both the pocket mouse and kangaroo rat range into the canyons where there is loose sand and the canyon floor is relatively wide. The deer mouse frequents both canyons and the open desert country.

Our knowledge of the amphibians and reptiles of this area is based on the rather intensive field work done from the base of the mountains east to the Colorado River through North Wash and south from North Wash at the base of the mountains along the bench lands to Star Spring. Both North Wash and Trachyte Creek support large populations of the Great Basin spadefoot, red-spotted and Rocky Mountain toads. The meadows around Star Spring have the spadefoot and Rocky Mountain toads, but we have not seen the red-spotted toad. Perhaps the largest population of toads observed was in North Wash at and near the Hog Springs. At the junction of North Wash and the Colorado River a few western leopard frogs were seen..

Lizards generally distributed in this area include the western collared, leopard, Utah spiny, northern plateau, northern side-blotched, northern cliff uta, and northern whiptail. In the ledges of the canyons extending up from the Colorado River the western chuckwalla occurs. On the sandy benchlands near the Henry Mountains and extending east between the canyons is a habitat which supports a low-growing, short-leafed yucca. In this plant we have taken the Utah night lizard (*Xantusia vigilis utahensis*). On the base of the mountains above the general bench lands the mountain short-horned lizard is common.

We have found the desert striped whipsnake, Great Basin gopher snake and midget faded rattlesnake to be the most common. However, none is seemingly abundant in this area. On the bench lands and base of the mountains the Utah black-headed snake is found.

San Rafael Swell - Castle Valley - Price River Area

This area is bounded on the east by the Green River, on the southeast by the Colorado River, on the south by the Fremont River, and on the southwest by the Thousand Lake Mountain. Westward the area is limited by the Wasatch Plateau and northward by the Roan and Book Cliffs.

The San Rafael Swell is the most prominent feature of the area. It is a massive anticlinal uplift about eighty miles long and twenty miles wide, being somewhat ovoid in shape. Between the Book Cliffs, which face southward, and the northern rim of the swell is the Price River Valley, while the large depression lying west of the San Rafael Swell and extending to the eastern base of the Wasatch Plateau is known as Castle Valley. (Figs. 2 and 7.)

Inside the San Rafael Swell numerous locally originating streams have dissected the landscape and in some cases have breached the outer rim forming deep canyons. The San Rafael River originates on the Wasatch Plateau and cuts across Castle Valley and the San Rafael Swell eastward to the Green River. For the most part it has formed narrow, crooked canyons but in some places the erosional channel is broad, particularly in Castle Valley. The Muddy River also originates on the Wasatch Plateau and crosses the lower end of Castle Valley, the southern tip of the swell, and the badlands area north of the Henry Mountains, joining the Fremont (Dirty Devil) River a few miles north of Hanksville.

The vegetation picture is somewhat similar to that which was discussed for the Henry Mountains area, the main difference being the comparative extent of the respective types of vegetation. The San Rafael Swell itself is almost completely surrounded by badlands except forthe region immediately southeast of the swell, which is a sand desert with active dunes. Due to soil and rock composition of the Mancos and Morrison geological formations which make up the landscape, the predominant plant life of the badlands is shadscale. Where there is an underground water supply or surface moisture available greasewood is found. Other plants commonly encountered are princess plume and several species of *Eriogonum*. Where the badlands country merges into the Green River Desert and sandy desert, there are joint fir, old man sage, yucca, and several species of *Eriogonum*. Along stream courses are cottonwood, willow, tamarisk, rabbitbrush and greasewood. In the confines of the San Rafael Swell itself on mesas and tablelands pinyon-juniper woodlands are dominant.

Mammal studies by our survey parties in the

San Rafael Swell area have been somewhat limited. The deer mouse is abundant and scattered throughout the area. The desert wood rat and the canyon mouse occur along cliffs and in rocky habitats. Great Basin pocket mice are found both in the pinyon-juniper woodland and in the desert shrub habitat. The western harvest mouse seems to be most abundant where Russian thistle clumps are piled along the fences and wind-blown sand is accumulating. In disturbed woodland situations and where there is loose soil, Ord's kangaroo rat is found occasionally. The black-tailed jack rabbit and the desert cottontail are present throughout the area. Several white-tailed prairie dog towns have been noted throughout both Castle Valley and Price River Valley. These animals, along with the black-tailed jack rabbit, are the most characteristic mammals of the open valley country.

East of Castle Dale at the north end of the swell is a transitional point between the badlands and the swell itself. At Buckhorn Reservoir, a few miles north of Buckhorn Wash, the main plant cover is pinyon-juniper. Westward from the reservoir the land merges into the badlands type. At the Reservoir the black-tailed jack rabbit is generally distributed, and in the rocky washes the rock squirrel is common. Other mammals found are the desert wood rat, Ord's kangaroo rat, western harvest mouse, Great Basin pocket mouse and deer mouse.

Near the junction of the San Rafael and Green Rivers is a rather wide valley with low red sandstone ledges rising on either side. The river floodplain at this point is vegetated with an extensive growth of tamarisk and willow, and there are a few cottonwoods. On higher ground the soil is sandy and supports a growth of rabbitbrush, Indian rice grass, several other grasses and a variety of forbs. Ord's kangaroo rat, western harvest mouse, and the deer mouse are common small mammals. Along the sandstone ledges the desert wood rat and canyon mouse are most characteristic, and in rocky situations the white-tailed antelope squirrel is found. Desert cottontails inhabit the floodplains and higher areas where there is ample cover.

The floodplains of the San Rafael River and other streams of the area furnish a habitat suitable for a large variety of birds. The mourning dove is very abundant and by far the most conspicuous species. Other characteristic kinds include the yellow-breasted chat, black-billed magpie, yellow warbler, western wood pewee, blue grosbeak, Brewer's sparrow, catbird (*Dumetella carolinensis*), ash-throated flycatcher, and red-shafted flicker.

In this area there is a varied series of habitats which provides for an abundance of amphibians. Along the Green River below Green River City we have taken the Rocky Mountain and red-spotted toads. In the upper Price River Valley between Wellington and Helper we have taken the Utah tiger salamander, Great Basin spadefoot, Rocky Mountain toad, and western leopard frog.

The lizards common to this area include the Utah spiny along the river south of Green River City, leopard, western collared, northern plateau, Great Basin sagebrush, northern side-blotched, northern cliff uta, northern whiptail and on the benches near the Wasatch Plateau the mountain short horned. Snakes common to the area include the wandering garter, Great Basin gopher, western whip, Utah milk, plateau night, and midget faded rattlesnake.

The Uinta Mountain Province

The Uinta Mountain Province includes the Uinta Mountains and the Uinta Basin. Except for the pinyon-juniper woodlands of the foothills, the desert communities occur in the Uinta Basin itself. This is a vast area of some 15,000 square miles that occupies northwestern Colorado and northeastern Utah. On the whole, the topography is less rugged than that of the Colorado Plateau Province. Much of the lower country of the Uinta Mountain Province is characterized by broad valleys and low hills, but there are also extensive badlands with some of the most barren country in the Upper Colorado Basin. The principal stream of the area is the Green River, which flows through it in a generally southward direction. This stream is joined by the Duchesne River and its tributaries from the west and by the Yampa and White Rivers from the east. A better concept of the nature of the Uinta Basin may be gained from a more detailed description of several specific areas within it. (Figs. 2 and 4)

Rainbow - Bonanza Area

Rainbow Station. The Rainbow area lies south of the White River in eastern Utah and contiguous Colorado. It is a rugged and inhospitable area with many deep and narrow canyons that are dry or else contain small salty streams, great areas of badlands, shallow valleys, and low hills practically devoid of all plants and animals. Gilsonite mining is the principal industry of the area. There is no farming but most of the area is heavily overgrazed, mostly by sheep. The area about Rainbow is topographically characterized by shallow valleys and low ridges with some rather colorful and prominent outcroppings of soft light brown sandstone.

Two principal types of communities occur in the Rainbow area. In the shallow valleys the soil is sandy or sand-clay and the predominant vegetation is sagebrush, greasewood, shadscale, and rabbitbrush. On the ridges and in the higher ravines where the soil is more rocky there is a scattered growth of pinyon and juniper. Many of the trees are very old and there is much fallen timber.

Mammals in this area are sparsely represented but there are a number of interesting species. In the shallow valleys where desert shrubs predominate the deer mouse, Apache pocket mouse, and Ord's kangaroo rat, western harvest mouse, and least chipmunk (*Eutamias minimus*) are characteristic. In the pinyon-juniper woodlands, particularly around the bases of ledges, the piñon mouse, bushy-tailed wood rat, and porcupine (*Erethizon dorsatum*) are found. There are also many signs of mule deer (*Odocoileus hemionus*) in the pinyon-juniper. Presumably these animals move down from the Tavaputs Plateau during the winter, but an occasional deer is also seen during the summer. Desert cottontails are fairly common in the desert shrub and less so in the pinyon-juniper. There are a few white-tailed jack rabbits (*Lepus townsendii*) replacing the black-tailed jack rabbits of the Colorado Plateau Province, particularly in sagebrush and greasewood communities. Both the golden-mantled ground squirrel (*Citellus lateralis*) and antelope ground squirrel occur in small numbers in the pinyon-juniper and desert shrub, usually in the vicinity of rocky outcroppings.

Bird populations in the Rainbow area are fairly high considering the scarcity of water. In the pinyon-juniper community the plain titmouse, solitary vireo (*Vireo solitarius*), blue-gray gnatcatcher, gray flycatcher, black-throated gray warbler, piñon jay, scrub jay (*Aphelocoma coerulescens*), chipping sparrow, Bewick's wren (*Thryomanes bewickii*), and ash-throated flycatcher are common. The most typical birds in the desert shrub community are the loggerhead shrike, Say's phoebe, and horned lark.

Bonanza Station. The area immediately north of White River and east of the Green River possesses extensive areas of flat plains and rolling hills with a few ridges where low ledges of rock are exposed. An area some fifteen miles north of Bonanza is typical. The plains and hills are clothed with desert shrubs among which sagebrush, several types of shadscale, and *Tetradymia* predominate. The higher hills and ridges are vegetated with a rather scattered pinyon-juniper woodland mixed with sagebrush and other desert shrubs. For the most part the soil is sandy, especially on the plains, and there are places where the situation is rather unstable and the sand is thrown up into low ridges.

During our period of study populations of small mammals were considerably greater at this station than in the more rugged and less hospitable situation at Rainbow. In the desert shrub community, particularly where the soil is sandy, Ord's kangaroo rat is abundant and the following additional species are characteristic, although less common: olive-backed pocket mouse (*Perognathus fasciatus*), western harvest mouse, deer mouse, least chipmunk, thirteen lined ground squirrel (*Citellus tridecemlineatus*), and northern grasshopper mouse. The desert cottontail was very abundant in the desert shrubs in 1954 and to a lesser degree extended into the pinyon-juniper woodland. The latter community contains its typical mammals, with the bushy-tailed wood rat, piñon mouse, and white-tailed antelope squirrel being most characteristic.

Birds of the Bonanza area are similar in kind to those of the Rainbow area, although they are less abundant. In the desert shrub type of community the horned lark is probably the most abundant species, while in the pinyon-juniper the piñon jay is very common.

Amphibians in this area are sparsely represented, and only a few species are known to occur. The Great Basin spadefoot is perhaps the most common, with the Rocky Mountain toad and the western leopard frog seen occasionally along the streams of the area.

Reptiles are more abundant both as to numbers and kinds. In the valleys among the sage and other low-growing brush are the Great Basin sagebrush lizard and the northern side-blotched uta. On the rocky hillsides is found the northern plateau lizard, and in suitable areas of both habitats one encounters the northern whiptail. The mountain short-horned lizard is found on the higher plateaus of the area.

Our records indicate that the Great Basin gopher snake ranges throughout this area and is the commonest of the serpents. In the lower valleys, particularly on the rocky brushy hillsides not far from the Green River, the desert striped whipsnake is found.

Brown's Park - Clay Basin Area

While the Brown's Park-Clay Basin Area is not strictly a part of the Uinta Province geographically, it appears to be closely related to it faunistically.

It lies in the northeast corner of Utah and contiguous areas of Wyoming and Colorado. Brown's Park itself is a broad valley floodplain of the Green River. The stream flows in an easterly direction at this point, enters the state of Colorado, and then turns southward across the east end of the Uinta Mountains. This section of the river runs at an elevation of about 5,400 feet. Two small streams, Red Creek and Willow Creek, drain into it from the north. To the northward the ground rises rather gently to a low mountain range of which Home Mountain and Bender Mountain are a part and then descends again into a wide and irregularly-shaped valley known as Clay Basin. The latter basin is about 1,000 feet higher than the floodplain of the river.

Within the general area described above, exclusive of the mountains, the following communities may be recognized: (1) stream-border community where scattered groves of cottonwoods and willows predominate, (2) greasewood flats and knolls with heavier clay or sand-clay soils, (3) sagebrush-shadscale-rabbitbrush communities occupying higher benchlands where the soil is predominantly sand, (4) scattered juniper woodlands on higher ridges within the valley. Most of the better lowlands adjacent to the river are occupied by farms and ranches while the higher slopes and benchlands have been heavily overgrazed.

Brown's Park Station (Fig. 19). The several desert-shrub types of plant communities here seem to possess much the same kinds of mammal, although there is some distinction on the basis of soil differences. On the more sandy and especially the less stable soils Ord's kangaroo rat is very abundant, and the northern grasshopper mouse is characteristic although far less common. The olive-backed pocket mouse and the western harvest mouse live mostly on the more gravelly or rocky soils where sagebrush and shadscale are predominant, but are occasionally taken on greasewood flats. The desert cottontail is very abundant in willow thickets along the streams and more especially in greasewood, and a few white-tailed jack rabbits also live in the latter community. The northern pocket gopher (*Thomomys talpoides*) is common on the cultivated lands. In the scattered juniper communities that occur on ridges where the soil is more rocky the cliff chipmunk is common and seems to replace the white-tailed antelope ground squirrel that is characteristic of similar habitats farther south. During our study we have not found the latter species in the Brown's Park area. The wood rat was collected in the Bridgeport-Red Creek environs on several occasions. Wood rats were found in abandoned log houses.

As is true for the Upper Basin, in general bird populations are concentrated mainly along the waterways in the Brown's Park Area. Brewer's blackbird, mourning dove, red-shafted flicker and black-billed magpie are most common and characteristic in the floodplain groves and thickets. Most characteristic of the desert shrub types are the sage thrasher, Brewer's sparrow and the horned lark. The common nighthawk nests on the juniper-covered ridges and feeds over the entire area. The plain titmouse and the black-throated gray warbler are the most common birds in the junipers themselves. We found the blue-gray gnatcatcher, so characteristic of the pinyon-juniper in much of the Upper Basin, to be very uncommon in the Brown's Park Area.

Clay Basin Station. As was previously stated, Clay Basin, lying to the north of Brown's Park, is about 1,000 feet higher in elevation than Green River and has an average elevation of about 6,400 feet. In this entire area there is relatively little exposed rock, canyons are shallow and the soil is well stabilized. The bottom of the basin, as well as the surrounding slopes, is covered with a uniform growth of desert shrubs with three-toothed sagebrush as the predominant plant. In the bottoms of the shallow canyons there are some small patches of greasewood. On higher slopes and hills surrounding the basin there are a few junipers and pinyons, especially toward the west and south, but many of the surrounding mountains appear at a distance to be bald, owing to the absence of desert shrubs and trees and to the presence in their place of a number of grasses and low-growing herbs. In several of the surrounding draws there are small springs, and around these springs are groves of aspens and other mesic plants.

In general it may be said that the Clay Basin station is representative of a high semidesert type, intermediate in many ways between the lower deserts characteristic of the Uinta Basin and the higher plains of the extensive Green River Basin Province that occupy much of the southwestern Wyoming area. Around the springs aspens typical of montane forest occur in small groves, whereas desert shrubs are found at the same elevation on ridges and in valleys where the habitat is drier. The two principal types of communities, therefore, are the aspen groves bordering springs and the open desert shrubs.

Around the borders of the springs certain typically montane mammals are found such as the long-tailed vole (*Microtus longicaudus*), the vagrant shrew (*Sorex vagrans*), and the northern pocket gopher, although the latter species also occurs at lower elevations in Brown's Park and throughout the Uinta Basin. The deer mouse is very common both in aspen groves near water and in the open desert shrubs, and the western harvest mouse is also present. Pocket mice, grasshopper mice and kangaroo rats appear to be absent or at least uncommon. Of the larger mammals the white-tailed jack rabbit is common and perhaps most typical of the open desert shrub community. This animal also utilizes the aspen groves for cover, especially in winter. The pronghorn (*Antilocapra americana*) is present in both Clay Basin and Brown's Park and is apparently increasing in numbers in these areas. The mule deer winters in large number in juniper woodlands.

Among the birds the sage grouse (*Centrocercus urophasianus*) is undoubtedly the most characteristic species in the Clay Basin area. These birds require a habitat where there is ample water, particularly in the form of small springs and streams and where sagebrush-covered ridges are available for roosting and feeding. Other typical birds in the sagebrush community are the horned lark (especially in more

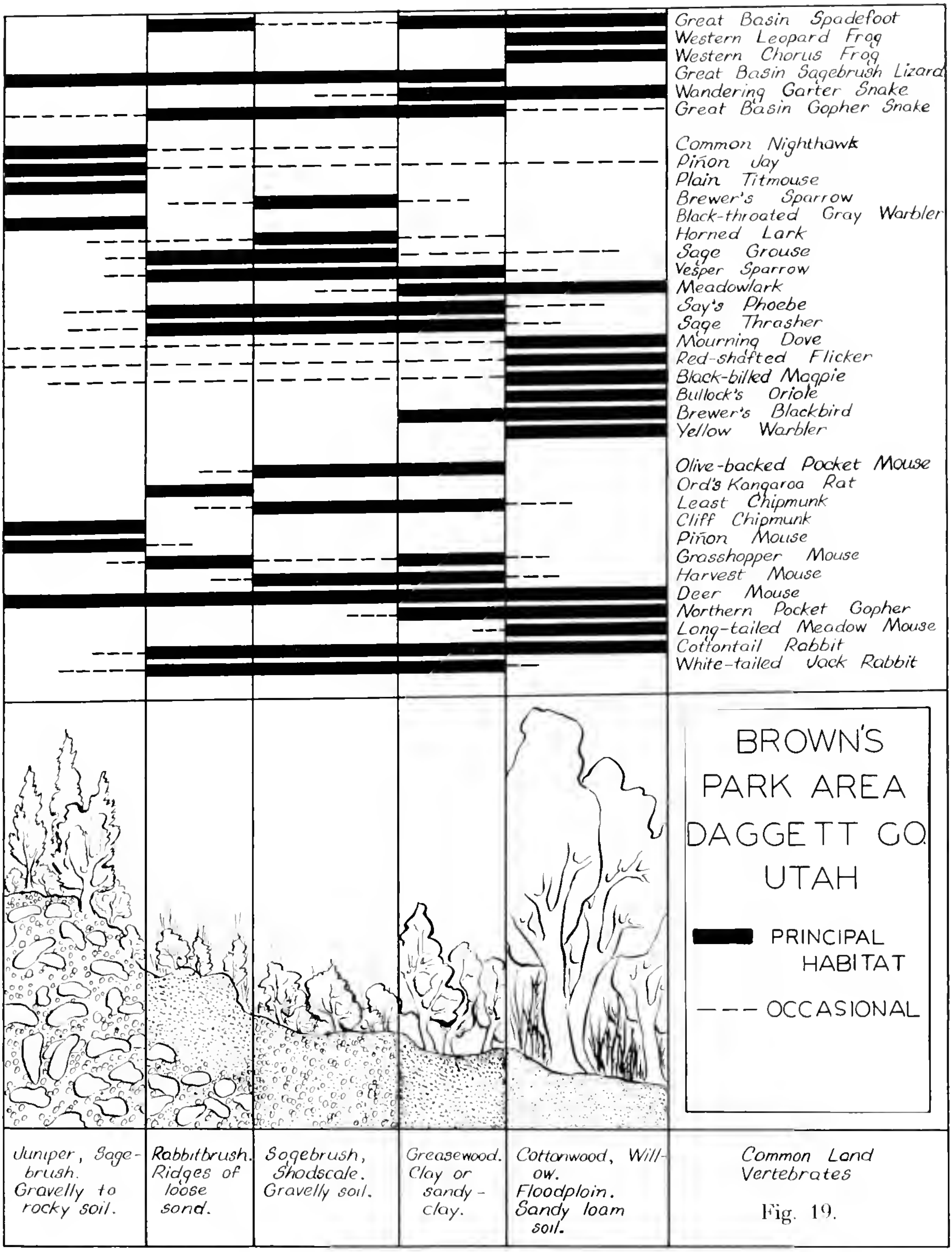

Great Basin Spadefoot
Western Leopard Frog
Western Chorus Frog
Great Basin Sagebrush Lizard
Wandering Garter Snake
Great Basin Gopher Snake
Common Nighthawk
Piñon Jay
Plain Titmouse
Brewer's Sparrow
Black-throated Gray Warbler
Horned Lark
Sage Grouse
Vesper Sparrow
Meadowlark
Say's Phoebe
Sage Thrasher
Mourning Dove
Red-shafted Flicker
Black-billed Magpie
Bullock's Oriole
Brewer's Blackbird
Yellow Warbler
Olive-backed Pocket Mouse
Ord's Kangaroo Rat
Least Chipmunk
Cliff Chipmunk
Piñon Mouse
Grasshopper Mouse
Harvest Mouse
Deer Mouse
Northern Pocket Gopher
Long-tailed Meadow Mouse
Cottontail Rabbit
White-tailed Jack Rabbit
BROWN'S PARK AREA DAGGETT CO. UTAH
PRINCIPAL HABITAT
OCCASIONAL
Juniper, Sagebrush. Gravelly to rocky soil.
Rabbitbrush. Ridges of loose sand.
Sagebrush, Shadscale. Gravelly soil.
Greasewood. Clay or sandy-clay.
Cottonwood, Willow. Floodplain. Sandy loam soil.
Common Land Vertebrates

Fig. 19.

open areas), green-tailed towhee, and chipping sparrow.

The amphibians and reptiles of the two stations in the Brown's Park-Clay Basin areas are not well known. Our field records indicate that on the sandy lowlands and floodplains the Great Basin spadefoot is common and can be seen hopping among the desert shrubs in the late evening during the summer.

Some of the reptiles which are common in the area east and south of Vernal, Uintah County, are not present in these higher valleys However, the sagebrush lizard and the Great Basin gopher snake are widely distributed throughout the valleys and into the surrounding mountains.

Westcn Uinta Basin Area

This area is composed of that part of the Uinta Basin which lies west of the Green River and is bordered on the north, west and south by the Uinta Mountains, Wasatch Mountains, and West Tavaputs Plateau, respectively. It contains the Strawberry, Duchesne, and Uinta Rivers, as well as some lesser streams that arise from the watershed of the Wasatch and Uinta Mountains. Owing to the fairly abundant water supply and to some good alluvial soils, much of the land in the western Uinta Basin is under cultivation and is one of the most populous areas within the entire Upper Colorado River Basin.

Three stations are selected for review at this time as representative of this portion of the basin; namely, the Jensen-Ouray area along the Green River floodplain, the Bluebell area on the benchlands south of the Uinta Mountains, and an area south of Myton.

Jensen-Ouray Station. In the vicinity of Ouray, near a point where the White and Duchesne Rivers join the Green, there are wide floodplains where Fremont cottonwoods are predominant. The soil in this area ranges from sand near the river to fine clay and in places is thrown up into low sandy ridges which are vegetated with greasewood and squaw-bush. In the depressions and flats saltgrass (*Distichlis stricta*) is abundant where the saline soil is periodically flooded by fresh water, and there are also extensive areas of tamarisk. (Fig. 4)

The town of Jensen is located on the west bank of the Green River. In this area much of the floodplain is occupied by farms. At a point a few miles south of Jensen where Ashley Creek joins the Green River there is a fairly large marshland, and a lesser one occurs at the mouth of Brush Creek. The montane vole (*Microtus montanus*) and the western harvest mouse live in grassy areas around these marshes, and the muskrat (*Ondatra zibethicus*) is reported to occur in this habitat, although there appear to be no published records. The Ashley Creek marshes in particular support one of the richest aquatic bird faunas to be found in the Upper Basin. These include many species of ducks and wading birds which have been reported by Twomey (1942). Bordering the river there are areas of loose sand where the Ord's kangaroo rat is common. On the wide grassy floodplains near Ouray the deer mouse is very abundant, and the northern pocket gopher is present on higher ridges that are not subject to periodic flooding.

Benchlands and low mesas that rise above the river floodplain are vegetated with a mixture of desert shrubs. This is the Mixed Desert Shrub Zone including several associations described in detail by Graham (1937: 66-70). Three-toothed sagebrush, rabbitbrush, greasewood (in lower areas), shadscale, gray molly (*Kochia vestita*), and *Tetradymia* are the more common shrubs represented. In the main the soil is rocky or gravelly, but there are also some low sand hills and rock ledges. Typical mammals are Ord's kangaroo rat (on sandy soil), white-tailed prairie dog, thirteen-lined ground squirrel, and white-tailed antelope squirrel. Both the white-tailed jack rabbit and the desert cottontail are present. The deer mouse is abundant in the desert shrub communities, and the golden mantled ground squirrel occurs fairly commonly along the floodplains as well as in the desert shrubs.

In the Jensen area birds are similar in kind to those previously described for the Upper Basin. In cottonwood groves and high shrub thickets along the river and its tributaries, the western kingbird, yellow warbler, Brewer's blackbird, mourning dove and red-shafted flicker are probably the most common. In the wide floodplains south of Ouray where there are ample nesting sites in dead but standing cottonwoods we found Lewis' woodpecker (*Asyndesmus lewis*) very common. The red-headed woodpecker (*Melanerpes erythrocephalus*) is a characteristic, although uncommon resident of this habitat. Other common birds inhabiting the floodplain community are the ash-throated flycatcher, Bullock's oriole, black-billed magpie, white-breasted nuthatch (*Sitta carolinensis*), yellow-breasted chat, warbling vireo, western meadowlark, robin, western wood pewee and lark sparrow. On one visit to this area we found flocks of turkey vultures roosting in the cottonwoods.

In the desert shrub community Say's phoebe, the lark sparrow, horned lark, western meadowlark, and sage thrasher are most common.

Bluebell Station. An area about seven miles northwest of the town of Roosevelt near the road to Bluebell is typical of higher benchlands that lie at the south base of the Uinta Mountains as well as the east base of the Wasatch. At this point there is a series of low brown sandstone ledges with rather flat intervening areas that rise one above another like steps. The soil on the flats is predominantly sandy, and there are places where the sand has drifted into low ridges. Two kinds of junipers (*Juniperus scopulorum* and *Juniperus utahensis*), along with a few pinyon pines, form the predominant vegetation, but the trees are somewhat scattered and between them are desert shrubs consisting of three-toothed sagebrush, rabbitbrush, joint fir, shadscale and *Tetradymia*. This area has been intensely grazed, and as a result, prickly pear (*Opuntia*) has become established to the extent that in places it forms a nearly solid mat over the surface of the ground. There are a few grasses of which galleta grass and Indian rice grass are the most common.

Since there is more or less a mixture of the desert shrub and pinyon-juniper woodland it is impractical to separate communities on the basis of vegetation types. The rocky ledges form a somewhat distinct habitat where the piñon mouse is abundant and characteristic, and there are also a few yellow-bellied marmots (*Marmota flaviventris*), white-tailed antelope squirrels, and cliff chipmunks. The rock wren is the most characteristic bird.

Sandy, pinyon-juniper-desert shrub communities support a high population of small rodents. The deer mouse is very abundant and the Great Basin pocket mouse is not uncommon. Other species present include Ord's kangaroo rat, western harvest mouse, northern pocket gopher, least chipmunk, and thirteen-lined ground squirrel. There are also some white-tailed jack rabbits and desert cottontails.

Birds of this area are typical of the pinyon-juniper woodland elsewhere in the Upper Basin. The plain titmouse, black-throated gray warbler, blue-gray gnatcatcher and piñon jay are all common.

Myton Station. An area about five miles south of the town of Myton is typical of extensive flat or rolling country that occupies much of the lower benchlands of the western Uinta Basin. In these areas the soil is gravelly or sometimes sandy and the vegetation is of the desert shrub type with shadscale and *Tetradymia spinescens* being predominant plants. Graham (1937) refers to this type of vegetation as the Atriplex-Tetradymia Association. The most common small rodent is the deer mouse, but the Great Basin pocket mouse, western harvest mouse, Ord's kangaroo rat, and thirteen-lined ground squirrel are present. Perhaps the most characteristic mammal of this type of community is the white-tailed prairie dog. This animal lives in colonies in the most colorless and barren flats where it would seem that very little food is available to them.

Birds are very limited in kind as well as number on these flat desertlands. The most abundant and typical one, however, is the horned lark.

The stations considered in the western Uinta Basin are similar enough that the amphibians and repitles of the three stations are considered as one unit.

Extensive irrigation of the broad valleys and benchlands has created numerous marshes and water habitats throughout much of this vast area. As a result, the western chorus frog is abundant. The Rocky Mountain toad and the western leopard frog are also common inhabitants.

In the lower eastern part of this area on the rock-strewn hillsides and ledges one encounters the northern plateau lizard and the cliff uta. On the higher benchlands which extend generally to the west and north these species disappear, while the sagebrush lizard, northern side-blotched lizard, northern whiptail, and mountain short-horned lizard become the common lizards of this western portion of the Uinta Basin.

By far the most common snake in this area is the Great Basin gopher snake. Other species such as the desert striped whipsnake, wandering garter snake, Utah milk snake, and midget faded rattlesnake are common, although more abundant in local habitats. In and near the thickets along the rivers and irrigation canals is the western blue racer (*Coluber constrictor mormon*). Although this species is not commonly seen, owing perhaps to its habit of staying close to cover, records indicate that it too is widely distributed in the western Uinta Basin. Along the foothills and in the canyons which drain into the basin from the north and west, we have taken both the Rocky Mountain rubber boa (*Charina bottea utahensis*) and the western smooth green snake.

Green River Basin Province

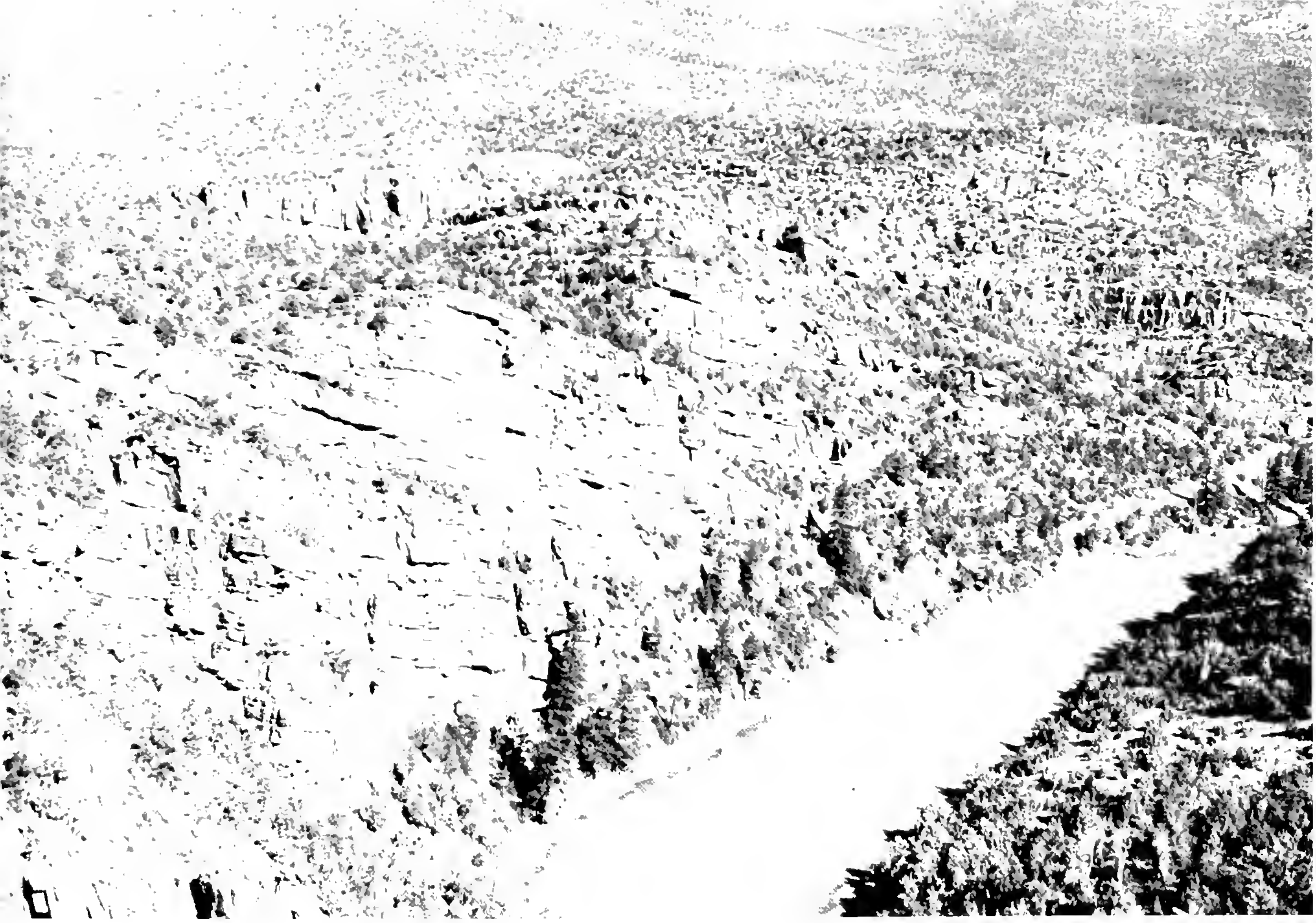
Topographical features of the Green River Basin Province have been described elsewhere in this report. We have not studied this province as intensively as we have the other two provinces of the Upper Basin, and our descriptions must be more general, especially with respect to the birds. Three areas within the province will be considered; namely, the Fort Bridger Area, the Kemmerer-Cumberland Area, and the Manila Area.

Fort Bridger Area

The town of Fort Bridger, Wyoming, lies in the valley of Black's Fork, which drains a part of the north side of the Uinta Mountains and eventually flows into the Green River. The valley contains much rich agricultural land where hay is the principal crop. In this area the floodplain soils are well stabilized for the most part and the border of the stream itself is wooded with cottonwoods, willows, and a few conifers. On either side of the stream valley the land rises abruptly and then extends for many miles as flat or rolling country where

Fig. 20. Green River at the Flaming Gorge damsite, Daggett County, Utah. Note the narrow floodplain in this area. A mixture of pinyon-juniper and yellow pine forms the predominant vegetation on the slopes and ledges rising from the river.

Fig. 21. Typical Canyon Country in the vicinity of Dead Horse Point, Grand County, looking southward into the Canyon country of the Colorado River Province. In the foreground and middle distance are the horizontal sandstone formations with their precipitous and barren walls and flat, sparsely vegetated mesa tops. In the distance are the intrusive Abajo Mountains and the Elk Ridge. Frequently bordering the river is a narrow floodplain where tamarisk and willows are the predominant plants. Occasional clumps of cottonwood also are found.



sagebrush, rabbitbrush, and shadscale form the predominant vegetation.

Only a limited amount of collecting and observations has been made by us in the Fort Bridger Area. In the floodplain habitat adjacent to the stream the muskrat is common and the beaver (*Castor canadensis*) occurs. Of the smaller rodents, the deer mouse is again the most common but the montane vole is also abundant, and there are a few western jumping mice (*Zapus princeps*) in the grassy meadows. The last-named species is indicative of the closer relationship of these more elevated communities of the Upper Basin to the montane forest, and this relationship is still further indicated by the presence of the red squirrel (*Tamiasciurus hudsonicus*) and the northern pocket gopher.

The most characteristic mammal of the plains adjacent to the river valley is Richardson's ground squirrel (*Citellus richardsonii*). This species naturally occurs also in the river valley, but poisoning activities by ranchers have tended to reduce their number in that habitat. Colonies of the white-tailed prairie dog are scattered over the plain, and the white-tailed jack rabbit is abundant.

Kemmerer-Cumberland Area

An area some fifteen miles south of the town of Kemmerer in the vicinity of the old and abandoned townsite of Cumberland is typical of much of the plains country of the Green River Province. In this area there is a series of low hills or ridges running mainly in a north-south direction with shallow intervening valleys that frequently contain deep erosional washes. The soil is predominantly gray clay or sand and clay with a mixture of fine gravel in places. There are also a few outcroppings of sedimentary rocks which bear record of the rich coal deposits of the general area.

The vegetation of the area is one of the desert-shrub type. In the bottoms of the draws and valleys greasewood and three-toothed sagebrush constitute the predominant vegetation while in more disturbed areas along roadways and elsewhere rabbitbrush is abundant. On higher ridges and hilltops two or three species of shadscale and *Tetradymia* form a sparse vegetation cover. There are no junipers or other trees in this area.

Our present knowldege of this area is limited to the small rodents. The deer mouse was found by us to be more abundant here than in any other place in the Upper Basin. The Great Basin pocket mouse is also very common as well as the least chipmunk. Less common species include the sagebrush vole (*Lagurus curtatus*), northern grasshopper mouse, and the northern pocket gopher. Of the larger rodents Richardson's ground squirrel, white-tailed prairie dog, and white-tailed jack rabbit are also common.

In the marshes along the Green River and its tributaries are large populations of the western chorus frog. In late May and June this frog has been heard calling along the marshes from Kemmerer to Green River City. Less common are the western leopard frog and the Rocky Mountain toad.

Reptiles in this area, and in fact throughout this entire province, are sparse. Perhaps the most common species are the sagebrush lizard, eastern short-horned lizard (*Phrynosoma d. brevirostris*), Great Basin gopher snake and, along the streams and marshes, the wandering garter snake.

Manila-Linwood Area

An area south of Manila, Daggett County, Utah, is typical of the southern part of the Green River Basin. It lies at the north foothills of the Uinta Mountains and is more or less continuous with the desert shrub plains that extend northward into Wyoming. This continuity in interrupted a few miles north of the base of the mountains by a series of badland formations that are not exceeded in barrenness by any such formations in any other area of the Upper Basin. The influence of the Uinta Mountain anticline is here indicated by beds of rock that are tilted and have eroded in such a manner as to leave exposed a series of rocky ledges.

The higher benchlands that lie near the mountains are wooded with a pinyon-juniper forest while the plains extending to the northward are vegetated with desert shrubs. On the lower benches and slopes three-toothed sagebrush forms the predominant vegetation while in the lower valley there is a mixture of greasewood, sagebrush, and shadscale. (Fig. 11 and 20)

Svihla (1931 and 1932) has published two papers dealing with the mammals in and adjacent to the Manila-Linwood Area. Our own observations indicate that of the small rodents the deer mouse is typically the most abundant mammal in both the desert shrub and pinyon-juniper community. The Great Basin pocket mouse is also very common in this community, and there are fairly large numbers of the least chipmunk. Colonies of white-tailed prairie dogs occur in this area and the white-tailed jack rabbit is common.

Our field work has not included a study of the pinyon-juniper woodland and its associated rocky ledges, but Svihla (*op. cit.*) found the cliff chipmunk, cañon mouse, brush mouse and bushy-tailed woodrat to be common.

Our bird records from the Manila area are very incomplete. The mourning dove occurs in abundance throughout the summer both in the pinyon-juniper and plains areas. The poorwill is another fairly common species, and the common nighthawk is also present.

VII. THE LARGER MAMMALS OF THE UPPER COLORADO RIVER BASIN

The previous discussions on the biotic communities of the desert lands of the Upper Colorado River Basin have dealt in the main with the smaller mammals, the ranges and ecological adaptions of which are more limited. In addition there are the larger ungulate, predatory and furbearing mammals that range widely through the Upper Basin and are often less limited by local ecological factors.

Our knowledge is, in many cases, limited to signs, or reports from local residents and trappers rather than from direct observations. The Fish and Game Departments of the states of Utah, Colorado, and Wyoming have been most helpful in furnishing us with information relative to the larger game animals.

It is difficult to compare the populations of these larger mammals today with the conditions that prevailed prior to the exploration and settlements of the white man. The observations of Powell (1875) during his first exploration of the Green and Colorado Rivers in 1869-70 are of some value since he covered much of the Upper Basin and made a few notes, especially on the large mammals, as he went along. However, his observations were limited to the close proximity of the waterway. He and his men climbed the walls of the canyon to gain a better view of the surrounding country. Limitation of game close to the streams is indicated by the fact that even though Powell's party lost much of their food supply through accidents and spoilage and often felt the pinch of hunger, they were able to obtain fresh meat on only a few occasions.

During Powell's second expedition of 1871-72 a number of his men kept extensive diaries. These included the writings of Stephen V. Jones, John F. Steward, W. C. Powell, and Frederick S. Dellenbaugh. (See *Utah Historical Quarterly*, Vols. XVI-XVII, 1948, 1949, and Dellenbaugh, 1902). Game was taken for food at every opportunity, or at least efforts were made to obtain it, and this was usually mentioned in the diaries. Very few observations were recorded for smaller mammals. Perusal of these records indicates a general pattern of the distribution of the larger animals along the course of the principal streams.

Beaver
Castor canadensis

Prior to the coming of the white trapper the beaver was widespread along the Green, Grand, and Colorado rivers and their tributaries. We are aware of this from the activities of the early trappers such as Ashley, Bridger, and Provost (Provot) especially in the Green River Valley of southwestern Wyoming and northeastern Utah around the year 1825. These trappers, along with many others, had a rendezvous at a point on the Green River near the entrance to Flaming Gorge and another at Brown's Park. The latter area especially was an important trading post for beaver furs in those early days.

The canyon country of the Green and Colorado was apparently not visited to any extent by the early trappers, but Powell and his men record the beaver from several points along the way, and early records from Mormon and other explorers indicate their presence in that area as well.

Activities of the early trappers greatly reduced the numbers of beaver and in places eliminated them entirely. However, protective laws of the several states in the past several decades, as well as restoration programs, have permitted them to return, and they are now again widespread throughout the entire Upper Basin. Along the main course of the Green and Colorado Rivers we have noted the animals or their signs at nearly every point we have visited. They often fell large cottonwood trees along the floodplains, but they seem to feed principally on willows.

Porcupine
Erethizon dorsatum

The porcupine is an important large rodent throughout the entire Upper Basin. In recent years its numbers seem to have increased considerably. In the desertlands it is probably most abundant in the pinyon-juniper woodlands where it feeds extensively on the pinyon pine. However, the animal is by no means confined to this habitat but also frequents the floodplains along the waterways and is often found even in more open desert types, especially in the canyon lands. The pinyon-juniper forests in the Flaming Gorge area showed about an 85% damage.

Coyote
Canis latrans

The coyote was formerly widespread and common throughout the Upper Basin. In our earlier trips into the area we frequently saw or heard the animals, but we have rarely encountered them the last few years. Presumably the determined efforts of livestock men and government trappers and the modern means of extermination have reduced their numbers effectively.

Gray Wolf
Canis lupus

Young and Goldman (1944) indicate that the wolf formerly ranged throughout the Upper Basin. Powell (1875) records wolves among herds of antelope near what is now Jensen in the Uinta Basin. In reference to "wolves" in the later writings of other members of Powell's second party it seems doubtful whether the animals actually seen were wolves or coyotes. At any rate it is doubtful if any wolves occur in the Upper Basin today unless it is in the extreme northern part.

Red Fox
Vulpes fulva

According to Durrant (1952) the red fox is not a common animal in the Utah portion of the Upper Basin at least. It appears to be more common southward in the basin where he recorded it near Henrieville and Blanding. Indications are that it is continually being reduced in numbers. We have not encountered the animal directly in our studies.

Gray Fox
Urocyon cinereoargenteus

This fox inhabits the Upper Colorado River Basin at least as far north as the Uinta Mountains. It seems to be more common than the red fox. Considerable numbers are taken each year by trappers. Two specimens from Garfield County, taken near Boulder, are in the Brigham Young University collection. Fox tracks have been noted at nearly all of our stations in the Upper Basin in suitable habitats. This fox commonly inhabits the more rugged foothill and canyon country rather than the open plains.

Black Bear and Grizzly Bear
Ursus americanus and *Ursus horribilis*

Available information indicates that both the black and grizzly bears formerly inhabited the mountains and high plateaus of the Upper Basin in considerable numbers. It is doubtful if they visited the desertlands and lower river valleys to any extent. The grizzly bear has now been eliminated from most of the Upper Basin. The black bear still remains in small numbers at higher elevations.

Ringtail
Bassariscus astutus

The ringtail, or "ring-tailed cat" as it is sometimes called, apparently inhabits the canyons and more rugged country of the desertlands of the Upper Basin at least as far north as the Uinta Basin. We have not had direct contact with the animal in our field work but trappers and local residents consider it to be fairly common. Durrant (1952, 411-413) recognized two subspecies from the area and includes several records from Kane, San Juan, Emery, Duchesne, and Uintah Counties.

Mustelid Mammals

Several species of mustelids occur irregularly but consistently throughout the Upper Colorado Basin. The long-tailed weasel (*Mustela frenata*) is more common in the mountains and high plateaus but also occurs along the waterways at lower elevations. The ermine (*Mustela erminea*) was collected a few miles south of Manila in Daggett County by one of our parties. The black-footed ferret (*Mustela nigripes*) is recorded by Durrant (1952) from San Juan County. He states that the animal preys upon prairie dogs and is often associated with their colonies. The mink (*Mustela vison*) is fairly common along the tributaries of the Upper Green river especially, but in the more southern portion of its range it is apparently confined mostly to the high plateaus and mountains. Throughout the Upper Basin the badger (*Taxidea taxus*) is present in small numbers especially in areas where there are squirrels and pocket gophers. Powell's parties mention seeing the animals on several occasions along the course of the Green and Colorado Rivers. However, very few actual collections have been recorded from the Upper Basin.

The western spotted skunk (*Spilogale gracilis*) and striped skunk (*Mephitis mephitis*) both inhabit the Upper Basin. The spotted skunk has been recorded at scattered localities of the area both in Utah and Colorado. It seems to be less common farther north. A record is available for Sheep Creek, Daggett County, Utah (Svihla; 1931:259), but we have no other recard from the Green River Province. However, it has been recorded from southwestern Montana (Jellison, *Jour. Mammalogy*, 12:314, 1931) which would indicate that it might occur throughout the Green River Province. The striped skunk is also found throughout the Upper Basin. Our field experience with these animals is not sufficient to indicate their ecological relations although at present they seem to be more common near settlements or farming communities.

The river otter (*Lutra canadensis*) occurred formerly along the main streams of the Upper Basin. This statement is based on a few scattered records that are available. Members of Powell's second Colorado River expedition (1871) reported otters south of Green River, Wyoming; Durrant (1952) has published a record from near Ouray, Uintah County, and Gregory (1931) refers to a record from Glen Canyon, San Juan County, Utah.

Mountain Lion
Felis concolor

This animal ranges throughout the entire Upper Basin in suitable habitats. It seems to be more abundant in wooded areas at higher elevations, and in the desertlands of the basin it occurs particularly in more rugged country where pinyon-juniper woodlands predominate.

Lynx and Bobcat
Lynx canadensis and *Lynx rufus*

Both the lynx and bobcat inhabit the Upper Basin area although the former seems to be confined to the montane forests at higher elevations and is much less common than the bobcat (Durrant, 1952:444). Since size is not a reliable criterion for separating the two, there seems to be considerable confusion in the reports of their occurrence. Insofar as the desertlands are concerned the bodcat is far more important than the lynx. Judging from the numbers killed by trappers bobcats are more abundant than is commonly suspected. They live in the more rugged areas or along streams where pinyon-juniper forests or other taller vegetation predominates.

Wapiti or "elk"
Cervus canadensis

The wapiti was indigenous to the Upper Basin area but was probably confined mainly to the higher mountain parks and upper parts of the drainage systems. Members of Powell's parties found it in the Uinta Mountains (Red Canyon and Red Lake) and on the Tavaputs Plateau. Gregory (1950) states that it formerly occurred in the Paria Valley of Kane County. The name "Paria" is interpreted as meaning "elk" in the Paiute language. It was likewise common in the higher valleys of the Upper Green River in Wyoming and in the Upper Colorado drainage of Colorado.

Although natural populations of elk were greatly reduced following the settlement by the white man, in recent years they have been reintroduced in many areas and have increased considerably. The Wyoming Game and Fish Commission estimates that there are about 3,300 head in the Upper Green River drainage. The Game and Fish Commission of Colorado reports large herds in the upper drainage of the Yampa and White Rivers. The upper White River drainage served as one of the last important refuges of the Colorado herds (Swift, 1945: 118), and a large herd exists there today. According to Swift the Yampa River drainage "was famous as an elk country in the early days, one estimate for 1880 being 20,000." Apparently some native elk were able to survive in the Colorado, Gunnison, Dolores and San Juan drainages (Swift, 1945:117) and have since been supplemented by introductions from other areas.

In Utah the State Department of Fish and Game has published data on elk for 1957. In the Ashley National Forest west and south of the Green River in Daggett County there were estimated to be about 300 animals. In the Brown's Park Area there were about 140 animals. About 460 elk were estimated for the Ashley National Forest in Uintah County. No herds are reported for the southern part of the Upper Basin in Utah.

The Mule Deer
Odocoileus hemionus

The mule deer was formerly distributed in suitable habitats throughout the Upper Basin. Powell's parties record deer among the willows and on the sagebrush plains at various points along the Green River as far south as the junction of the Green and Duchesne. At the present time deer still occur commonly even in summer on the floodplains at Brown's Park, the Ouray area and other points along the Green and its tributaries. Farther south in the Upper Basin the animals apparently were confined in summer to the higher plateaus and mountains but moved down in winter into the pinyon-juniper woodlands as they do today. No records of deer were made by the Powell parties in the canyon country. Since the men were low on rations it seems likely that deer would have been killed or at least mentioned if any had been noted along the floodplains in this area. However, deer may have extended down into the canyons during the winter in the early days as they do at the present time.

At present deer are widely distributed in suitable habitats throughout the Upper Basin except in the Navajo Mountain Area. Their principal impact upon the desertlands of the basin is in the pinyon-juniper woodlands or foothill brushland, which they use as winter range. Undoubtedly these animals are now far more abundant over most of their range than they were before the coming of the white man. In fact they are so abundant that their winter range in particular is being gradually depleted and special hunts are being organized to control their numbers.

Pronghorn
Antilocapra americana

A number of scattered reports indicate that the pronghorn or "prong-horned antelope" was present throughout the Upper Basin prior to the advent of the white man. Indications are, however, that it was much more abundant in the northern part of the basin (Uinta and Green River Provinces) than it was southward. Powell's parties reported herds on the plains south of Green River, Wyoming, and again in the Uinta Basin (Wonsits). They were also reported early in the San Rafael and Escalante Basin areas (Tanner, 1940:104), Moab and La-Sal Mountains area (Barnes, 1927:169), and Bryce Canyon area (Presnall, 1938:20). Pioneer settlers in Rabbit Valley, Wayne County, report their presence there in early days.

Aside from the excessive hunting of the animals by white men, competition with live stock, especially sheep, for the winter range may have been partly responsible for the near extermination of the pronghorn. Protection and restoration measures have resulted in their come-back within the last decade. In places they are again becoming abundant enough to permit limited hunting. This is particularly true in the northern part of the basin. The Wyoming Game and Fish Commission (Letter from T. C. Baker, April 29, 1958) estimates that there are now some 7,000 pronghorns in the Green River drainage of that state. The Game and Fish Commission of Colorado (Letter from R. N. Denney, June 10, 1958) estimate about 1,500 animals in the Yampa and White River drainages of that state.

In the Utah portion of the Upper Basin

small herds resulting from migration of plants are found in Daggett County, Uintah County, Grand County, and the San Rafael area. (Utah Big Game Report, Utah State Department of Fish and Game, 1957). The Daggett County herd is the largest. In the Bonanza, Uintah County, area the maximum herd estimate is 250 animals.

Eighteen head of antelope were seen in Grand County near the Colorado line in 1951 but have not been reported since. The San Rafael herd is supposed to number about 500 head. These animals have come from a nucleus of native animals and some transplants from Daggett County.

Bison
Bison bison

Information relative to the occurrence of the bison in the intermountain area recently has been compiled and reviewed by Roe (1951: 257-282). There were many conflicting reports by the early explorers and fur traders. It seems evident, however, that the animals were never as abundant west of the Colorado Rocky Mountains as they were on the Great Plains. In the Upper Colorado River Basin they were probably most numerous in the Green River Valley. Fremont (1846) writes that about 1824 ". . . the buffalo were spread in immense numbers over the Green and Bear River valleys. . ." He apparently obtained his information from Mr. Fitzpatrick who was an early fur trader. The Ashley and Smith party traveling along the Yampa River and along the Green River in southern Wyoming noted an abundance of game, including buffalo, in 1825 (Dale, 1918).

Fremont also refers to buffalo along the Yampa, White and Grand Rivers and notes that they extended as far westward as the mouth of the White River. Father Escalante and his party recorded killing a bison September 13, 1776, at a point near where he crossed the Green River. This is close to the present town of Jensen. (Durrant, 1952:11).

The bison had mostly disappeared from the Upper Basin before the Mormon pioneers arrived. Several later reports are available from the writings of Allen (1876). He reported that Stansbury found them on the Upper Yampa in 1849. Allen also reported that a solitary bull was seen near Fort Bridger in 1875 which was the first animal seen in that area for thirty years. One of the last specimens in the Green River area was supposed to have been shot on Henry's Fork in 1844.

We have not been able to find any authentic records of indigenous buffalo in the southern part of the Upper Basin.

A few small herds of introduced animals are now living in the Upper Basin. There is a small herd at Colorado National Monument west of Grand Junction. T. C. Baker of the Wyoming Game and Fish Commission reports (Letter, April 29, 1958) that there are no bison in the Green River drainage at the present time except privately owned animals. In Utah there is at the present time a small herd in the Hanksville-Henry Mountains area. Twenty-three animals were released in the Robber's Roost area in 1941 and 1942. By 1957 these had increased to about 43 animals which summer an the Henry Mountains and winter on the Burr Desert. Ten hunting permits were issued in 1950 and 10 animals were killed.

According to Gregory (1950) bison were introduced into the House Rock Valley in 1895 but we have no further information about the herd.

Mountain Sheep
Ovis canadnsis

It is evident from numerous records that mountain sheep were formerly common in the rugged country all along the Green and Colorado Rivers and their large tributaries. Powell's parties made several references to them and occasionally used them for food. The Wyoming Game and Fish Commission estimates that there are now about 300 sheep in the Green River drainage. The Colorado Game and Fish Commission estimate that there are about 400 animals in the Yampa and White River areas. In Utah there are scattered reports from the Uinta Mountains, White Canyon and Hite. Unverified records are available for eastern Grand and San Juan Counties. Older records are available for Dark Canyon southeast base of Kaiparowits Plateau and the Grand Gulch Plateau (Gregory 1931 and 1938). Hunt (1953) also reports sheep from the Henry Mountains (Mt. Holmes and Mt. Ellsworth) and states that they were formerly common on Mt. Ellen and throughout the canyons.

VIII. FAUNAL RELATIONS OF THE UPPER COLORADO RIVER BASIN

A number of systems have been used to analyze the fauna of a given area in the light of their geographic distribution and their relationships to the faunas of surrounding areas. The tendency has been to set up faunal areas which are defined in terms of geographic or topographic factors and the animals that are known to be limited in distribution by these factors. Such systems have been utilized locally by Hall (1946) for Nevada, Davis (1939) for Idaho, Durrant (1952) for Utah, and more particularly Kelson (1951) for the Colorado River drainage. All of these systems are based on mammals alone and are not supposed necessarily to apply to other animals. In the proposals mentioned above each state or region under consideration is divided into faunal areas of large dimension which are in turn subdivided into provinces and subcenters. All of these areas are indicated on maps where it becomes necessary to define their limits by definite lines.

Although these faunistic systems have considerable usefulness when dealing with one group of animals, they tend to break down when applied to animals as a whole, and one must seek a more flexible system for dealing with the problem. As has been previously pointed out in this report, *the distribution of any particular kind of animal depends upon a complex set of factors which are both geographic and ecologic.* It soon becomes apparent to the field investigator that *it is necessary to consider each kind of animal in the light of its own distributional peculiarity and that variation rather than identity is the rule when it comes to a consideration of the geographical relations of a group of animals.* Unfortunately, neither space nor knowledge are sufficent to evaluate here the geological history of the animals of the Upper Basin. Our knowledge of their ecologic limitation is also incomplete. Our analysis of the general faunal relationships of the area must be based, therefore, mainly upon our knowledge of their present-day occurrence as populations within the Upper Basin and surrounding country. Furthermore, our knowledge at the present writing is based entirely upon the land vertebrates since our collections of the invertebrates are still far from complete or have not been sufficiently studied to allow conclusive results to be given.

With respect to the land vertebrates we now have sufficient information from our own observations and those of others to give us a fairly clear picture of the faunal relations of this group within the desertlands of the Upper Basin. However, even with this relatively limited group of animals the innate and environmental factors that control their distribution are so variable as to make the mapping of faunal areas or provinces quite impractical. In consequence of this we have chosen to utilize the system of Dunn (1931) and of Mayr (1946) proposed by them to deal with the faunal relations of reptiles and birds respectively. Although their proposals were applied on a continental and intercontinental scale and were based in part upon paleontological information, we find them to be helpful tools when used on a much smaller scale and when based purely upon recent zoogeographical knowledge.

In analyzing the fauna of a given region Dunn and Mayr used the term "element" in referring to the several components that make up the fauna. When the vertebrate fauna of the Upper Basin is considered, it becomes apparent that it also is composed of elements that have their principal areas of distribution in surrounding territory. This is particularly evident with the mammals and reptiles but applies also to the birds in a lesser degree.

Before the several groups of land vertebrates are considered, it is desirable to review once more certain topographical features of the Upper Basin that bear upon the elements of its fauna. On the west the Wasatch Mountains and high plateaus of Utah and the continuation of the highland into Idaho appear to separate effectively several typically Great Basin elements, particularly mammals and reptiles, from the Colorado Basin and vice versa. On the east the wide chain of the Colorado Rocky Mountains performs a similar function in separating the Colorado Basin from the Great Plains, yet there is a certain amount of ingress, particularly of the northern Great Plains fauna via the relatively low Continental Divide in Wyoming. The northward extent of the Upper Basin Fauna is limited in part by the high Windriver and Wyoming Ranges and in part by the gradual rise in altitude northward toward these ranges. Southward the boundary of the Upper Basin is less well defined and merges gradually with the Lower Colorado Basin as the elevation becomes lower. This latter situation is well illustrated by the strong element of southern fauna that enters the Upper Basin and penetrates northward in varying degrees.

Within the confines of the Upper Basin itself certain highlands have their influence upon the distribution of its desert fauna. Especially notable among these are the Uinta Mountains, the Tavaputs Plateau and the Abajo Mountains and Sage Plain highlands, all of which more or less extend across the Upper Basin in an east-west direction. The Green and Colorado Rivers and their major tributaries are at the same time barriers and lanes of ingress into the Upper Colorado Basin. Certain mammals and reptiles seem to be effectively stopped by their wide channels and deep canyons while other land vertebrates, particularly birds, are able to penetrate farther into the Basin owing to the relatively low base level of their streambeds and the favorable water supply and concomitant streamside vegetative cover made available through an otherwise desert land. Furthermore, in the case of birds the principal river system seems to furnish a convenient migratory passageway for both land and water birds through an otherwise inhospitable land.

In the present report it will be necessary to limit our remarks on the faunal relations of the land vertebrates of the Upper Basin to relatively typical examples, and, in the main, to confine our observation to the species level. It is anticipated that in future papers on the several groups of animals it will be possible to deal with the faunal relations of the subspecies. It should be further pointed out once more that our present writing is concerned with the desert fauna only and does not account for the animals of the somewhat isolated mountain ranges and high plateaus of the area, which in and of themselves present an interesting and complex problem.

Elements of the Bird Fauna of the Upper Colorado Basin

The bird fauna of the Upper Basin may be analyzed from a number of aspects. Such factors as winter vs. summer resident populations, transient populations and their routes of transition, and penetration of species belonging primarily to surrounding areas into the Basin all are interesting problems and add to the complexity of the analysis. It is not proposed at this writing to consider all of the bird species known to occur in the Upper Basin, but to use certain examples which serve to illustrate the several elements that enter into the total annual picture of the avian fauna.

Summer Resident and Breeding Elements.

1. *The Cosmopolitan Element.* This is the largest element of the summer populations and includes species that are widespread in Northern Desert communities, wherever these occur in the west. It includes two groups; namely, those species that are truly desert or prairie such as the burrowing owl, poor-will, Say's phoebe, horned lark, pinyon jay, sage thrasher, loggerhead shrike, vesper sparrow, and black-throated sparrow, and those that inhabit streamside groves and thickets such as the mourning dove, western kingbird, western wood pewee, house wren, catbird, warbling vireo, yellow warbler, yellow-breasted chat, Brewer's blackbird, song sparrow and a great host of others.
2. *The Southern Element.* This includes an interesting group of species that are more typically southern in distribution but penetrate northward in the Upper Basin, apparently along the warmer waterways. Typical among these are the spotted owl, Gambel's quail, mocking bird, Cassin's kingbird, Bendire's thrasher, Lucy's warbler, Grace's warbler, Scott's oriole, and the blue grosbeak.
3. *The Eastern or Great Plains Element.* A small number of species belonging to this element enter the Upper Basin, especially in its northern part. Their breeding status is at present uncertain although their presence during the breeding season would indicate that they will eventually be found nesting. They include the red-headed woodpecker, brown thrasher, red-eyed vireo, and lark bunting. The northern redstart and columbian sharp-tailed grouse may also be included in this group although their distribution is in general more northern than eastern.
4. *The Transient Element.* This includes a long list of species that pass through the Upper Basin during migration and breed in more northerly areas or in the mountains within and adjacent to the basin. These birds appear to follow along the main water courses and the floodplain vegetation associated with them. The list includes almost all of the shorebirds known to migrate through the intermountain region as well as several species of waterbirds. Certain small birds such as the pileolated warbler, northern waterthrush, Townsend's warbler, Nashville warbler, orange-crowned warbler, and western tanager are good examples of these transients.
5. *The Winter Element.* Aside from the permanent residents of the Upper Basin that are included in the cosmopolitan element, several important species of birds inhabit the area only during the winter. Relatively less is known about this element. Of the smaller birds the several kinds of juncos are perhaps the most widespread and common winter birds. The slate-colored, Oregon, and gray-headed juncos have been recorded. Also included are Harris' sparrow, white-crowned sparrow, tree sparrow, Lapland longspur, common redpoll, snow bunting and several kinds of horned larks.

Elements of the Mammal Population of the Upper Colorado Basin

Considering the mammal population of the deserts of the Upper Basin on the species level it will be seen that there are several faunal elements:

1. *The Cosmopolitan Element.* This includes a large number of species that are common to Northern Desert Shrub communities in general and occur throughout most of the Upper Basin. These include such common species as the deer mouse, canyon mouse, piñon mouse, northern grasshopper mouse, western harvest mouse, Ord's kangaroo rat, spotted skunk, desert cottontail and several kinds of bats. Other common desert species such as the black-tailed jack rabbit and the white-tailed antelope squirrel are also widespread although not recorded for the northern part of the basin.
2. *The Southern Element.* The absence of effective barriers along the southern boundary of the Upper Basin has permitted the extension of a number of typically southern species into the area. These include the spotted ground squirrel, rock squirrel, cliff chipmunk (south

and west), Botta's pocket gopher, silky pocket mouse, Apache pocket mouse (south and east), rock pocket mouse, brush mouse, rock mouse, white-throated wood rat, Stephens' wood rat, Mexican wood rat, and ringtail.

3. *The Great Basin Element.* Although the highlands of central Utah seem to bar several typically Great Basin species of mammals from the Upper Basin, three species of pocket mice are found in that part of the basin west of the Colorado and Green Rivers; namely, the Great Basin pocket mouse, little pocket mouse (mostly), and long-tailed pocket mouse.
4. *The Northern and Eastern Great Plains Element.* A small though important element of the Upper Basin, particularly in the northern part, is a few species that are typical of the Great Plains areas to the east and north. These are Richardson's ground squirrel, thirteen-lined ground squirrel, olive-backed pocket mouse, and white-tailed jack rabbit.
5. *The Endemic Element.* There seem to be no species of mammals that are endemic in the Upper Basin. The white-tailed prairie dog and its near relative Gunnison's prairie dog seem to be more nearly confined to the Upper Basin than any other species of mammals.

Elements of the Amphibian and Reptile Populations of the Upper Basin

1. *The Cosmopolitan Element.* The species of this element comprise the larger number and also the ones found more commonly throughout the entire basin. Such amphibians as the Great Basin spadefoot, Rocky Mountain toad and the western leopard frog belong to this element. The following reptile species also belong here: northern side-blotched lizard, northern plateau lizard, sagebrush lizard, northern whiptail, desert striped whipsnake, Great Basin gopher snake, and midget faded rattlesnake.
2. *The Southern Element.* Species in this group are those which have a typically southern distribution and enter the Upper Basin primarily in the lower warmer habitats near the channel of the Colorado River. Species in this group are rather numerous and include the following: canyon treefrog, red-spotted toad, chuckwalla, Utah spiny lizard, southern desert horned lizard, desert night lizard, black-necked garter snake, Mojave patch-nosed snake, California kingsnake, and Utah black-headed snake.
3. *The Central or Great Basin Element.* Between the Tavaputs Plateau and the Uinta Mountains and extending down on the eastern and western edges of the basin is an area in which such species as the Utah tiger salamander, western chorus frog, mountain short-horned lizard, western blue racer, and Utah milk snake are more commonly found. An examination of the fauna of this area indicates that the northern cliff uta and the Colorado plateau night snake occur in both the southern and central areas.
4. *The Northern and Western Great Plains Element.* North of the Uinta Mountains and extending on to the head waters of the Green River is a part of the Upper Basin which has a small but distinct herpetological fauna. Although the western chorus frog is an important species here also, other species such as the boreal toad, eastern short-horned lizard, Rocky Mountain rubber boa and western smooth green snake are found along the streams near the mountains and on the higher benchlands.

IX. DISTRIBUTIONAL BARRIERS AND LANES OF DISPERSAL

Considered on the level of the species, the physical features that may serve on one hand as barriers and on the other hand as lanes of dispersal are most evident in the case of mammals and reptiles. The high plateaus and Wasatch Mountains of central Utah seem to bar certain Great Basin mammals and reptiles from the Upper Basin deserts. Typical of the mammals are the chisel-toothed kangaroo rat, the kit fox, and the pigmy rabbit. In the reptiles the Great Basin fence lizard and western long-nosed snake are seemingly barred. Certain other Great Basin species are able to surmount the high elevations but have not, in the main, been able to cross the Green and/or Colorado Rivers. Such species as the Great Basin pocket mouse, little pocket mouse, and long-tailed pocket mouse are good examples. Such reptiles as the California kingsnake and the Mojave patch-nosed snake are also good examples. Conversely these streams and their deep canyons appear to prevent the dispersal of certain Colorado Basin mammal species westward. These include the Apache pocket mouse, silky pocket mouse, Aberts' squirrel, and white-throated wood rat.

The central Utah highlands, although effective barrier for most reptile forms, have at least two portals which permit some, though obviously small, population interchange between the Great Basin and the Upper Basin. Perhaps the most important of these is the low pass east of Kanab, Kane County, Utah, which extends between the Kaibab Plateau and the Vermillion Cliffs. To the north the low pass in Salina Canyon, Sevier County, Utah, has permitted the northern plateau lizard to enter the Great Basin, where it has extended its range along the western base of Wasatch Plateau.

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XI. REFERENCES CITED

Abert, J. J., 1845. Fremont's first and second expeditions of 1842-3-4. Printed by order of the U.S. Senate, Washington: Gale and Seaton, printers.

Allen, J. A., 1872. Notes of an ornithological reconnaissance of portions of Kansas, Colorado, Wyoming, and Utah. *Bull. Mus. Comp. Zool.* 3:113-183.

——, 1876. The American bison, living and extinct. *Memoirs of the Museum of Comp. Zoology*, 4(10).

——, 1893. List of mammals collected by Mr. Charles P. Rowley in the San Juan Region of Colorado, New Mexico, and Utah, with descriptions of new species. *Bull. American Museum of Natural History*, 5:69-84.

——, 1896. List of mammals collected by Mr. Walter W. Granger in New Mexico, Utah, Wyoming, and Nebraska, 1895-96, with field notes by the collector. *Bull. American Museum of Natural History*, 8:241-258.

American Ornithologists' Union, 1957.—*Check list of North American birds.*

American Society of Ichthyologists and Herpetologists, 1956. Common names for North American amphibians and reptiles. *Copea.*

Bailey, V., 1913. Life zones and crop zones of New Mexico. *North American Fauna No.* 35, *Bureau of Biological Survey*, U.S.D.A.: 100 pp.

Baird, S. F., 1857. General report upon the zoology of the several pacific railroad routes: Pt I. Mammals, reports of the explorations and surveys to ascertain the most practicable and economical route for a railroad from the Mississippi River to the Pacific Ocean, made under direction of the Secretary of War, in 1853-56, 8: 34 & 764.

——, 1859. I. Mammals. Route near the 38th and 39th parallels, explored by Capt. J. W. Gunnison and near the 41st parallel, explored by Lt. E. G. Beckwith. Exploration and surveys for a railroad route from the Mississippi River to the Pacific Ocean, 10: 8.

Barnes, C. T., 1927. Utah mammals. *Bull. Univ. Utah*, 17 (12): 1-183.

Beck, D. E., 1954. Distributional records of some aquatic *Coleoptera* in Utah. *Proc. Utah Acad. Sci., Arts, and Let.* 31: 52-56.

——, 1955. Distributional studies of parasitic arthropods in Utah. *Brigham Young University Science Bull., Biological Series* 1: 1-64.

Benson, S. B., 1935. Biological Reconnaissance of Navajo Mountains, Utah. *Univ. of Calif. Publ. in Zool.* 40 (14): 439-456.

Cary, M., 1911. A biological survey of Colorado. U.S.D.A., *Bureau of Biol. Survey N. A. Fauna No.* 33: 1-256.

——, 1917. Life zone investigations in Wyoming. *U.S.D.A., North American Fauna* 42: 1-95.

Castle, E. S., 1954. The succession of vegetation on a southern Utah sand dune. Master's Thesis, Brigham Young University, Provo, Utah.

Chandler, H. P., 1941. New species of *Coleoptera* from Utah. *Great Basin Nat.*, 2: 99-104.

Dale, H. C., 1918. The Ashley-Smith explorations and the discovery of a central route to the Pacific 1822-1829.

Davis, W. B., 1939. The recent mammals of Idaho. Caldwell, Idaho: The Caxton Printers, Ltd., 400 pp.

Dellenbaugh, F. S., 1902. The romance of the Colorado River. G. P. Putnam's Sons, New York 35: 399 pp.

Dice, L. R., 1943. The biotic provinces of North America. Ann Arbor: University of Michigan Press, 78 pp.

Dixon, H., 1935. Ecological studies on the high plateaus of Utah. *Botanical Gazette* 97 (2): 272-320.

Dunn, E. R., 1931. The herpetological fauna of the Americas. *Copeia*: 106-119.

Durrant, S. D., 1934. A new wood rat from southeastern Utah. *Jour of Mammalogy* 15 (1): 65-67.

——, 1952. Mammals of Utah. *University of Kansas Publications. Mus. of Nat. Hist.* 6: 1:549.

Freeman, L. R., 1923. The Colorado River—yesterday, today and tomorrow.

Fremont, J. C., 1846. Report of exploring expedition to the Rocky Mountains in the year 1842, and to Oregon and North California in the years 1843-44. London.

Gregory, H. E., 1917. Geology of the Navajo country. *U.S. Dept. of Interior, Geological Survey, Prof. Paper* 93.

——; Thorpe, M. R., 1938. The San Juan country. U.S. Dept. of Interior, Geological Survey, Prof. Paper 188.

——; Anderson, J. C., 1939. Geographic and geologic sketch of the Capitol Reef region, Utah. *Bull. of Geological Society of America*, 50: 1827-1850.

——, 1948. Geology and geography of central Kane County, Utah. *Bull. Geological Society of America*, 59: 211-248.

——, 1950. Geology and geography of the Zion Park region, Utah and Arizona. *U.S. Dept. of Interior, Geological Survey, Prof. Paper* 220.

——; Moore, R. C., 1931. The Kaiparowits region. *U.S. Dept. of Interior, Geological Survey, Prof. Paper* 164.

Graham, Edward H., 1937. Botanical studies in the Uinta Basin of Utah and Colorado. *Annals of the Carnegie Museum*, 26: 1-432.

Hall, Ansel F., 1934. General report, Rainbow

Bridge, Monument Valley expedition, 1933. Univ. of California Press.

Hall, E. R., 1946. Mammals of Nevada. Berkeley, California: Univ. of California Press. 710 pp.

Hunt, C. B., et. al., 1953. Geology and geography of the Henry Mountains region, *U.S. Dept. of the Interior, Geological Survey, Prof. Paper* 228.

Hall, E. R., *et. al.*, 1957. Vernacular names of North American mammals north of Mexico. *University of Kansas, Museum of Nat. Hist., Misc. Pub.*, 14: 1-16.

Kelson, K. R., 1951. Speciation in rodents of the Colorado River drainage. *Univ. of Utah Biological Series*, 6 (3): vii & 125 pp.

Mayr, E., 1946. History of the North American bird fauna. *Wilson Bulletin*, 58 (1): 3-41.

Merriam, C. H., 1890. Results of a biological survey of the San Francisco mountain region and desert of the Little Colorado, Arizona. *North American Fauna*, 3: 1-136.

——, 1892. The geographical distribution of life in North America with special reference to mammalia. *Proc. Biol. Soc. Wash.*, 7: 1-64.

——, 1894. Laws of temperature control of the geographic distribution of terrestrial animals and plants. *Nat. Geographic Mag.*, 6: 229-238.

——, 1898. Life zones and crop zones of the United States. *U.S.D.A., Div. Biol. Survey, Bull. No.* 10: 79 pp.

Miller, G. S., and Kellog, R., 1955. List of North American recent mammals. *U.S. National Museum, Bulletin* 205.

Powell, J. W., 1875. Exploration of the Colorado River to the west and its tributaries. Exploration of 1859-72. Smithsonian Institution.

Presnall, C. C, 1938. Mammals of Zion, Bryce, and Cedar Breaks. *Zion-Bryce Mus. Bull.*, 2: 1-20.

Roe, F. G., 1951. The North American buffalo. University of Toronto Press. viii & 947 pp.

Schmidt, C., 1953. Check-list of North American amphibians and reptiles. Chicago: University of Chicago Press.

Svihla, Ruth D., 1931. Mammals of the Uinta Mountain region. *Journal of Mammalogy*, 12 (3): 256-266.

——, 1932. The ecological distribution of the mammals on the north slope of the Uinta Mountains. *Ecological Monographs*, 2: 47-82.

Swift, L. W., 1945. A partial history of the elk herds of Colorado. *Journal of Mammalogy*, 26: 114-119.

Tanner, V. M., 1940. A chapter on the natural history of the Great Basin. *Great Basin Naturalist*, 1: 33-61.

——, 1940. A biotic study of the Kaiparowits region of Utah. *Great Basin Naturalist*, 1: 97-126.

——; and Hayward, C. L., 1934. A biological study of the La Sal Mountains, Report No. 1 (Ecology). *Proc. Utah Academy Science*, 11: 209-234.

Tidestrom, I., 1925. Flora of Utah and Nevada. *Contr. U.S. Nat. Herb.*, 25: 1-665.

Twomey, A. C., 1942. The birds of the Uinta Basin, Utah. *Annals of the Carnegie Museum*, 28: 341-490.

U. S. Department of Interior, 1950. A survey of the recreational resources of the Colorado River Basin. Washington: U.S. Government Printing Office.

Wing, L. W., 1956. Natural history of birds; a guide to ornithology. New York: Ronald Press Co., 539 pp.

Woodbury, A. M., 1954. Principles of general ecology. New York: The Blakiston Company, Inc.

——; and Russell, Jr., H. N., 1945. Birds of the Navajo country. *Biological Series, University of Utah*, 9 (1).

——, et. al., 1958. Preliminary report on biological resources of the Glen Canyon reservoir. *Anthropological Papers, No.* 31, *Glen Canyon Series, No.* 2: 1-219.

Young, S. P. and Goldman, E. A., 1944. The wolves of North America. American Wildlife Institute, The Monumental Printing Company, Baltimore: 636 pp.

APPENDIX

Check-list of Land Vertebrates of the Upper Colorado River Basin Deserts, Showing their Known Distribution by Provinces.
x record B.Y.U.
o record published

	Colo. Plateau Province		Uinta Mt. Province		Green River Basin Province
	East of the Colorado and Green Rivers	West of the Colorado and Green Rivers	East of the Green River	West of the Green River	
AMPHIBIANS					
Utah tiger salamander					
Ambystoma tigrinum	o x	o x		x	
Great Basin spadefoot					
Scaphiopus hammondi	o x	o x	x	o	x
Boreal toad					
Bufo boreas		x			
Red-spotted toad					
Bufo punctatus	o x	x			
Rocky Mountain toad					
Bufo woodhousei	o x	o x	x	x	
Canyon treefrog					
Hyla arenicolor		x			
Western chorus frog					
Pseudacris nigrita			o	o x	x
Western leopard frog					
Rana pipiens	o x	o x	o x	o x	o x
REPTILES					
Yellow-headed collard lizard					
Crotaphytus collaris	o x				
Western collard lizard					
Crotaphytus collaris		o x			
Leopard lizard					
Crotaphytus wislizeni	o x	o x		x	
Western chuckwalla					
Sauromalus obesus		x			
Speckled earless lizard					
Holbrookia maculata	o x				
Utah spiny lizard					
Sceloporus magister	x	o x			
Northern plateau lizard					
Sceloporus undulatus	o x	o x	o x	o x	
Great Basin sagebrush lizard					
Sceloporus graciosus	o x	o x	o x	o x	o x
Northern side-blotched uta					
Uta stansburiana	o x	o x	o x	o x	
Northern cliff lizard					
Urosaurus ornata	o x	o x			
Eastern Short-horned lizard					
Phrynosoma douglassi					o
Mountain short-horned lizard					
Phrynosoma douglassi	o x	o x	x	o x	
Southern desert horned lizard					
Phrynosoma platyrhinos		o x			
Utah night lizard					
Xantusia vigilis	x	o x			
Northern whiptail					
Cnemidophorus tigris	o x	o x	o x	o x	
Plateau whiptail					
Cnemidophorus velox	o x	o x			
Many-lined lizard					
Eumeces multivirgatus	o x				
Great Basin skink					
Eumeces skiltonianus		o x			
Black-necked garter snake					
Thamnophis cyrtopsis	x				
Wandering garter snake					
Thamnophis elegans	o x	o x	o x	o x	x

	Colo. Plat. E	W	Uinta Mt. E	W	Green Riv.
Western blue racer *Coluber constrictor*			x	o x	
Desert Striped whipsnake *Masticophis taeniatus*	o x	x	x	x	
Mojave patch-nosed snake *Salvadora hexalepis*		o x			
Great Plains rat snake *Elaphe guttata*	o x				
Great Basin gopher snake *Pituophis catenifer*	o x	o x	x	x	x
California kingsnake *Lampropeltis getulus*		x			
Utah milk snake *Lampropeltis doliata*	o x	o x	o x	o x	
Great Basin Ground Snake *Sonora semiannulata*				o	
Spotted night snake *Hypsiglena torquata*		o x			
Plateau night snake *Hypsiglena torquata*	o x	o x			
Utah black-headed snake *Tantilla utahensis*		o x			
Great Basin rattlesnake *Crotalus viridis*		x			
Hopi rattlesnake *Crotalus viridis*	x				
Midget faded rattlesnake *Crotalus viridis*	o x	o x	x	o x	
BIRDS					
Turkey vulture *Cathartes aura*	o x		x	x	
Goshawk *Accipiter gentilis*	o				
Sharp-shinned hawk *Accipiter striatus*	o x	o		o x	
Cooper's hawk *Accipiter cooperii*	o	x		o	
Red-tailed hawk *Buteo jamaicensis*	o x	o x	x	o x	o
Swainson's hawk *Buteo swainsoni*	o			o	o
Ferruginous hawk *Buteo regalis*	x			o	
Golden eagle *Aquila chrysaetos*	o x	o	x	o	o
Marsh hawk *Circus cyaneus*	o	o	o	o	o
Osprey *Pandion haliaetus*				o	
Prairie falcon *Falcon mexicanus*	o x	o		o	o
Pigeon hawk *Falco columbarius*	o			o	
Sparrow hawk *Falco sparverius*	o x	o x	x	o x	o
Peregrine Falcon *Falco peregrinus*	o		o	o	
Sharp-tailed grouse *Pedioecetes phasianellus*					o
Sage grouse *Centrocercus urophasianus*	o		o		o
California quail *Lophortyx californicus*	o			o	
Gambel's quail *Lophortyx gambelii*	o	o			
Ring-necked pheasant *Phasianus colchicus*			o	o	
Band-tailed pigeon *Columba fasciata*	o			o	
Mourning dove *Zenaidura macroura*	x	x	x	x	x
Yellow-billed cuckoo *Coccyzus americanus*	x			o	
Barn owl *Tyto alba*					

	Colo. Plat.		Uinta Mt.		
	E	W	E	W	Green Riv.
Screech owl *Otus asio*	o			o	
Flammulated owl *Otus flammeolus*	o				
Great horned owl *Bubo virginianus*	o x	o x		x	o
Burrowing owl *Speotyto cunicularia*	o x		o	o	
Spotted owl *Strix occidentalis*	o				
Long-eared owl *Asio otus*	o			o x	o
Short-eared owl *Asio flammeus*				o	o
Poor-will *Phalanoptilus nuttallii*	o x	x	x	o	x
Common nighthawk *Chordeiles minor*	o x	x	x	o x	o
White-throated swift *Aeronautes saxatalis*	o x	x	o	o	
Black-chinned hummingbird *Archilochus alexandri*	o x	x		x	
Broad-tailed hummingbird *Selasphorus platycercus*	o x	o	o	o	
Rufous hummingbird *Selasphorus rufus*	o	o x		o	
Belted kingfisher *Megaceryle alcyon*	o		o	o	
Red-shafted flicker *Colaptes cafer*	o x	x	x	x	o
Pileated woodpecker *Dryocopus pileatus*	o			o	
Red-headed woodpecker *Melanerpes erythrocephalus*				x	
Lewis' woodpecker *Asyndesmus lewis*	o	x		x	
Yellow-bellied sapsucker *Sphyrapicus varius*	o			o x	o
Hairy woodpecker *Dendrocopos villosus*	o	x		o	o
Downy woodpecker *Dendrocopos pubescens*				o x	
Eastern kingbird *Tyrannus tyrannus*			o	o	
Western kingbird *Tyrannus verticalis*	o x	x		x	
Cassin's kingbird *Tyrannus vociferans*	x				
Ash-throated flycatcher *Myiarchus cinerascens*	x	x	x	x	
Black phoebe *Sayornis nigricans*		o			
Say's phoebe *Sayornis saya*	o x	o x	x	x	o
Traill's flycatcher *Empidonax traillii*	o	x		o x	
Hammond's flycatcher *Empidonax hammondii*	x	x		o	
Dusky flycatcher *Empidonax oberholseri*	o x		x	o	
Gray flycatcher *Empidonax wrightii*	o			o	o
Western flycatcher *Empidonax difficilis*	o			o	
Western wood pewee *Contopus sordidulus*	o x	o x	o	o	o
Olive-sided flycatcher *Nuttallornis borealis*	o	o	o	o	
Horned lark *Eremophila alpestris*	o x	o x	x	o	o
Violet-green swallow *Tachycineta thalassina*	o x	x	x	o	
Tree swallow *Iridoprocne bicolor*	o x	x			

	Colo. Plat. E	Colo. Plat. W	Uinta Mt. E	Uinta Mt. W	Green Riv.
Bank swallow *Riparia riparia*				o	
Rough-winged swallow *Stelgidopteryx ruficollis*		o x		o	
Barn swallow *Hirundo rustica*	x			o	o
Cliff swallow *Petrochelidon pyrrhonota*	o	o x		o	o
Scrub jay *Aphelocoma coerulescens*	o x	x	x	o	
Black-billed magpie *Pica pica*	o x	o	x	o x	o x
Common raven *Corvus corax*	o x	o x		o x	o
Common crow *Corvus brachyrhynchos*				o	o
Pinon jay *Gymnorhinus cyanocephala*	o x	o x	x	o x	
Black-capped chickadee *Parus atricapillus*		o		o x	o
Plain titmouse *Parus inornatus*	o x	o x	x	x	
Common bush tit *Psaltriparus minimus*	o x	o x			
White-breasted nuthatch *Sitta canadensis*				o x	
Pigmy nuthatch *Sitta pygmaea*	o	x			
Dipper *Cinclus mexicanus*	o x	x			
House wren *Troglodytes aedon*	o x	x		o x	
Bewick's wren *Thryomanes bewickii*	o x		x		
Long-billed marsh wren *Telmatodytes palustris*	o	o		o	o
Canon wren *Catherpes mexicanus*	o x	o x			
Rock wren *Salpinctes obsoletus*	o x	o x	x	o x	
Mockingbird *Mimus polyglottos*	o x	x	x	o x	
Catbird *Dumetella carolinensis*	x	x		o	
Brown thrasher *Toxostoma rufum*				x	
Bendire's thrasher *Toxostoma bendirei*	x	o x			
Sage thrasher *Oreoscoptes montanus*	o x	o x	x	o	o
Robin *Turdus migratorius*	x	x	x	o x	o x
Hermit thrush *Hylocichla guttata*	x			o	
Swainson's thrush *Hylocichla ustulata*				o x	
Western bluebird *Sialia mexicana*	o x	o x			o
Mountain bluebird *Sialia currucoides*	o x	o x	x	o	o
Townsend's solitaire *Myadestes townsendi*	o x			o	o
Blue-gray gnatcatcher *Polioptila caerulea*	o x	o x	x	o x	
Ruby-crowned kinglet *Regulus calendula*	o x			o	
Water pipit *Anthus spinoletta*				x	
Cedar waxwing *Bombycilla cedrorum*		x			
Loggerhead shrike *Lanius ludovicianus*	o x	o x	x	o	o
Northern shrike *Lanius excubitor*				o	
Starling *Sturnus vulgaris*				x	

	Colo. Plat. E	W	Uinta Mt. E	W	Green Riv.
Solitary vireo *Vireo solitarius*	o x	x	x	o	o
Red-eyed vireo *Vireo olivaceus*				o	
Warbling vireo *Vireo gilvus*	o x	x		o x	o
Orange-crowned warbler *Vermivora celata*				o	
Nashville warbler *Vermivora ruficapilla*	o				
Virginia's warbler *Vermivora virginiae*	x			o	
Lucy's warbler *Vermivora luciae*	o		o x		
Yellow warbler *Dendroica petechia*	o x	o x		o x	o
Myrtle warbler *Dendroica coronata*					o
Audubon's warbler *Dendroica auduboni*	o x			o x	
Black-throated gray warbler *Dendroica nigrescens*	o x	o x	x	o x	o
Townsend's warbler *Dendroica townsendi*	o	o		o	
Hermit warbler *Dendroica occidentalis*	o				
Grace's warbler *Dendroica graciae*	o				
Northern waterthrush *Seiurus noveboracensis*	o			o	o
MacGillivray's warbler *Operornis tolmiei*	o x	x		o	o
Yellowthroat *Geothlypis trichas*	o	o		o x	
Yellow-breasted chat *Icteria virens*	o x		x	x	
Wilson's warbler *Wilsonia pusilla*	o x			o	
American redstart *Setophaga ruticilla*			o	o	
House sparrow *Passer domesticus*	x	x	x	x	x
Bobolink *Dolichonyx oryzivorus*	o			o	
Western meadowlark *Sturnella neglecta*	o x	x	x	x	x
Yellow-headed blackbird *Xanthocephalus xanthocephalus*	o			o	o
Redwinged blackbird *Agelaius phoeniceus*	o x	o x		o	
Scott's oriole *Icterus parisorum*	o	o		o	
Bullock's oriole *Icterus bullockii*	x	x	x	x	
Brewer's blackbird *Euphagus cyanocephalus*	o x	x	x	x	o
Brown-headed cowbird *Molothrus ater*	x	o x		x	x
Western tanager *Piranga ludoviciana*	o x	o		x	o
Black-headed grosbeak *Pheucticus melanocephalus*	o	x		o x	
Blue grosbeck *Guiraca caerulea*	x	x		o x	
Lazuli bunting *Passerina amoena*	x	x		o	o
Evening grosbeak *Hesperiphona vespertina*				x	
Cassin's finch *Carpodacus cassinii*		x			
House finch *Carpodacus mexicanus*	o x	o x	x	x	o
Common redpoll *Acanthis flammea*				x	o

	Colo. Plat. E	Colo. Plat. W	Uinta Mt. E	Uinta Mt. W	Green Riv.
Pine siskin					
Spinus pinus	o			o	o
American goldflinch					
Spinus tristis	o	x		o x	x
Lesser goldfinch					
Spinus psaltra	o	x		o	o
Red crossbill					
Loxia curvirostra		x			
Green-tailed towhee					
Chlorura chlorura	o x	x		o	
Rufous-sided towhee					
Pipilo erythrophthalmus	o x	x	x	o	
Lark bunting					
Calamospiza melanocorys		o		x	o
Savannah sparrow					
Passerculus sandwichensis		x		x	
Vesper sparrow					
Pooecetes gramineus	x	o x		x	o x
Lark sparrow					
Chondestes grammacus	o x	x	x	o	
Black-throated sparrow					
Amphispiza bilineata	o x	o x			
Sage sparrow					
Amphispiza belli	o x	x		o	o
Slate-colored junco					
Junco hyemalis	o	o		o	
Oregon junco					
Junco oreganus	o x	x			o
Gray-headed junco					
Junco caniceps	x	x			o
Tree sparrow					
Spizella arborea	o	x		x	o
Chipping sparrow					
Spizella passerina	o x	o x	x	o	o
Brewer's sparrow					
Spizella breweri	o x	o x	x	o	o
Harris' sparrow					
Zonotrichia querula		o		x	o
White-crowned sparrow					
Zonotrichia leucophrys	x	x		x	o
Lincoln's sparrow					
Melospiza lincolnii	o			o	o
Song sparrow					
Melospiza melodia	o	x		o	o
Lapland longspur					
Calcarius lapponicus				x	
Snow bunting					
Plectrophenax nivalis				x	
MAMMALS					
Vagrant shrew					
Sorex vagrans					o
Little brown myotis					
Myotis lucifugus		x		o	
Yuma myotis					
Myotis yumanensis				o	
Long-eared myotis					
Myotis evotis	o		o	o	
Fringed myotis					
Myotis thysanodes	o				
Long-legged myotis					
Myotis volans	o	x			
California myotis					
Myotis californicus	o	o x		o	
Small-footed myotis					
Myotis subulatus	o	o x	o		o
Silver-haired bat					
Lasionycteris noctivagans	o	o x		o	
Western pipistrelle					
Pipistrellus hesperus	o x	o x		o	
Big brown bat					
Eptesicus fuscus	o	o x			
Red bat					
Lasiurus borealis		o			
Hoary bat					
Lasiurus cinereus		o			

	Colo. Plat. E	W	Uinta Mt. E	W	Green Riv.
Spotted bat					
Euderma maculatum	o	o			
Big-eared bat					
Corynorhinus rafinesquii	o x	o		o	
Pallid bat					
Antrozous pallidus	o	o x		o	
Free-tailed bat					
Tadarida mexicana	o	o		o	
Nuttall's cottontail					
Sylvilagus nuttallii	o	o	o	o	o
Desert cottontail					
Sylvilagus audubonii	o x	o x	x	o x	
White-tailed jack rabbit					
Lepus townsendii		o	x	o x	x
Black-tailed jack rabbit					
Lepus californicus	x	x			
Least chipmunk					
Eutamias minimus	x	x	x		x
Cliff chipmunk					
Eutamias dorsalis		x	x		x
Colorado chipmunk					
Eutamias quadrivittatus	o x	x	x	o	x
White-tailed antelope squirrel					
Citellus leucurus	o x	o x	x		
Richardson's ground squirrel					
Citellus richardsonii					x
Uinta ground squirrel					
Citellus armatus					x
Thirteen-lined ground squirrel					
Citellus tridecemlineatus			x	x	
Spotted ground squirrel					
Citellus spilosoma	x				
Rock squirrel					
Citellus variegatus	o x	x	x	o x	
Golden-mantled ground squirrel					
Citellus lateralis		x	x	x	o x
White-tailed prairie dog					
Cynomys leucurus	x	x	x	x	x
Gunnison's prairie dog					
Cynomys gunnisoni	o x				
Abert's squirrel					
Sciurus aberti	x				
Red squirrel					
Tamiasciurus hudsonicus					x
Botta's pocket gopher					
Thomomys bottae	x	x			
Northern pocket gopher					
Thomomys talpoides			x	x	o x
Olive-backed pocket mouse					
Perognathus fasciatus			x		
Silky pocket mouse					
Perognathus flavus	o x				
Little pocket mouse					
Perognathus longimembris	o	x			
Apache pocket mouse					
Perognathus apache	o x		x	o	
Great Basin pocket mouse					
Perognathus parvus		x		x	x
Long-tailed pocket mouse					
Perognathus formosus		x			
Rock pocket mouse					
Perognathus intermedius	x				
Ord's kangaroo rat					
Dipodomys ordii	x	x	x	x	x
Beaver					
Castor canadensis	x	x	x	x	x
Western harvest mouse					
Reithrodontomys megalotis	x	o x	x	x	
Canyon mouse					
Peromyscus crinitus	o x	x	x	x	x
Deer mouse					
Peromyscus maniculatus	x	x	x	x	x
Brush mouse					
Peromyscus boylii	x	x			o

	Colo. Plat. E	W	Uinta Mt. E	W	Green Riv.
Pinon mouse *Peromyscus truei*	o x	o x	x	o	o
Rock mouse *Peromyscus nasutus*	o				
No. grasshopper mouse *Onychomys leucogaster*	o x	o x	x	o	x
White-throated wood rat *Neotoma albigula*	o x				
Deseret wood rat *Neotoma stephensi*	x				
Mexican wood rat *Neotoma mexicana*					
Bushy-tailed wood rat *Neotoma cinerea*	o x	o x	x	o x	o
Montane vole *Microtus montanus*		x		x	x
Sagebrush vole *Lagurus curtatus*		o		o	o
Norway rat *Rattus norvegicus*				x	
House mouse *Mus musculus*		x		o	
Western jumping mouse *Zapus princeps*					x
Porcupine *Erethizon dorsatum*	o x	x	x	x	x
Coyote *Canis latrans*	o	o x	o	o	o
Red fox *Vulpes fulva*	o	o			
Gray fox *Urocyon cinereoargenteus*	o	o x	o	o	
Ringtail *Bassariscus astutus*	o	o	o	o	
Ermine *Mustela erminea*					x
Long-tailed weasel *Mustela frenata*	o	x		x	
Black-footed ferret *Mustela nigripes*	o				
Badger *Taxidea taxus*	o	x			
Mink *Mustela vison*		o	o	o	o
Western spotted skunk *Spilogale gracilis*	o				
Striped skunk *Mephitis mephitis*	o			o	o
River otter *Lutra canadensis*				o	
Mountain lion *Felis concolor*		o x	o	o	o
Bobcat *Lynx rufus*	o	o x	x	x	x
Wapiti *Cervus canadensis*	o		o	o	o
Pronghorn *Antilocapra americana*		o	x		x
Bison *Bison bison*		o			
Mountain sheep *Ovis canadensis*		o		o	
Mule deer *Odocoileus hemionus*	o x	o x	o x	o x	o x

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TICKS OF THE GENUS IXODES IN UTAH

by

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Brigham Young University

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TICKS OF THE GENUS *IXODES* IN UTAH

by

Dorald M. Allred, D Elden Beck,
Leland D. White

INTRODUCTION

It is known that ticks of some species of the genus *Ixodes* are vectors of organisms pathogenic to man and his domestic animals in certain parts of the world and in North America (Philip 1939; Belding 1952; Anastos 1957). The vector potentiality of most known species is far from complete, and the same can be said for information on host-parasite relationships, life history, and other aspects of their ecology. Much work has been done concerning the taxonomy of the adults, and to a limited extent the nymphal stages have been studied. With most species, however, it is difficult to specifically identify the larval stage because the morphological and anatomical characteristics have not been studied sufficiently to make taxonomic separation possible.

Several thousand specimens of ticks have been collected in Utah by staff members and students of the Brigham Young University Zoology Department during the past 10 years. Many hundreds of these are of the genus *Ixodes*, representing all stages in their life history. It was felt that if the larval stages could be accurately identified, additional information recorded in the field records for distribution, host relationships, seasonal occurrence and population index for all stages would:

1. Contribute to a better understanding of taxonomy, life history, and seasonal occurrence.
2. Supplement information to better interpret vector-pathogen associations when such conditions are determined.
3. Assist in the interpretation of the phenomenon of maintenance of reservoirs of infection for pathogenic organisms in nature.

The study of the collections of ticks of the genus *Ixodes* made by Brigham Young University and some ticks obtained by loan form the basis of this publication. Primary emphasis has been given to larval taxonomy and secondarily to biological factors of ecological importance for the nine species of ticks of the genus *Ixodes* known to occur in Utah. These are *angustus*, *kingi*, *marmotae*, *muris*, *ochotonae*, *pacificus*, *sculptus*, *spinipalpis* and *texanus*.

The taxonomy and biology of the larval ticks of the above species have received little attention from previous workers. Nuttall *et al.* (1911) constructed a key to the larvae of eleven species of *Ixodes* of which only *angustus* is known to occur in Utah. Hooker *et al.* (1912) gave a description for the larva of *kingi*, but the description was brief and of little taxonomic value. Clifford (1958) has given a comprehensive discussion of, and constructed a key to, *Ixodes* larvae of the southeastern United States. Of these, only two species, *texanus* and *muris*, are known to occur in Utah. Edmunds (1951) listed collection records for eight species, one of which is *diversifossus*, a record of questionable validity. Beck (1955) listed additional notes on host relationships for *texanus*, *spinipalpis* and *pacificus*, and Kohls (1952) reported the presence of *muris* from muskrats in Utah.

There have been few other papers published on Utah ticks which deal with their taxonomy and biology. The study of the genus *Ixodes* by Cooley and Kohls (1945) is at present the most comprehensive publication dealing with these investigations.

The purpose of our study was twofold: (1) To make a morphological and anatomical analysis to determine which characteristics may be used for taxonomic separation of the larvae of species known to occur in Utah, and (2) to determine the biology of each species collected in Utah. The data on the biology of the several species were derived from field collection records supplemented by similar information taken from the literature.

Larvae of five of the species used for morphological and anatomical analysis were reared from identified females in the laboratory. Larvae from the other four species were identified on the basis of their presence with identifiable nymphs and adults.

All larval ticks were cleared, mounted on microslides, and examined with phase microscopy, and drawings were made to scale using a net reticule. The terminology and chaetotaxy follow Clifford (1958) and Cooley and Kohls (1945) except for the terms **posterolateral extension, median auricula** and **lateral auricula** which are original (Figures 1, 2, and 3). The measurements of the following structures are in microns and were taken as follows:

Scutum: The length was determined as the distance from the flattened anterior border to the posterior border. The width was measured at the area of the greatest width.

Palpus: The length was measured from the base of article two to the distal end of the palpus. The width was measured at the junction of articles two and three. The width of article two was measured at its base.

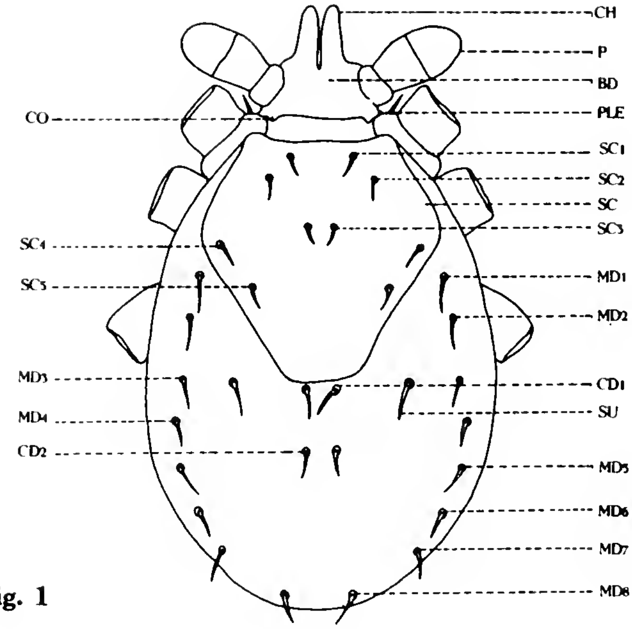


Fig. 1

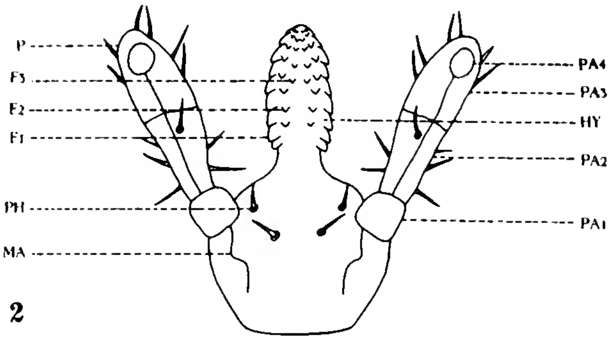


Fig. 2

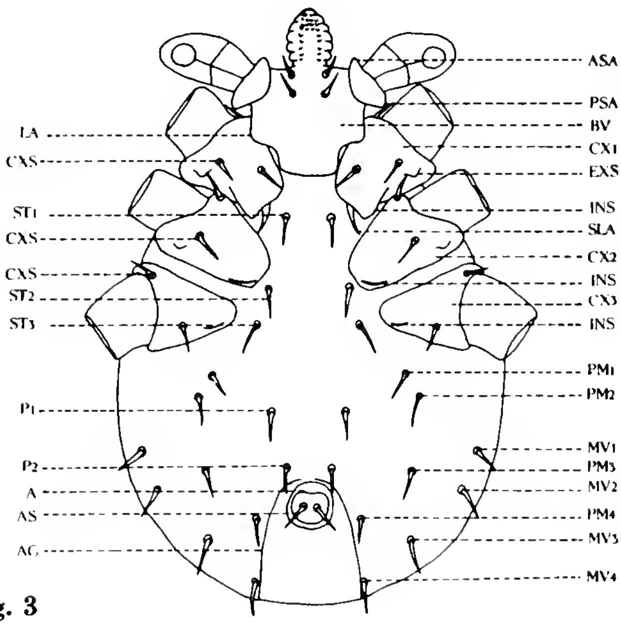


Fig. 3

CH: CHELICERAL SHEATH
P: PALP
BD: BASIS CAPITULI (DORSAL)
PLE: POSTEROLATERAL EXTENSION
CO: CORNU
SC: SCUTUM
SC_1: SCUTAL SETA ONE
SC_2: SCUTAL SETA TWO
SC_3: SCUTAL SETA THREE
SC_4: SCUTAL SETA FOUR
SC_5: SCUTAL SETA FIVE
MD_1: MARGINAL DORSAL SETA ONE
MD_2: MARGINAL DORSAL SETA TWO
MD_3: MARGINAL DORSAL SETA THREE
MD_4: MARGINAL DORSAL SETA FOUR
MD_5: MARGINAL DORSAL SETA FIVE
MD_6: MARGINAL DORSAL SETA SIX
MD_7: MARGINAL DORSAL SETA SEVEN
MD_8: MARGINAL DORSAL SETA EIGHT
SU: SUPPLEMENTARY SETA
CD_1: CENTRAL DORSAL SETA ONE
CD_2: CENTRAL DORSAL SETA TWO
PA_1: PALPAL ARTICLE ONE
PA_2: PALPAL ARTICLE TWO
PA_3: PALPAL ARTICLE THREE
PA_4: PALPAL ARTICLE FOUR
HY: HYPOSTOME
F_1: FILES ONE
F_2: FILES TWO
F_3: FILES THREE
PH: POSTHYPOSTOMAL SETA
MA: MEDIAL AURICULA
ASA: ANTERIOR SPUR ARTICLE ONE
PSA: POSTERIOR SPUR ARTICLE ONE
BV: BASIS CAPITULI (VENTRAL)
LA: LATERAL AURICULA
CX_1: COXA ONE
CX_2: COXA TWO
CX_3: COXA THREE
CXS: COXAL SETA
EXS: EXTERNAL SPUR
INS: INTERNAL SPUR
SLA: SPUR-LIKE APODEME
ST_1: STERNAL SETA ONE
ST_2: STERNAL SETA TWO
ST_3: STERNAL SETA THREE
PM_1: PRE-MARGINAL SETA ONE
PM_2: PRE-MARGINAL SETA TWO
PM_3: PRE-MARGINAL SETA THREE
PM_4: PRE-MARGINAL SETA FOUR
MV_1: MARGINAL VENTRAL SETA ONE
MV_2: MARGINAL VENTRAL SETA TWO
MV_3: MARGINAL VENTRAL SETA THREE
MV_4: MARGINAL VENTRAL SETA FOUR
P_1: PRE-ANAL SETA ONE
P_2: PRE-ANAL SETA TWO
A: ANUS
AS: ANAL SETA
AG: ANAL GROOVE

Hypostome: The length was determined from the tip to the curvature at the base. The width was taken at the widest point.

Seta: The length did not include the basal collar.

In order to determine the biology and host relationships of ixodid ticks and other ectoparasites in Utah, the Department of Zoology and Entomology of Brigham Young University initiated a systematic survey to determine relationships of parasitic arthropods and their vertebrate hosts. This survey, initially called Project 10, was begun in April of 1949 by D. Elden Beck, Dorald M. Allred, Vernon J. Tipton and Dale Rupert with Beck as the project director. Subsequent to the beginning date other faculty members and students have participated in the project. Although primary concern has been given to the rodents, collections have been made from other mammals, birds, reptiles, and nests of these animals as they were available.

In the following listings the numbers following the scientific names of the hosts designate the numbers of animals collected on this project, and the letters indicate whether fleas (F), lice (L), mites (M) and ticks (T) were found. Numbers and letters in parentheses refer to nests of animals. In many cases the designation of specific groups of ectoparasites is based on tentative field identifications and awaits laboratory corroboration. Although most of the collections are from Utah, a few hosts from other states are included. The listing of the mammals is adapted from Durrant (1952) and Hall (1957), the reptiles from Schmidt (1953), and the birds from the American Ornithologist's Union check-list (1957). For convenience, some families and genera are arranged alphabetically and are therefore not in phylogenetic order. Most of the figures represent only those animals actually killed and examined for ectoparasites by personnel associated with this project. Many porcupines, jack rabbits, badgers, marmots, large herbivores and carnivores killed by sportsmen and automobiles were examined. Such animal records were not entered as a systematic part of our project unless ectoparasites were found.

Class Reptilia

Order Squamata

Family Anguidae
Gerrhonotus kingi ssp. 1: M
Arizona Alligator Lizard

Family Iguanidae
Cnemidophorus sp. 1: M
Racerunner

Crotaphytus collaris auriceps 12: M
Yellow-headed Collared Lizard

Crotaphytus collaris baileyi 4: M
Western Collared Lizard

Crotaphytus wislizeni wislizeni 3: M
Long-nosed Leopard Lizard

Phrynosoma cornutum 1: M
Texas Horned Lizard

Sceloperus graciosus graciosus 46: M
Great Basin Sagebrush Lizard

Sceloperus undulatus consobrinus 2: M
Southern Prairie Lizard

Sceloperus undulatus virgatus 1: M
Striped Plateau Lizard

Sceloperus sp. 1: MT
Spiny Lizard

Uta stansburiana stansburiana 1: M
Northern Side-blotched Lizard

Family Scincidae
Eumeces skiltonianus 1: M
Western Skink

Order Serpentes

Family Colubridae
Pituophis catenifer deserticola 1: M
Great Basin Gopher Snake

Class Aves

Order Podicipediformes

Family Podicipedidae
Podiceps sp. (1)
Grebe

Order Ciconiiformes

Family Ardeidae
Ardea herodias 4
Great Blue Heron

Family Threskiornithidae
Plegadis falcinellus 1: L
White-faced Ibis

Order Anseriformes

Family Anatidae
Anas platyrhynchos 5 (1): L (M)
Mallard Duck

Branta canadensis 1: L
Canada Goose

Order Falconiformes

Family Accipitridae
Accipiter cooperii 1
Cooper's Hawk

Family Falconidae
Falco sparverius 2: L
Sparrow Hawk

Order Galliformes

Family Phasianidae
Lophortyx californicus (1): (M)
California Quail

Order Gruiformes

Family Rallidae
Fulica americana 1: L
American Coot

Order Charadriiformes

Family Charadriidae

Charadrius vociferus 3: L
Killdeer

Family Laridae

Larus delawarensis 1: L
Ring-billed Gull

Order Columbiformes

Family Columbidae

Columba livia 1: L
Domestic Pigeon

Zenaidura macroura 1: M
Mourning Dove

Order Strigiformes

Family Strigidae

Asio flammeus 2 (1): L (FM)
Short-eared Owl

Bubo virginianus 3 (1): L (FM)
Great Horned Owl

Order Piciformes

Family Picidae

Colaptes cafer 6 (1): L
Red-shafted Flicker

Colaptes sp. 2: LM
Woodpecker

Dendrocopos pubescens 1
Downy Woodpecker

Order Passeriformes

Family Alaudidae

Eremophila alpestris 2: M
Horned Lark

Family Cinclidae

Cinclus 1: F L M
Dipper

Family Corvidae

Aphelocoma coerulescens 2: L
Scrub Jay

Corvus brachyrhynchos 4: L
Common Crow

Corvus corax (1)
Common Raven

Cyanocitta stelleri 2: L M
Steller's Jay

Pica pica 1 (5): L
Black-billed Magpie

Family Fringillidae

Calcarius lapponicus 1
Lapland Longspur

Carpodacus mexicanus (5): (M)
House Finch

Chlorura chlorura 4: LT
Green-tailed Towhee

Junco caniceps 1: L
Gray-headed Junco

Leucosticte tephrocotis 1
Gray-crowned Rosy Finch

Melospiza melodia (1): (M)
Song Sparrow

Pheucticus melanocephalus (1): (M)
Black-headed Grosbeak

Pipilo erythrophthalmus 1: T
Rufous-sided Towhee

Pooecetes gramineus 1: L
Vesper Sparrow

Spinus tristis 1
American Goldfinch

Spizella breweri 1: L
Brewer's Sparrow

Spizella passerina 3 (1): L (M)
Chipping Sparrow

Zonotrichia leucophrys 1
White-crowned Sparrow

Family Hirundinidae

Petrochelidon pyrrhonota 1 (72): FM (FMT)
Cliff Swallow

Family Icteridae

Agelaius phoeniceus 3: L M
Red-winged Blackbird

Euphagus cyanocephalus (6): (M)
Brewer's Blackbird

Molothrus sp. 1
Cowbird

Family Laniidae

Lanius excubitor 1: L
Northern Shrike

Family Paridae

Parus gambeli 1
Mountain Chicadee

Family Parulidae

Dendroica petechia (1): (M)
Yellow Warbler

Icteria virens (1): (M)
Yellow-breasted Chat

Family Ploceidae

Passer domesticus 1 (1): M (M)
English Sparrow

Family Sturnidae

Sturnus vulgaris 1: L
Starling

Family Troglodytidae

Telmatodytes palustris (1): (M)
Long-billed Marsh Wren

Family Turdidae

Hylocichla mustelina 1: F
Hermit Thrush

Sialia mexicana 2: M
Bluebird

Turdus migratorius (6): (M)
Robin

Family Tyrannidae

Empidonax sp. 1: M
Flycatcher

Myiachus cinerascens 1: M
Ash-throated Flycatcher

Sayornis sp. 1: L
Phoebe

Class Mammalia

Order Insectivora

Family Molossidae

Tadarida mexicana 1: T
Mexican Free-tailed Bat

Family Soricidae

Sorex obscurus obscurus 4: M
Dusky Shrew

Sorex palustris navigator 1: M
Water Shrew
Sorex vagrans monticola 2: FT
Vagrant Shrew
Sorex sp. 2
Shrew

Family Vespertilionidae
Corynorhinus rafinesquii pallescens 2: M
Rafinesque's Big-eared Bat
Myotis californicus stephensi 645: F L M
California Myotis
Pipistrellus hesperus hesperus 3: M T
Western Pipistrelle

Order Lagomorpha

Family Leporidae
Lepus americanus bairdii 1: T
Snowshoe Rabbit
Lepus californicus ssp. 404: F L M T
Black-tailed Jack Rabbit
Lepus townsendii townsendii 13: F T
White-tailed Jack Rabbit
Oryctolagus cuniculus ssp. 2: FL
Domestic Rabbit
Sylvilagus audubonii ssp. 29: F L M T
Desert Cottontail
Sylvilagus idahoensis 2: F T
Pygmy Rabbit
Sylvilagus nuttallii ssp. 19: F M T
Nuttall's Cottontail
Sylvilagus sp. 57: F M T
Cottontail

Order Rodentia

Family Castoridae
Castor canadensis ssp. 4 (1)
Beaver

Family Cricetidae
Clethrionomys gapperi uintaensis 26: F L M T
Gapper's Red-backed Mouse
Lagurus curtatus ssp. 1: M
Sagebrush Vole
Microtus longicaudus ssp. 43: F L M T
Long-tailed Vole
Microtus mexicanus navaho 1: M
Mexican Vole
Microtus montanus ssp. 55 (4): F L M T (M)
Montane Vole
Microtus pennsylvanicus modestus 3: L M
Meadow Vole
Microtus sp. 95 (5): F L M T (L M)
Vole
Neotoma albigula ssp. 2: F
White-throated Wood Rat
Neotoma cinerea ssp. 29 (50): F L M T (F M)
Bushy-tailed Wood Rat
Neotoma lepida ssp. 136 (194): F L M T (F L M T)
Desert Wood Rat
Neotoma mexicana inopinata 1: F
Mexican Wood Rat
Neotoma stephensi relicta 2: F M
Stephens' Wood Rat
Neotoma sp. 9 (5): F L M T (M T)
Wood Rat
Ondatra zibethicus ssp. 5: L M
Muskrat
Onychomys leucogaster ssp. 29: F L M T
Northern Grasshopper Mouse
Onychomys torridus longicaudus 4: F L M T
Southern Grasshopper Mouse
Onychomys sp. 8: F L M
Grasshopper Mouse
Phenacomys intermedius intermedius 2: F L M
Heather Vole
Peromyscus boylii ssp. 12: F L M
Brush Mouse
Peromyscus crinitus ssp. 118: F L M T
Canyon Mouse
Peromyscus eremicus eremicus 198 (2): F L M T (M)
Cactus Mouse
Peromyscus maniculatus ssp. 2814 (7): FLMT (FLMT)
Deer Mouse
Peromyscus truei ssp. 150: F L M T
Piñon Mouse
Peromyscus sp. 19 (1): F L M T (F M)
White-footed Mouse
Reithrodontomys megalotis ssp. 122 (1): F L M T (M)
Western Harvest Mouse

Family Erethizontidae
Erethizon dorsatum ssp. 28 (1): F L T (M)
Porcupine

Family Geomyidae
Thomomys bottae ssp. 72: F L M T
Botta's Pocket Gopher
Thomomys talpoides ssp. 143: F L M T
Northern Pocket Gopher
Thomomys sp. 10: F L M T
Pocket Gopher

Family Heteromyidae
Dipodomys deserti deserti 7: F L M T
Desert Kangaroo Rat
Dipodomys merriami ssp. 130: F L M T
Merriam's Kangaroo Rat
Dipodomys microps ssp. 84 (1): F L M T (F M)
Chisel-toothed Kangaroo Rat
Dipodomys ordii ssp. 791 (2): F L M T (M)
Ord's Kangaroo Rat
Dipodomys sp. 8: LT
Kangaroo Rat
Microdipodops megacephalus ssp. 3: T
Dark Kangaroo Mouse
Perognathus apache ssp. 12: L M
Apache Pocket Mouse
Perognathus formosus ssp. 95: F L M T
Long-tailed Pocket Mouse
Perognathus intermedius crinitus 1
Rock Pocket Mouse

Perognathus longimembris ssp. 72: F L M T
Little Pocket Mouse
Perognathus parvus ssp. 215: F L M T
Great Basin Pocket Mouse
Perognathus sp. 56: F L M T
Pocket Mouse

Family Muridae
Mus musculus ssp. 23 (6): L M (F L M)
House Mouse
Rattus norvegicus norvegicus 151 (6): F L M T (FM)
Norway Rat
Rattus rattus alexandrinus 9: F L M
Black Rat

Family Sciuridae
Ammospermophilus leucurus ssp. 106 (1): F L M T (F)
White-tailed Antelope Squirrel
Cynomys gunnisoni zuniensis 1: F
Gunnison's Prairie Dog
Cynomys leucurus 11 (4): F L M T (F M T)
White-tailed Prairie Dog
Cynomys parvidens 2: F M T
Utah Prairie Dog
Cynomys sp. 2:: F L M T
Prairie Dog
Eutamias dorsalis utahensis 24: F L M T
Cliff Chipmunk
Eutamias minimus ssp. 111: F L M T
Least Chipmunk
Eutamias quadrivittatus ssp. 81: F L M T
Colorado Chipmunk
Eutamias sp. 21: F L M T
Chipmunk
Glaucomys sabrinus lucifugus 4: F L M T
Northern Flying Squirrel
Marmota flaviventer ssp. 42: F L M T
Yellow-bellied Marmot
Sciurus aberti navajo 1: F M T
Abert's Squirrel
Spermophilus armatus 234: F L M T
Uinta Ground Squirrel
Spermophilus beldingi crebrus 4: F T
Belding's Ground Squirrel
Spermophilus lateralis ssp. 117: F L M T
Golden-mantled Ground Squirrel
Spermophilus richardsonii ssp. 7: F L M T
Richardson's Ground Squirrel
Spermophilus spilosoma cryptospilotus 2: F T
Spotted Ground Squirrel
Spermophilus townsendii mollis 8: F L M T
Townsend's Ground Squirrel
Spermophilus tridecemlineatus parvus 5: F L M T
Thirteen-lined Ground Squirrel
Spermophilus variegatus ssp. 55: F L M T
Rock Squirrel
Tamiasciurus hudsonicus ssp. 40 (6): F L M T (FM)
Red Squirrel

Family Zapodidae
Zapus princeps ssp. 72: F L M T
Western Jumping Mouse

Order Carnivora

Family Canidae
Canis familiaris ssp. 5: LT
Domestic Dog
Urocyon cinereoargenteus scottii 1: T
Gray Fox
Vulpes macrotis nevadensis 3: F T
Kit Fox

Family Cervidae
Cervus canadensis nelsoni 1: T
Wapiti
Dama hemionus hemionus 8: L T
Mule Deer

Family Felidae
Felis catus ssp. 2: F
Domestic Cat
Lynx rufus ssp. 6: F T
Bobcat

Family Mustelidae
Martes sp. 1: F T
Marten
Mephitis mephitis ssp. 1: T
Striped Skunk
Mustela erminea muricus 1
Ermine
Mustela frenata nevadensis 9: F L M T
Long-tailed Weasel
Mustela vison energumenos 2: T
Mink
Spilogale gracilis ssp. 10: F L M T
Western Spotted Skunk
Taxidea taxus ssp. 6: L T
Badger

Family Procyonidae
Procyon lotor pallidus 1: F
Raccoon

Order Perissodactyla

Family Equidae
Equus caballus ssp. 5
Horse

Order Artiodactyla

Family Bovidae
Ovis dalli ssp. 2: T
Domestic Sheep

Family Suidae
Sus scrofa ssp. 1: L
Domestic Pig

LARVAL TAXONOMY AND SPECIES BIOLOGY

Each of the nine Utah species is discussed separately. A detailed morphological and anatomical analysis of the larval stage is first presented, followed by the biological and ecological factors of host preference, seasonal activity, habits of infestation, and geographical and ecological distribution. Following the biology, specific collection records for Utah are listed. All collections were made by Brigham Young University except as noted by the literature references, or by Rocky Mountain Laboratory (RML), or Richard M. Hansen (RMH).

Ixodes angustus Neumann, 1899
(Figs. 4, 5, 6, 54)

Description of the Larva

Specimens examined. Twenty-one specimens were analyzed, all of which were collected from a canyon mouse, *Peromyscus crinitus*, at Wild Mountain, Uintah County, Utah.

Hypostome. The width varies from 29 to 44, with 34 to 36 as the most common. The length varies from 270 to 328 with variations equally dispersed and showing an average of 297. The hypostome is widest at mid-point with a moderately rounded apex. The basal width is approximately one-half that of the maximum width. The denticles moderately overlap, they are rounded and coarse. The files are arranged 2/2 for three-fourths of the hypostomal length. Only one or two denticles appear in file three. Files one and two usually possess eight and six denticles, respectively, although sometimes there is one tooth more or less per file.

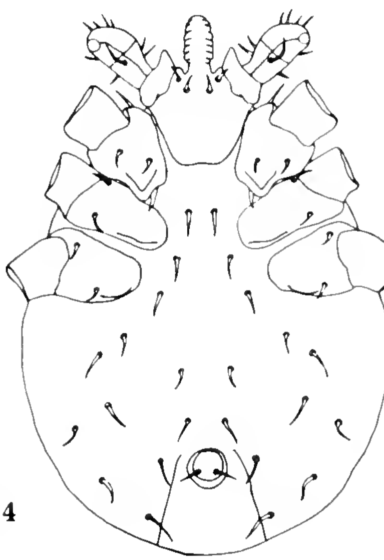


Fig. 4

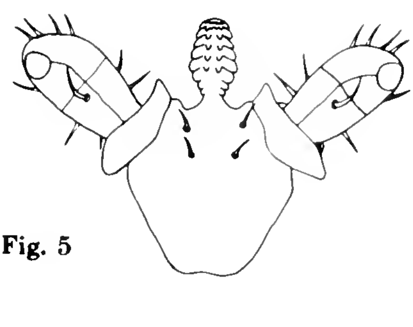


Fig. 5

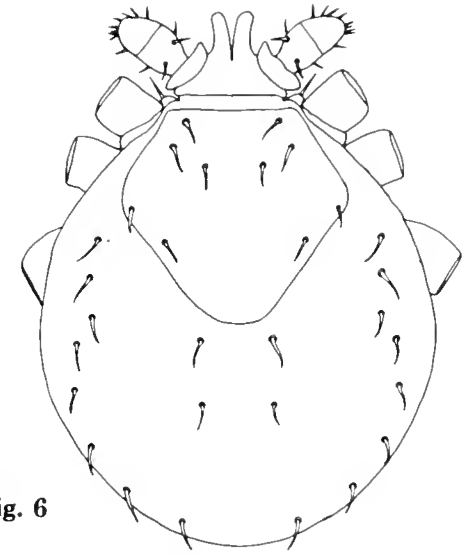


Fig. 6

Palpi. The width at the widest point varies from 48 to 60, with 54 to 60 as the most common. The length from the base of article two to the tip of article three varies from 92 to 112, with 102 to 108 as the most common. The width at the base of article two varies from 31 to 42, with 36 to 42 as the most common. Article one has an anterior spur which is acute to attenuate, and a posterior spur which is prominent and rounded. The inner margin of article three possesses a slight, terminal concavity. Article four is terminal.

Basis capituli. The posterolateral margin possesses blunt posterolateral extensions.

Scutum. The width varies from 288 to 328, with 310 to 319 as the most common. The length varies from 270 to 328, with 282 to 301 as the most common. The posterolateral margin has a narrowly rounded curvature. There are five pairs of scutal setae. Setae one, two and three usually are closely grouped near the anterolateral margin, while four and five are grouped near the posterolateral curvature. Pair number three ranges in length from 23 to 36, with 26 to 28 as the most common.

Coxae. Coxa one has a prominent inner spur. The anterior margin is variable in shape. There are three setae present. Coxa two bears a slight, inner ridge. The anterior and posterior margins are straight to slightly concave. The inner margin is broadly rounded, and there are two setae present. Coxa three sometimes bears a slight inner ridge. The anterior margin is straight, while the posterior margin is straight to slightly convex. There are two setae present.

General body setae. Eight (rarely seven) pairs of marginal dorsal setae are present. Pair number one ranges in length from 40 to 52 with variations equally dispersed and showing an average of 45. Two pairs of central dorsal setae are present. Pair number one ranges in length from 36 to 48, with 36 to 52 as the most common. Three pairs of sternal setae are present. Pair number one ranges in length from 34 to 42, with 36 as the most common. The setae are arranged in a triangular outline. Two pairs of pre-anal setae are present. Pair number one ranges in length from 29 to 36, with 30 as the most common. Four pairs of pre-marginal setae are present. Pair number one ranges in length from 30 to 40 with variations equally dispersed and showing an average of 34. Three pairs of marginal ventral setae are present. Pair number one ranges in length from 29 to 40, with 31 to 36 as the most common. Two pairs of post-hypostomal setae are present.

Biology

Host preference. The few larvae of this species collected were found only on white-footed mice of the genus *Peromyscus*. Nymphal ticks were found most commonly on the deer mouse, *Peromyscus maniculatus*. Adults and nymphs were taken from three other genera of hosts. Cooley and Kohls (1945) listed at least 16 genera of animals that serve as hosts for this tick, mostly in northwestern United States.

Geographical and ecological distribution. This species probably is statewide in its distribution, but was infrequently collected during this study. We found it about equally distributed in coniferous forest and desert shrub areas, but records from the literature indicate high altitude hosts for the most part.

Seasonal activity. Larval ticks were collected only in May, nymphs from May to September, adult males in June, and adult females in May, June and August. Cooley and Kohls (1945) listed records of nymphs from April to August (except July), females from March to December, and males in February, April and June.

Habits of infestation. Infested animals rarely possessed more than a single tick per host. One deer mouse possessed 22 larvae, and one canyon mouse, *Peromyscus crinitus*, had 48 larvae.

Larvae and nymphs were found together on the same host in May, nymphs and adults together in June and July, and all three stages together in May.

Collection Records

Microtus montanus ssp.: Pine Valley, Washington Co., 17 July 1953, 1 F

Microtus sp.: Koosharem, Sevier Co., 23 July 1953, 1 F

Microtus sp. nest: Lake Town, Rich Co., 25 June 1953, 2 N, 1 M

Ochotona princeps ssp.: Beaver Co., 17 July 1936 (RML)

Delano Ranger Sta., Beaver Co., 25 June 1957, 2 N

Emerald Lake, Utah Co., 7 Aug. 1958, 1 N, 2 F

Timpooneke Ranger Sta., Mt. Timpanogos, Utah Co., 18 June 1958, 5 N, 6 Aug. 1958, 1 F

Peromyscus crinitus ssp.: Wild Mtn., Uintah Co., 3 May 1953, 85 L, 2 N

Peromyscus maniculatus ssp.: Castledale, Emery Co., 22 May 1952, 2 N

Diamond Valley, Washington Co., 15 July 1953, 2 N, 2 F

Lynndyl Sand Dunes, Juab Co., 24 June 1955, 1 N

Mt. Timpanogos, Utah Co., 19 July 1952, 1 N

Red Creek, Daggett Co., 16 June 1953, 1 N

Wild Mtn., Uintah Co., 2 May 1953, 22 L, 1 N, 1 F

Peromyscus truei ssp.: Wild Mtn., Uintah Co., 3 May 1953, 1 L, 1 N

Urocyon cinereoargenteus scottii: Tridell, Uintah Co., 26 Sept. 1957, 1 N

Unknown: Schofield Reservoir, Utah Co., 7 June 1957, 1 N

Edmunds (1951) listed the following Utah records:

Ochotona sp.: Paradise Park, Uintah Co., Aug. 1947

Shrew: Camp Hunt, Cache Co., Aug. 1942

Weasel: Sardine Canyon, Cache Co., Dec. 1937

Ixodes diversifossus Neumann, 1899

Edmunds (1951) listed a record of *Ixodes diversifossus* from a cottontail rabbit taken by J. S. Stanford. According to Cooley and Kohls (1945) and the extensive collections of the authors, it is doubtful that this is a valid record for this species in Utah. It seems reasonable to assume that this was possibly a misidentification of *sculptus* or *kingi*.

Ixodes kingi Bishopp, 1911

(Figs. 7, 8, 9, 55)

Description of the Larva

Specimens examined. Twenty-five larvae were lab-reared from a female taken from an Ord's kangaroo rat, *Dipodomys ordii*, from Dugway, Tooele Co., Utah.

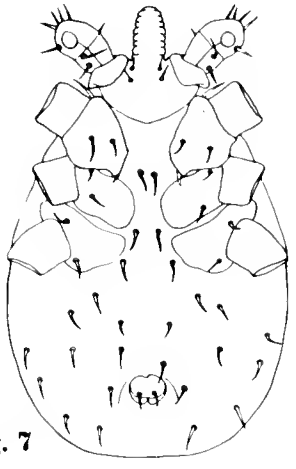


Fig. 7

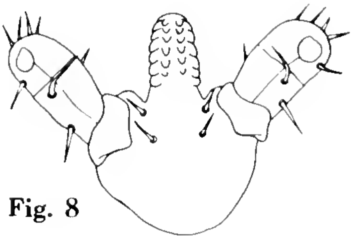


Fig. 8

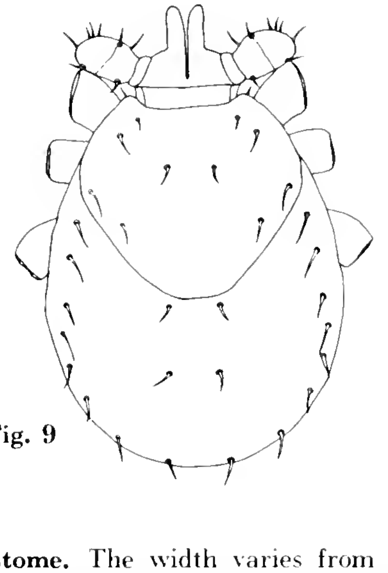


Fig. 9

Hypostome. The width varies from 38 to 44 with 42 as the most common. The length varies from 60 to 72 with 66 as the most common. The sides are parallel to slightly convex with the apex broadly rounded. The denticles closely overlap, are rounded, coarse, and arranged in a 2/2 sequence to the base. Files one and two usually possess seven and six denticles, respectively; sometimes there is one tooth more or less per file. File two extends at least seven-eighths of the length of the hypostome.

Palpi. The width at the widest point varies from 54 to 66 with 60 as the most common. The length from the base of article two to the tip of article three varies from 90 to 106 with 96 as the most common. The width at the base of article two varies from 31 to 42 with 40 as the most common. Article one has a prominent, posteriorly projecting spur. The inner margins of articles two and three are slightly convex, while the outer margins are slightly concave. Article four is sub-terminal.

Basis capituli. The posteroventral margin is broadly convex with the curvature beginning at the base of palpal article one. The posterodorsal margin is flattened with a slight to prominent posterolateral extension.

Scutum. The width varies from 261 to 306 with 292 as the most common. The length varies from 270 to 292, with 274 to 279 as the most common. The posterior margin is rounded with the posterolateral margins flattened to slightly concave. There are five pairs of scutal setae. Setae one and two are grouped near the anterolateral margin, setae three are situated medially, while four and five are located along the posterolateral curvature. Pair number three ranges in length from 14 to 20 with 15 as the most common.

Coxae. Coxa one has an acute inner spur of moderate size. The anteromedial margin is straight to concave, whereas the posterior margin may be straight, concave, or convex. There are three setae present. Coxa two has flattened edges anteriorly and posteriorly. Both ends are bluntly rounded. There are two setae present. Coxa three has a concave anterior margin, a convex posterior margin, and is rounded medially. Two setae are present.

General body setae. Eight pairs of marginal dorsal setae are present. Pair number one ranges in length from 37 to 48 with 42 as the most common. Two pairs of central dorsal setae are present. Pair number one ranges in length from 18 to 24, with 23 to 24 as the most common. Three pairs of sternal setae are present. Pair number one varies in length from 29 to 36 with 30 as the most common. The setae are arranged in a triangular outline. Two pairs of pre-anal setae are present. Pair number one ranges in length from 18 to 24 with 24 as the most common. Four pairs of pre-marginal setae are present. Pair number one ranges in length from 19 to 31 with 24 as the most common. Four pairs of marginal ventral setae are present. Pair number one ranges in length from 18 to 29 with 24 as the most common. Two pairs of post-hypostomal setae are present.

Biology

Host preference. The larvae of *kingi* apparently prefer the deer mouse, *Peromyscus maniculatus*, to other hosts. Ord's kangaroo rat, *Dipodomys ordii*, is another preferred host. Other species of white-footed mice, kangaroo rats, rabbits, wood rats and pocket mice commonly living in the same communities as the deer mice and Ord's kangaroo rats were occasionally found parasitized with *kingi* larvae.

Ord's kangaroo rat seems to be the preferred host of nymphal *kingi*, whereas the deer mouse is less preferred by nymphs. Apparently the nymphs are not so selective for their hosts as are the larvae, for they were also frequently found on the chisel-toothed kangaroo rat, *Dipodomys microps*, and the Great Basin pocket mouse, *Perognathus parvus*. Other animals in the same community were rarely found parasitized with nymphs.

The few adult male *kingi* collected were found primarily on Ord's kangaroo rats. Adult female *kingi* were collected most frequently from Ord's kangaroo rats and infrequently from a variety of other hosts.

Cooley and Kohls (1945) listed at least 14 genera of animals that serve as hosts for this tick in the western United States.

Geographical and ecological distribution. *Ixodes kingi* is generally statewide in its distribution. It was found primarily in desert shrub areas, but was collected occasionally in the lower elevations of coniferous forest areas.

Seasonal activity. Larval and nymphal *kingi* were found on deer mice every month of the year and on Ord's kangaroo rats every month except July. We have no explanation for their apparent absence on kangaroo rats during July.

Adult females were collected every month except September, December and January, and adult males from March to November except in July, September and October.

On animals other than their common hosts, ticks were found from April through November, mainly from April to June.

Except for the month of June in each case, Cooley and Kohls (1945) listed records of females from April to December, males from April to September, and nymphs from May to September.

Habits of infestation. Apparently few animals are heavily infested with *kingi* ticks. Most of the animals infested with larvae possessed only one or two ticks. The few extremes of larval infestation were five Ord's kangaroo rats which possessed 20, 22, 38, 44 and 50 larvae, respectively. A deer mouse showed an extreme of 25 larvae, and a desert wood rat 28. Other than these extremes, few animals had more than 10 larvae. With respect to the nymphs, the same general picture held true. Most mammals had one or two ticks with less than a dozen extremes of more than nine nymphs. Usually only one adult female tick, and never more than three, was found on a single host animal. Not more than one adult male tick was found on an animal. Such small numbers of ticks on an animal may be indicative of a high mortality of these ticks in nature. Laboratory rearing experiments show that engorged adult females are capable of producing several thousand eggs.

Host animals are not resistant to infestation by more than one developmental stage of ticks at the same time. Larvae and nymphs were found together on the same animal every month except July and September. Larvae, nymphs and adults were taken together in February, April and October, larvae and adults in March and April, and nymphs and adults from February to October, except in July and September.

Collection Records

Cynomys leucurus: Jensen, Uintah Co., 13 June 1953, 1 L, 3 N
  Roosevelt, Duchesne, Co., 21 Aug. 1952, 4 L, 3 N
Cynomys parvidens: Panguitch (10 mi. N.), Garfield Co., 26 July 1952, 2 N
Cynomys sp.: Linwood, Daggett Co., 24 June 1958, 3 N
Prairie dog: Grand Co., 2 Sept. 1940 (RML)
  San Juan Co., 21 Apr. 1937, (RML)
Dipodomys microps ssp.: Chimney Rock Pass, Utah Co., 21 June 1953, 6 N
  Desert Range Exp. Sta., Millard Co., 12 Aug. 1958, 2 N
  Fish Springs, Juab Co., 14 July 1951, 1 N, 1 F
  Lucin, Box Elder Co., 18 June 1952, 4 N, 11 Oct. 1952, 1 N, 23 May 1953, 1 L
Dipodomys ordii ssp.: Brown's Park, Daggett Co., 11 June 1953, 120 N, 3 F
  Cedar Valley, Utah Co., 27 Oct. 1948, 44 L; 28 Sept. 1950, 20 L; 25 Mar. 1951, 2 N, 2 M, 2 F; 8-14 Oct. 1951, 32 L, 24 N, 4 F; 4-14 Oct. 1952, 2 N; 11 Nov. 1952, 1 L; 20 Dec. 1952, 11 L, 5 N; 28 Aug. 1953, 1 L, 1 N; 10 Oct. 1953, 124 L, 9 N; 14 Aug. 1957, 26 L
  Chimney Rock Pass, Utah Co., 28 Mar. 1953, 16 L, 4 N, 2 M, 4 F; 23 Apr. 1953, 7 L, 2 N, 1 M, 4 F; 28 May 1953, 3 N, 1 F; 21 June 1953, 2 L, 21 N
  Desert Range Exp. Sta., Millard Co., 10 Sept. 1950, 1 L; 12 Aug. 1958, 1 N
  Elberta, Utah Co., 30 Jan. 1953, 2 L
  Fairfield, Utah Co., 28 Apr. 1952, 2 L, 1 N
  Jensen, Uintah, Co., 13 June 1953, 1 N
  Joy, Juab Co., 1 June 1951, 17 L, 52 N, 1 F
  Locomotive Springs, Box Elder Co., 18 June 1952, 19 N
  Lucin, Box Elder Co., 18 June, 1952, 1 L, 18 N, 1 F; 10 Oct. 1952, 74 L, 18 N; 14

Feb. 1953, 154L, 25 N, 6 F; 23 May 1953, 13 L, 7 N, 1 M, 2 F
Lynndyl Sand Dunes, Juab Co., 8 Oct. 1950, 12 L, 7 N; 19-26 June 1955, 1 L, 21 N, 3 F
Moab (20 mi. S), San Juan Co., 7 May 1951, 2 L, 6 N, 1 F
Price, Carbon Co., 8 June 1951, 3 N
Richfield, Sevier Co., 30 Apr. 1952, 3 L, 2 N, 1 F
Roosevelt (7 mi. NW), Duchesne Co., 22 Apr. 1953, 1 L

Dipodomys sp.: Lucin, Box Elder Co., 18 June 1952, 1 L, 4 N

Mustela sp.: San Juan Co., 22 Apr. 1937 (RML)

Neotoma lepida ssp.: Chimney Rock Pass, Utah Co., 15 Oct. 1949, 62 L, 4 N
Lucin, Box Elder Co., 14 Feb. 1953, 5 L

Neotoma sp. nest: North Wash, Garfield Co., 10 June 1955, 1 M

Onychomys leucogaster ssp.: Browns Park, Daggett Co., 11 June 1953, 6 N
Lucin, Box Elder Co., 23 May 1953, 1 N
Moab (20 mi. S), San Juan Co., 7 May 1951, 4 N

Onychomys torridus longicaudus: Beaver Dam Wash, Washington Co., 17 Apr. 1952, 3 L

Perognathus longimembris ssp.: Glenwood, Sevier Co., 30 Apr. 1952, 2 N

Perognathus parvus ssp.: Cedar Valley, Utah Co., 8 Oct. 1951, 1 L, 1 N; 11 Nov. 1952, 2 L, 2 N; 10 Oct. 1953, 3 L
Fish Springs, Juab Co., 15 July 1951, 1 N
Hieroglyphic Gap, Iron Co., 18 July 1953, 1 N
Joy, Juab Co., 1 June 1951, 1 L, 34 N, 1 F
Lucin, Box Elder Co., 19 June 1952, 1 N; 11 Oct. 1952, 1N; 24 May 1953, 7 L, 1 N
Price, Carbon Co., 8 June 1951, 1 L
Yuba Reservoir, Sanpete Co., 22 July 1951, 2 N

Perognathus sp.: Callao, Juab Co., 12 Aug. 1953, 6 N
Grafton, Washington Co., 5 Apr. 1952, 1 L
Lucin, Box Elder Co., 18 June 1952, 1 N; 19 June 1953, 1 N

Peromyscus crinitus ssp.: Lucin, Box Elder Co., 24 May 1953, 2 L

Peromyscus eremicus eremicus: Grafton, Washington Co., 5 Apr. 1952, 2 L, 2 N
Parowan, Iron Co., 4 Sept. 1951, 1 L

Peromyscus maniculatus ssp.: Brown's Park, Daggett Co., 11 June 1953, 3 L, 5 N
Castledale, Emery Co., 22 May 1952, 1 L, 2 N
Cedar Valley, Utah Co., 12 Apr. 1950, 4 L; 25 Mar. 1951, 2 L, 12 N; 8 Oct. 1951, 7 L, 10 N; 28 Apr. 1952, 3 L; 31 Aug. 1952, 1 N; 4 Oct. 1952, 3 N; 1 Nov. 1952, 6 L, 2 N; 20 Dec. 1952, 5 L; 28 Feb. 1953, 3 L, 1 N; 10 Oct. 1953, 22 L, 1 F
Chimney Rock Pass, Utah Co., 13 Oct. 1948, 1 L; 15 Oct. 1949, 7 L, 2 N; 28 Mar. 1953, 31 L, 4 N; 23 Apr. 1953, 47 L, 2 N; 28 May 1953, 15 L, 5 N; 21 June 1953, 3 N
Desert Range Exp. Sta., Millard Co., 11 Sept. 1950, 4 N
Elberta, Utah Co., 30 Jan. 1953, 10 L, 3 N
Glenwood, Sevier Co., 30 Apr. 1952, 1 L
Hieroglyphic Gap, Iron Co., 18 July 1953, 1 N
Jensen (13 mi. E), Uintah Co., 13 June 1953, 2 L, 3 N
Joy, Juab Co., 1 June 1951, 5 N
Locomotive Springs, Box Elder Co., 18 June 1952, 1 N
Lucin, Box Elder Co., 18 June 1952, 3 L, 7 N; 14 Feb. 1953, 7 L; 23 May 1953, 36 L, 2 N
Lynndyl Sand Dunes, Juab Co., 8 Oct. 1950, 1 L, 4 N; 19-26 June 1955, 4 N; 12 June 1957, 1 N
Moab, (20 mi. S) San Juan Co., 7 May 1951, 2 N
Myton, (5 mi. S) Duchesne Co., 5 June 1953
Paradise Valley, Sevier Co., 10 Aug. 1952, 55 L
Pole Creek Mtn., Duchesne Co., 24 Aug. 1957, 1 L
Price, Carbon Co., 7 June 1951, 1 L, 2 N
Provo Canyon, Utah Co., 26 Apr. 1951, 1 L
Richfield, Sevier Co., 30 Apr. 1952, 3 L, 2 N
Roosevelt (7 mi. W), Duchesne Co., 12 Aug. 1951, 1 L
Wah Wah Springs, Beaver Co., 13 Sept. 1950, 5 L, 2 N
5 L, 2 N
Wild Mtn., Uintah Co., 2 May 1953, 1 L

Peromyscus truei ssp.: Marysvale, Piute Co., 27 June 1952, 1 L

Reithrodontomys megalotis ssp.: Chimney Rock Pass, Utah Co., 2 May 1953, 1 N
Lucin, Box Elder Co., 18 June 1952, 1 L

Spermophilus armatus: Strawberry Reservoir, Wasatch Co., 28 June 1951, 1 L

Spermophilus lateralis ssp.: Myton (15 mi. S), Duchesne Co., 5 Apr. 1953, 1 N

Spermophilus richardsoni ssp.: Highway Utah 51, Utah-Wyoming Border, Rich Co., 25 June 1952, 1 L, 1 N
Randolph, Rich Co., 16 July 1952, 1 N (RMH)

Spilogale gracilis ssp.: Callao, Juab Co., 12 Aug. 1953, 5 N, 1 M, 1 F
Cedar Valley, Utah Co., 31 Aug. 1952, 15 N, 1 F
Gandy, Millard Co., 14 Aug. 1953, 2 F

Sylvilagus nuttallii ssp.: Cedar Fort, Utah Co., 14 Sept. 1949, 2 L

Taxidea taxus ssp.: Ouray, Uintah Co., 18 Nov. 1951, 1 M, 2 F
Locality unknown, 24 Oct. 1956, 1 F
Thomomys talpoides ssp.: Cedar Breaks Nat. Mon., Iron Co., 20 July 1953, 1 F
Host unknown: Fairfield (20 mi. S), Utah Co., 28 Apr. 1952, 2 L
Lynndyl Sand Dunes, Juab Co., 12 June 1957, 1 N
Saratoga, Utah Co., 13 Jan. 1951, 12 N

In addition to the above listings, the following Utah records are listed by Cooley and Kohls (1945):

Burrow: San Juan Co., Aug. 1940, 1 F
Canis familiaris: Cedarview, Duchesne Co., 6 M, 13 F
Cynomys gunnisoni: San Juan Co., May 1937, 2 M
Prairie Dog: Grand Co., Sept. 1940, 2 M
Millard Co., Aug. 1940, 1 F, Sept. 1940, 1 F
Mustela sp.: San Juan Co., Apr. 1937, 1 M, 1 F
Mink: Randlett, Uintah Co., 2 F

Edmunds (1951) listed the following Utah record:

Prairie dog: San Juan Co., July 1947

Ixodes marmotae Cooley and Kohls, 1938
(Figs. 10, 11, 12, 54)

Description of the Larva

Specimens examined. Eight specimens were examined. Of these, seven were collected from *Marmota flaviventer* at Loa, Wayne County, Utah. The remaining specimen was collected by J. D. Gregson from *Marmota* species at Nichols, B. C., Canada.

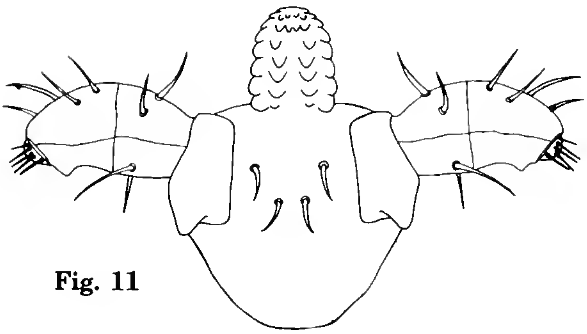


Fig. 11

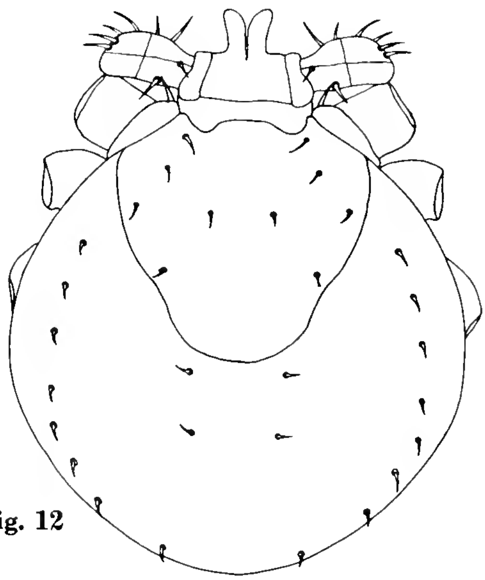


Fig. 12

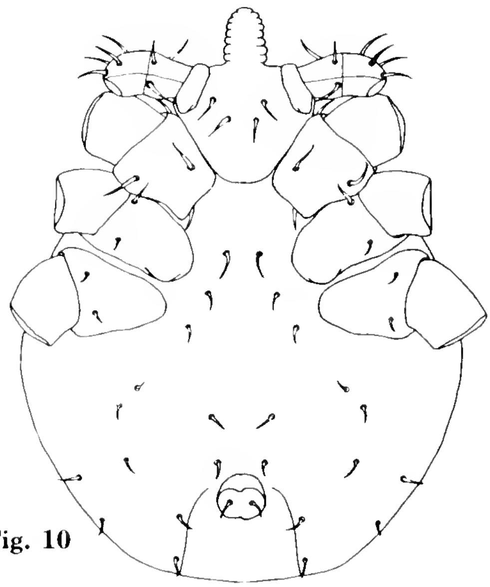


Fig. 10

Hypostome. The width varies from 62 to 72, with variations equally dispersed and showing an average of 67. The length varies from 80 to 93 with 81 as the most common. The sides are parallel with a broadly rounded apex. The denticles closely overlap, are rounded, coarse, and arranged 2/2 to the base. Files one and two usually possess eight and seven denticles, respectively. Sometimes there is one tooth more or less per file. File three is present only at the apex with one or two denticles.

Palpi. The width at the widest point varies from 66 to 78 with 72 as the most common. The length from the base of article two to the tip of article three varies from 122 to 135 with variations equally dispersed and showing an average of 129. The width at the base of article two varies from 48 to 52 with variations equally dispersed and showing an average of 50. Article one bears a prominent, posteriorly projecting spur. The inner margins of articles two and three are convex, while the outer margins are straight except for the distal end of article three, which is concave. Article four is terminal.

Basis capituli. The posteroventral margin is broadly convex with the medial curvature beginning at the base of palpal article one. The posterodorsal margin is flattened. There are no posterolateral extensions.

Scutum. The width varies from 337 to 382 with variations equally dispersed and showing an average of 361. The length varies from 328 to 351 with variations equally dispersed and showing an average of 341. The posterolateral margin is moderately to strongly concave. There are five pairs of scutal setae. Setae one, two, four, and five are uniformly spaced, while number three is situated medially. Pair number three ranges in length from 11 to 16 with 12 as the most common.

Coxae. Coxa one has a small, inner spur. There are three setae present. The anterior and posterior margins of coxa two are straight. The inner margin is broadly rounded, giving the coxa an oval appearance. A small inner tubercle, or ridge, is present. There are two setae present. Coxa three lacks spurs, has variable sides, and the inner margin is narrowly rounded.

General body setae. There apparently are eight pairs of marginal dorsal setae. An accurate count was not possible since only one specimen showed clear detail of these setae. The setal length ranges from 21 to 33 with variations equally dispersed and showing an average of 28. Two pairs of central dorsal setae are present. Pair number one ranges in length from 14 to 24 with 18 as the most common. Three pairs of sternal setae are present. Pair number one ranges in length from 28 to 31, with 28 to 30 as the most common. The setae are arranged in a triangular outline. Two pairs of pre-anal setae are present. Pair number one ranges in length from 18 to 24 with 24 as the most common. Four pairs of pre-marginal setae are present. Pair number one ranges in length from 19 to 26 with variations equally dispersed and showing an average of 23. Three pairs of marginal ventral setae are present. Pair number one ranges in length from 19 to 28 with variations equally dispersed and showing an average of 23. Two pairs of post-hypostomal setae are present.

Biology

Host preference. Ticks of this species were found most commonly on the yellow-bellied marmot, *Marmota flaviventer*. Cooley and Kohls (1945) listed records of this tick from two genera of hosts other than the marmot.

Geographical and ecological distribution. The range of this tick coincides with that of its common host which is generally found from 5,000 to 10,000 feet above sea level. All of our collections of marmots at high elevations (8,000-10,000 feet above sea level) have failed to produce a single specimen of tick in any stage of development.

Seasonal activity. Larvae were found only in April, and nymphs and adult females in April, June and August. Adult males were not found by us. Cooley and Kohls (1945) listed records of females collected from March to August, males from March to August (except July), nymphs from April to June, and larvae in April and June.

Habits of infestation. The few collection records we have obtained indicate that this tick demonstrates no distinctive pattern of infestation. A single marmot was infested with 12 larvae, whereas another marmot harbored nine adult female ticks. Larvae and nymphs were found together on the same host in April, and nymphs and adults together in June and August.

Collection Records

Marmota flaviventer ssp.: Elk Valley Ranger Sta., Cache Co., 26 June 1953, 1 N, 3 A
Loa, Wayne Co., 6 Aug. 1952, 17 L, 4N
Mt. Pleasant, Sanpete Co., 22 Apr. 1952, 12 L, 1 N, 1 F
Rich Co., 3 June 1938 (RML)
Salt Lake County, 18 May 1939, (RML)
Strawberry River Cnyn., Duchesne Co., 21 Aug. 1957, 6 F

Peromyscus maniculatus ssp.: Strawberry River Cnyn., Duchesne Co., 18 June 1957, 1 N

Spermophulus armatus: Cache Co., 24 May 1938 (RML)

Spermophilus lateralis ssp.: Delano Ranger Sta., Beaver Co., 25 June, 1957, 2 N
Strawberry River Cnyn., Duchesne Co., 18 June, 1957, 1 N

Cooley and Kohls (1945) listed additional Utah records as follows:

Spermophilus armatus: Cache Co., May 1938, 1 M
Marmota sp.: Rich Co., June 1938, 5 M, 3 F

Edmunds (1951) listed Utah records as follows:

Marmota sp.: Prairie Hollow, Salt Lake Co., May 1939
Tampo, Box Elder Co., July 1942

Ixodes muris Bishopp and Smith, 1937
(Figs 13, 14, 15, 54)

Description of the Larva

Specimens examined. Twenty-two lab-reared specimens were analyzed. Of these four were reared by J. D. Gregson and C. N. Smith in Canada. The remaining eighteen were received from C. M. Clifford, University of Maryland.

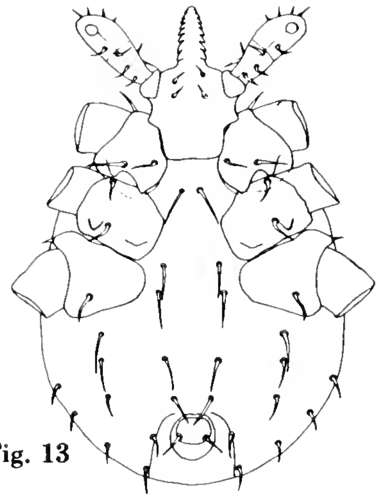


Fig. 13

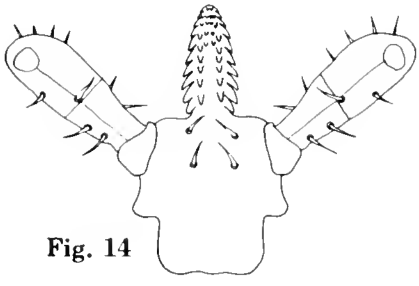


Fig. 14

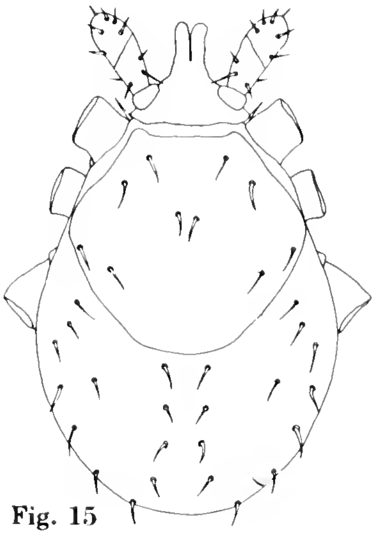


Fig. 15

Hypostome. The width varies from 34 to 48 with 42 as the most common. The length varies from 90 to 97 with 96 as the most common. The sides are nearly parallel, gradually tapering to a narrowly rounded apex. All denticles are relatively long, narrow and pointed, and are arranged 3/3 apically and 2/2 at the base. Files one, two and three usually possess ten, nine and four denticles, respectively. Sometimes there is one tooth more or less per file. File two extends to the hypostomal base. File three extends one-third of the length of the hypostome.

Palpi. The width at the widest point varies from 42 to 60 with 54 as the most common. The length from the base of article two to the tip of article three varies from 111 to 138, with 132 to 135 as the most common. The width of article two at the base varies from 23 to 39, with 30 to 36 as the most common. Article one has neither anterior nor posterior projections. The inner margins of articles two and three are slightly convex, while the outer margins are straight. Article four is sub-terminal

Basis capituli. There is a prominent auricular projection on the ventrolateral margin. The posteroventral margin is bluntly terminated. The posterodorsal margin is flattened with slightly pointed posterolateral extensions.

Scutum. The width varies from 301 to 347 with 337 as the most common. The length varies from 292 to 328 with 315 as the most common. The posterior margin is moderately rounded. There are five pairs of scutal setae. Paired setae one and two are grouped near the anterolateral margin, pair three is situated medially and slightly anteriorly, and four and five are located along the posterolateral curvature of the scutum. Pair number three ranges in length from 29 to 36 with 30 as the most common.

Coxae. Coxa one has an acute inner spur of moderate size. An outer spur is present and is about one-third as large as the inner spur. There are three setae present. Coxa two has a small inner tubercle and small outer spur. There are two setae present. Coxa three has neither spurs nor tubercles. The anterior and posterior margins are straight to slightly concave. There are two setae present.

General body setae. Seven pairs of marginal dorsal setae are present. Pair number one ranges in length from 25 to 42 with 30 as the most common. Four (rarely three) pairs of central dorsal setae are present. Pair number one ranges in length from 20 to 32 with 29 as the most common. There is one pair of supplementary setae which ranges in length from 20 to 30 with 24 as the most common. Three pairs of sternal setae are present. Pair number one ranges in length from 52 to 67 with 60 as the most common. The setae vary from a parallel to triangular arrangement. Two pairs of preanal setae are present. Pair number one ranges in length from 36 to 48 with 40 to 42 as the most common. Four pairs of pre-marginal setae are present. Pair number one ranges in length from 38 to 50, with 42 to 48 as the most common. Four pairs of marginal ventral setae are present. Pair number one ranges in length from 24 to 36, with 24 to 30 as the most common. Two pairs of post-hypostomal setae are present.

Biology

This species was rarely collected in this study as the following records indicate.

Peromyscus maniculatus ssp.: Callao, Juab Co., 12 Aug. 1953, 1 L

Cedar Valley, Utah Co., 8 Oct. 1951, 1 L

Cooley and Kohls (1945) listed only a few records taken from six genera of hosts. Kohls (1952) reported this species from muskrats at Locomotive Springs, Box Elder Co., Utah in March, 1951.

Ixodes ochotonae Gregson, 1941
(Figs. 16, 17, 18, 55)

Description of the Larva

Specimens examined. Eighteen specimens were analyzed. Of these, fourteen were collected by J. D. Gregson from *Ochotona* species at Glacier, B. C., Canada. The remaining four were collected from a pika at Baldy Lake, Duchesne County, Utah.

Hypostome. The width varies from 36 to 48 with variations equally dispersed and showing an average of 40. The length varies from 72 to 108, with 84 to 90 as the most common. The sides are oval in outline and taper to a moderately rounded apex. The denticles closely overlap, are rounded and coarse. The files are arranged 2/2 and 3/3 for a distance of two-thirds and one-eighth, respectively, the length of the hypostome. Files one, two and three usually possess nine, six and two denticles, respectively. Sometimes there is one tooth more or less per file.

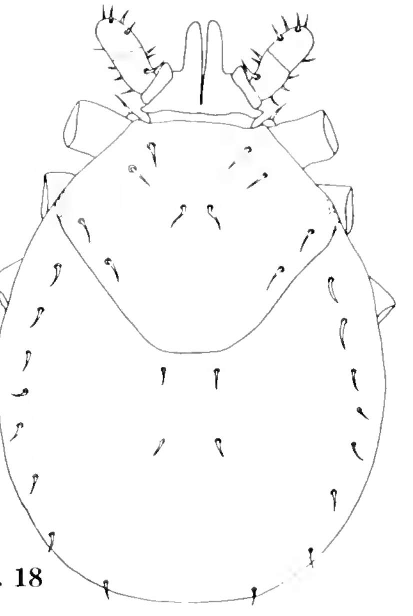


Fig. 18

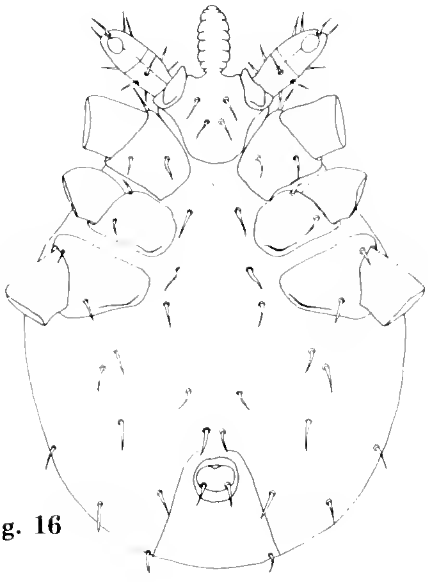


Fig. 16

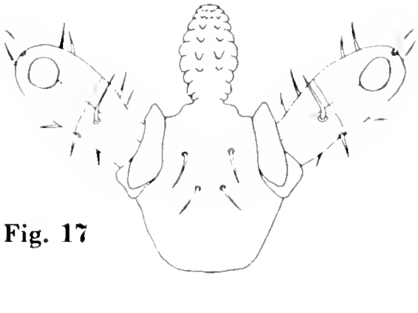


Fig. 17

Palpi. The width at the widest point varies from 42 to 72, with 60 to 64 as the most common. The length from the base of article two to the tip of article three varies from 112 to 130 with variations equally dispersed and showing an average of 118. The width of article two at its base varies from 30 to 48 with 42 as the most common. Both the inner and outer margins of articles two and three are straight to slightly convex. Article one has prominent anterior and posterior spurs. Article four is subterminal.

Basis capituli. The posteroventral margin is straight to slightly convex with the posterior curvature beginning at the base of palpal article one. The posterodorsal margin has a slight, medial convexity, and has prominently pointed, posterolateral extensions.

Scutum. The width varies from 342 to 382, with 369 to 382 as the most common. The length varies from 288 to 337, with 300 to 320 as the most common. The posterolateral margin is straight with a moderately rounded, posterior curvature. There are five pairs of scutal setae. Paired setae one and two are closely grouped, as are four and five. Pair number three is situated medially and ranges in length from 18 to 30, with 22 to 28 as the most common.

Coxae. Coxa one has an inner spur of moderate size. The anterior margin is straight to slightly convex. There are three setae present. Coxa two has a slight inner tubercle, or ridge. There are two setae present. Coxa three has a slight inner tubercle, or ridge. The anterior margin is slightly concave; the posterior margin is straight. There are two setae present.

General body setae. Eight (rarely seven) pairs of marginal dorsal setae are present. Pair number one ranges in length from 17 to 36, with 24 to 30 as the most common. Two pairs of central dorsal setae are present. Pair number one ranges in length from 18 to 30, with 24 to 30 as the most common. Three pairs of sternal setae are present. Pair number one ranges in length from 29 to 42 with 36 as the most common. The setae vary from a parallel to triangular arrangement. Two pairs of pre-anal setae are present. Pair number one ranges in length from 24 to 36 with 30 to 36 as the most common. Three pairs of marginal ventral setae are present. Pair number one ranges in length from 18 to 29, with 22 to 29 as the most common. Two pairs of post-hypostomal setae are present.

Biology

Host preference. The larvae of *ochotonae* were found with about equal frequency on the deer mouse, *Peromyscus maniculatus*, the Uinta ground squirrel, *Spermophilus armatus*, and the pika, *Ochotona princeps*. Only one nymph was collected, and no males were found. Adult females apparently prefer the pika as their host. Cooley and Kohls (1945) listed two genera of hosts beside the pika.

Geographical and ecological distribution. Apparently this species is statewide in its distribution. It was found about equally in coniferous forest and desert shrub areas.

Seasonal activity. Larval *ochotonae* were found from March through August, except in April. The single nymph collected by us was found in June. Females were collected from May through August. Ticks were taken from the deer mouse in March, May and August, from the pika in June, July and August, and from all other hosts only during May and June. Cooley and Kohls (1945) listed collections of larvae in March, May and June, nymphs for the same months including August, females in March, June and July, and males only in July.

Habits of infestation. Most animals infested with *ochotonae* did not have more than three larvae per host. However, one northern pocket gopher, *Thomomys talpoides*, was infested with 75 larvae, and one pika with 25. Not more than one adult female tick was found on any one host.

Larvae and adult females were found together on the same animal in May and August, and larvae, a nymph and an adult female together in June.

Collection Records

Ochotona princeps ssp.: Bald Mtn., Summit Co., 25 Aug. 1956, 14 L; 7 July 1958, 1 L, 2 F

Cedar Breaks Nat. Mon., Iron Co., 20 July 1953, 6 L

Delano Ranger St., Beaver Co., 25 June 1957, 2 L

Paradise Park, Uintah Co., 31 July 1947 (RML)

Pole Creek Mtn., Duchesne Co., 24 Aug. 1957, 24 L, 2 F

Timpooneke Ranger Sta., Mt. Timpanogos, Utah Co., 18 June 1958, 12 L, 4 N, 3 F

Peromyscus crinitus ssp.: Wild Mtn., Uintah Co., 3 May 1953, 3 L

Peromyscus maniculatus ssp.: Aspen Grove, Utah Co., 24 May 1951, 1 L

Castledale, Emery Co., 22 May 1952, 14 L, 1 F

Chimney Rock Pass, Utah Co., 28 May, 1953, 5 L

Fish Lake, Sevier Co., 5 Aug. 1952, 3 L

Goshen, Utah Co., 14 May 1954, 1 F

Kanab (25 mi. E), Kane Co., 9 May 1952, 3 L

Pole Creek Mtn., Duchesne Co., 24 Aug. 1957, 1 L

Wild Mtn., Uintah Co., 2 May 1953, 5 L

Peromyscus truei ssp.: Wild Mtn., Uintah Co., 2 May 1953, 5 L

Spermophilus armatus: Strawberry Reservoir, Wasatch Co., 28 June 1951, 38 L

Spermophilus lateralis ssp.: Deep Creek, Daggett Co., 23 June 1958, 12 L

Lynn, Box Elder Co., 10 June 1957, 4 L

Thomomys talpoides ssp.: Randolph, Rich Co., 21 Aug. 1952, 75 L

The following Utah records are listed by Edmunds (1951):

Ochotona sp.: Paradise Park, Uintah Co., July 1947 and 1948

Ixodes pacificus Cooley and Kohls, 1943
(Figs. 19, 20, 21, 55)

Description of the Larva

Specimens examined. Twelve specimens lab-reared by J. D. Gregson in Canada were analyzed.

Hypostome. The width varies from 42 to 49 with 42 to 44 as the most common. The length varies from 80 to 96 with variations equally dispersed and showing an average of 91. The sides are parallel and narrowly tapered at the apex. The denticles are long, narrow and pointed with a slight separation and overlapping; they are arranged 2/2 to the base. Files one, two and three usually possess ten, nine and

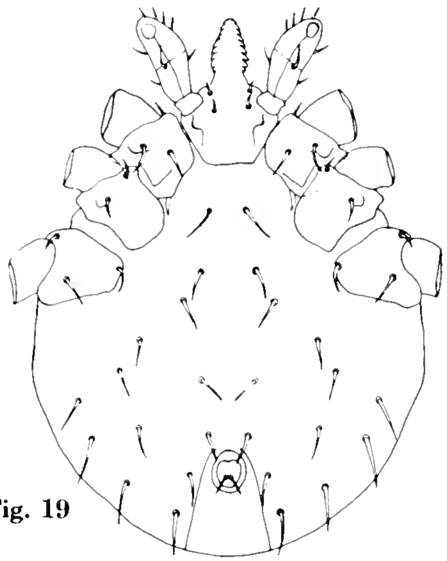


Fig. 19

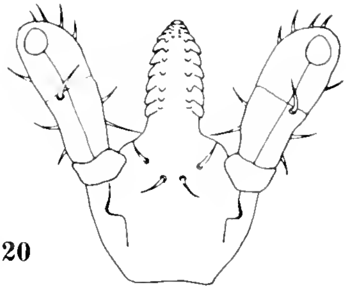


Fig. 20

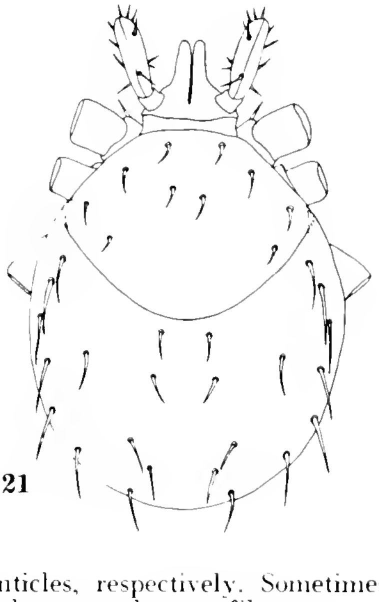


Fig. 21

three denticles, respectively. Sometimes there is one tooth more or less per file.

Palpi. The width at the widest point varies from 38 to 54 with variations equally dispersed and showing an average of 45. The length from the base of article two to the tip of article three varies from 114 to 124 with variations equally dispersed and showing an average of 119. The width of article two at its base varies from 24 to 35 with variations equally dispersed and showing an average of 30. Article one has neither anterior nor posterior projections. The inner margins of articles two and three are convex; the outer margins are straight. Article four is subterminal.

Basis capituli. The ventrolateral margin tapers medially to a narrow, blunt posterior margin. Ridged auriculae are present and are located medially to the posterolateral curvature on the venter. The posterodorsal margin is flattened with prominent posterolateral extensions which are rounded to slightly pointed.

Scutum. The width measurements were not made since the lateral margins were indistinct. The length varies from 270 to 292 with variations equally dispersed and showing an average of 284. The posterior margin is uniformly rounded. There are five pairs of scutal setae. Setae one, two, four and five are about equally spaced with one, two and four situated along the lateral margin. Pair five is situated posteromedially to the posterolateral curvature. Number three is situated anteromedially. Pair number three ranges in length from 28 to 38, with 29 to 30 as the most common.

Coxae. Coxa one has a prominent, acute inner spur. The outer spur is approximately one-sixth as large as the inner spur. There are three setae present. Coxa two has a small outer spur. The posterior margin is variable. There are two setae present. Coxa three is without spurs. The anteromedial and posteromedial margins bear a slight concavity. Three setae are present.

General body setae. Seven pairs of marginal dorsal setae are present. Pair number one ranges in length from 73 to 84 with variations equally dispersed and showing an average of 78. Four pairs of central dorsal setae are present. Pair number one ranges in length from 32 to 48 with variations equally dispersed and showing an average of 41. There is one pair of supplementary setae which ranges in length from 42 to 61 with 54 as the most common. The setae are arranged in a parallel to slightly triangular outline. Two pairs of pre-anal setae are present. Pair number one ranges in length from 28 to 43, with 32 to 36 as the most common. Four pairs of pre-marginal setae are present. Pair number one ranges in length from 29 to 42, with 35 to 36 as the most common. Four pairs of marginal ventral setae are present. Pair number one ranges in length from 38 to 64, with 44 to 48 as the most common. Two pairs of post-hypostomal setae are present, although pair number two is sometimes absent.

Biology

Host preference. Our few records of collection for this species indicate that the piñon mouse, *Peromyscus truei* is the most common host for the larval stage. Nymphs were found only on the deer mouse, *P. maniculatus*, whereas the adults were found more frequently on mammals other than rodents. Cooley and Kohls (1945) listed at least 19 genera of hosts for this tick, mostly from the Pacific coast region of the western United States. In their listing, lizards were indicated as frequent hosts for larvae and nymphs. This was especially true of the alligator lizard, *Gerrhonotus*, common to the Pacific Coast area, but absent in Utah.

Geographical and ecological distribution. The few records are known primarily from the ranges of mountains running north and south through central Utah. Ecologically, the ticks have been found in desert shrub as well as coniferous forest areas.

Seasonal activity. Larvae and nymphs were found in April and July, adult males and females in July and October, and females also in November. Ticks were found on the piñon mouse only in April.

Cooley and Kohls (1945) listed records for larvae from March to June, nymphs from March to June and in January and August, females from January to May and in July and November. and males from February to May, none of these being from Utah.

Habits of infestation. Usually no more than one tick of this species was found on a host. However, one piñon mouse had five larvae, and a mule deer had eight adult females.

Larvae, nymphs and adults were found on the same host in July.

Collection Records

Dama hemionus hemionus: Mt. Nebo, Utah Co., 22 Oct. 1955, 2 M, 8 F

Homo sapiens (adult): Mt. Nebo, Utah Co., 22 Oct. 1955, 1 F

Peromyscus eremicus eremicus: Beaver Dam Wash, Washington Co., 16 Apr. 1952, 2 L

Peromyscus maniculatus ssp.: Nephi, Juab Co., 12 July 1952, 1 L, 1 N, 1 M, 1 F
Provo Canyon, Utah Co., 26 Apr. 1951, 4 N

Peromyscus truei ssp.: Beaver Dam Wash, Washington Co., 17 Apr. 1952, 7 L
Rush Valley, Tooele Co., 7 Apr. 1950, 1 L

Magpie Nest: Provo, Utah Co., 9 Oct. 1953, 1 N, 1 F

Edmunds (1951) listed additional records from Utah as follows:

Homo sapiens: Bush Creek, Beaver Co., Oct. 1938
Holden, Millard Co., Oct. 1945
Pinto, Washington Co., Oct. 1938

Beck (1955) listed the following Utah records:

Canis familiaris: Provo, Utah Co., 8 Nov. 1953, 2 F

Dama hemionus: Silver City, Juab Co., 17 17 Oct. 1953, 2 M, 2 F

Homo sapiens (child): Provo, Utah Co., 6 Nov. 1953, 1 F

Ixodes sculptus Neumann, 1904
(Figs. 22, 23, 24, 56)

Description of the Larva

Specimens examined. Nineteen specimens were analyzed. Of these, eighteen were collected from *Thomomys talpoides* five miles northeast of Woodland, Wasatch County, Utah. The remaining specimen was collected from *Spermophilus richardsoni* at Cadillac, Saskatchewan, Canada.

Hypostome. The width varies from 46 to 58 with variations equally dispersed and showing an average of 51. The length varies from 64 to 84 with variations equally dispersed and showing an average of 73. The hypostome is oval in outline with a moderately rounded apex. The denticles moderately overlap and

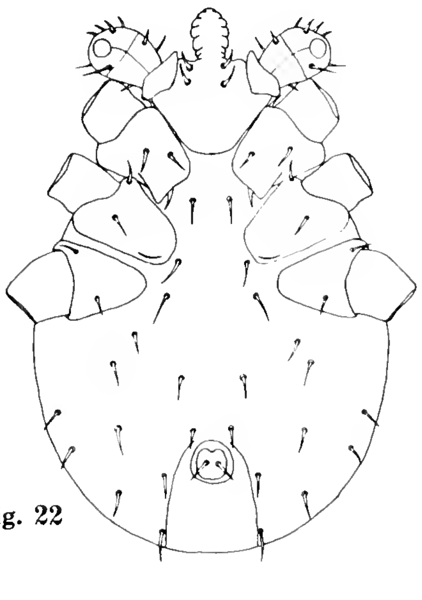


Fig. 22

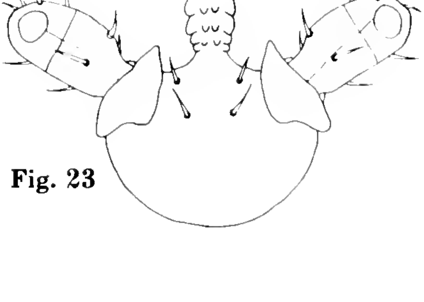


Fig. 23

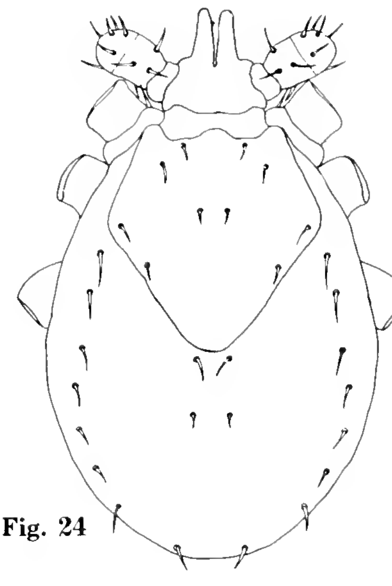


Fig. 24

are rounded. The files are arranged 2/2 to the base and 3/3 for a distance of one-eighth the length of the hypostome. Files one, two and three usually possess seven, six and two denticles, respectively. Sometimes there is one tooth more or less per file.

Palpi. The width at the widest point varies from 64 to 81 with variations equally dispersed and showing an average of 70. The length from the base of article two to the tip of article three varies from 94 to 108 with variations equally dispersed and showing an average of 100. The width of article two at its base varies from 31 to 54 with variations equally dispersed and showing an average of 45. The inner and outer margins of articles two and three are moderately to strongly convex. Article one bears prominent anterior and posterior spurs. Article four is sub-terminal.

Basis capituli. The posteroventral margin is broadly rounded. The posterodorsal margin is flattened with a prominent, moderately pointed cornu at the posterolateral margin.

Scutum. The width varies from 290 to 305 with variations equally dispersed and showing an average of 297. The length varies from 265 to 333, with 288 to 292 as the most common. The posterolateral margin is straight and tapers posteriorly to a narrowly rounded point. There are five pairs of scutal setae. Setae one and two, and four and five are closely grouped. One and two are situated anterolaterally while four and five are situated posterolaterally, with number three situated medially. Pair number three ranges in length from 8 to 18, with 10 to 13 as the most common.

Coxae. Coxa one has a prominent spur. The anterior and posterior margins are straight. There are three setae present. Coxa two has a slight inner ridge. The anterior and posterior margins of coxa two are straight. There are two setae present.

General body setae. Six to eight pairs of marginal dorsal setae are present. Pair number one ranges in length from 18 to 50, with 20 to 30 as the most common. Two pairs of central dorsal setae are present. Pair number one ranges in length from 12 to 29, with 16 to 20 as the most common. Three pairs of sternal setae are present. Pair number one ranges in length from 23 to 31, with 26 to 30 as the most common. The setae are arranged in a triangular outline. Two pairs of pre-anal setae are present. Pair number one ranges in length from 17 to 26, with 18 and 19 as the most common. Four pairs of pre-marginal setae are present. Pair number one ranges in length from 16 to 24 with variations equally dispersed and showing an average of 19. Four (sometimes three) pairs of marginal ventral setae are present. Pair number one ranges in length from 12 to 24, with 17 to 24 as the most common. Two pairs of post-hypostomal setae are present.

Biology

Host preference. Relatively few animals were found infested with larvae, and no host species was infested more than any other.

Nymphal ticks apparently select the Uinta ground squirrel, *Spermophilus armatus*, for their preferred host, although this stage was also found on a variety of other genera of animals.

The few adult female ticks collected were taken most commonly from the northern pocket gopher, *Thomomys talpoides*. No adult male ticks were found by our surveys.

Cooley and Kohls (1945) listed at least seven genera of hosts for this tick, most of them from the western United States. Their listing also showed *Spermophilus* to be the most frequently infested.

Geographical and ecological distribution. *Ixodes sculptus* was found at higher elevations in coniferous forest regions, although some collections were made at lower elevations in desert shrub habitats. Ticks collected at lower elevations in desert areas probably were transported there by animals from higher elevations.

Seasonal activity. Collections of all developmental stages were made during June, July and August. Adult females were also taken in April. This may not be a true picture of the seasonal activity, for few host animals were collected during the other months of the year because of their hibernation habits and the relative inaccessibility of the areas because of deep snows. Ticks were found on the Uinta ground squirrel from June to August, on the northern pocket gopher in April and from June to August, and on other hosts mainly in June and July.

Cooley and Kohls (1945) listed records of larvae from April to August, nymphs from April to December, females from February to December, and males from April to November (except October).

Habits of infestation. No animals were found heavily parasitized with *sculptus* ticks. Most animals had only one or two ticks, and none was found infested with more than eight larvae or nymphs. One Uinta ground squirrel was found infested with five adult females.

Larval and nymphal *sculptus* were found together on ground squirrels both in June and August, and all stages except adult males were found on a gopher in June.

Collection Records

Cynomys parvidens: Panguitch (10 mi. N.), Garfield Co., 25 July 1952, 1 L

Marmota flaviventer ssp.: Deep Creek, Daggett Co., 22 June 1958, 2 L, 6 N

Microtus longicaudus ssp.: Big Tree Camp, Mt. Timpanogos, Utah Co., 22 June 1951, 2 N

Mt. Pleasant (7 mi. E), Sanpete Co., 2 Aug. 1951, 8 L

Microtus montanus ssp.: Delano Ranger Sta., Beaver Co., 25 June 1957, 5 N

Mustela frenata nevadensis: Provo, Utah Co., 21 Aug. 1951, 1 F

Cedar Breaks Nat. Mon., Iron Co., 18 July 1953, 3 F

Ochotona princeps ssp.: Pole Creek Mtn., Duchesne Co., 24 Aug. 1957, 41 N

Perognathus longimembris ssp.: Joy, Juab Co., 1 June 1951, 1 N

Spermophilus armatus: Current Creek, Wasatch Co., 2 Aug. 1952, 3 F

Fish Lake, Sevier Co., 11 July 1952, 1 N

Lake Creek Summit (6 mi. W), Wasatch Co., 7 Aug. 1953, 2 L, 5 N

Laketown, Rich Co., 26 June 1953, 2 L, 1 N

Mt. Pleasant (11 mi. E), Sanpete Co., 1 Aug. 1951, 2 L, 1 N

Soldiers Summit, Wasatch Co., 7 June 1951, 4 N

Strawberry Reservoir, Wasatch Co., 28 June 1951, 16 N

Summit Co., 13 June 1938 (RML)

Woodland, Wasatch Co., 18 June 1953, 7 L, 5 N, 5 F

Spermophilus beldingi crebrus: Goose Creek Mountains, Box Elder Co., 9 May 1952

Lynn, Box Elder Co., 10 June 1957, 2 N

Spermophilus lateralis ssp.: Cedar Breaks Nat. Mon., Iron Co., 18 July 1953, 1 F

Delano Ranger Sta., Beaver Co., 25 June 1957, 3 L

Woodruff, Rich Co., 24 June 1953, 6 N

Spermophilus richardsoni ssp.: Randolph, Rich Co., 17 July 1951, 1 F

Taxidea taxus ssp.: Deer Creek Dam, Wasatch Co., 26 July 1952, 1 F

Thomomys talpoides ssp.: Cedar Breaks Nat. Mon., Iron Co., 19 July 1953, 1 F

Delano Ranger Sta., Beaver Co., 25 June 1957, 6 N

Fish Lake, Sevier Co., 5 Aug. 1952, 3 N

Kigalia Ranger Sta., San Juan Co., 9 June 1953, 4 F

Provo, Utah Co., 14 Apr. 1951, 1 F

Woodland (5 mi. NE), Summit Co., 17 June 1953, 53 L, 2 N, 6 F

Zapus princeps ssp.: Big Tree Camp, Mt. Timpanogos, Utah Co., 22 June 1951, 1 L

Host Unknown: Lucin, Box Elder Co., 18 June 1952, 1 L

Additional Utah records listed by Cooley and Kohls (1945) are as follows:

Spermophilus armatus: Rich Co., May 1938, 1 F

Summit Co., June 1938, 1 N, 2 F, 3 Adults

Edmunds (1951) listed the following records for Utah:

Spermophilus armatus: Logan Canyon, Cache Co., Mar. 1942

Thomomys sp.: Gooseberry Ranger Sta., San Juan Co., July 1947

Monticello (5 mi. W), San Juan Co., July 1947

Ixodes spinipalpis Hadwen and Nuttall, 1916 (Figs. 25, 26, 27, 56)

Description of the Larva

Specimens examined. Thirteen specimens were analyzed. Of these, eleven were collected

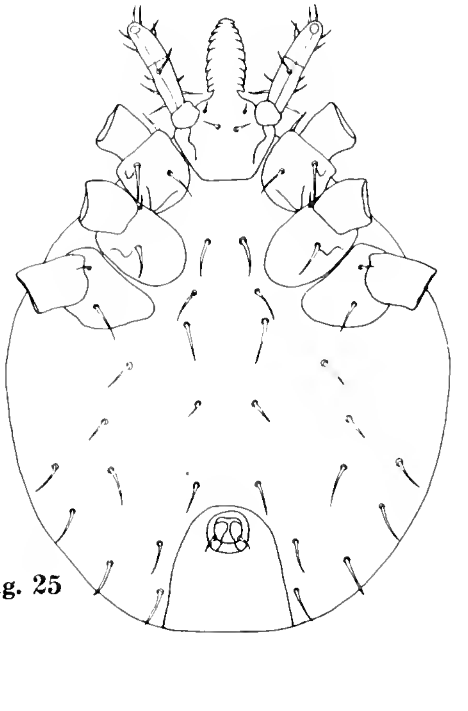


Fig. 25

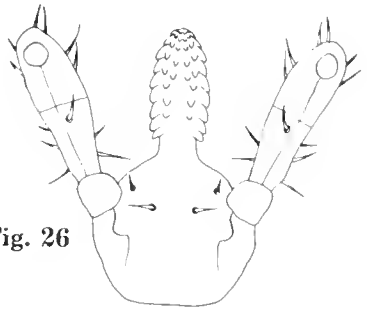


Fig. 26

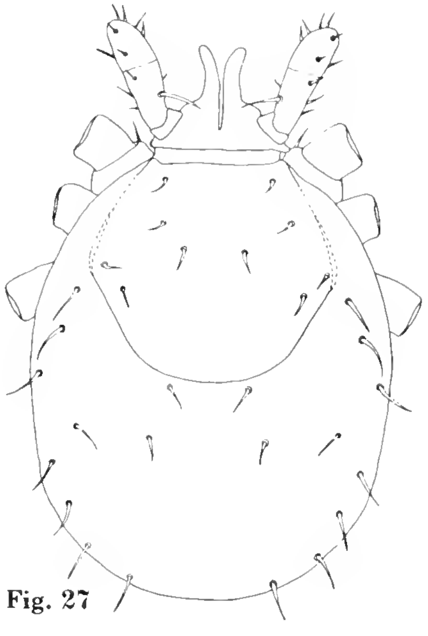


Fig. 27

from *Peromyscus maniculatus* at Marysvale, Piute County, Utah. The remaining two were collected by J. D. Gregson from *P. maniculatus* at Silver Creek, B. C., Canada.

Hypostome. The width varies from 44 to 48 with variations equally dispersed and showing an average of 47. The length varies from 101 to 114 with 110 to 114 as the most common. The sides are the widest at the mid-point and taper to a moderately rounded apex. The denticles are moderately pointed and overlap. The files are arranged 2/2 and 3/3 for a distance of seven-eighths and one-third, respectively, of the hypostome length. Files one, two and three usually have ten, eight and four denticles, respectively. Sometimes there is one tooth more or less per file.

Palpi. The width at the widest point varies from 36 to 54 with variations equally dispersed and showing an average of 47. The length from the base of article two to the tip of article three varies from 134 to 150, with 138 to 144 as the most common. The width of article two at its base varies from 23 to 36 with variations equally dispersed and showing an average of 29. Article one has neither anterior nor posterior projections. The inner margins are straight. Article four is sub-terminal.

Basis capituli. The ventrolateral margin tapers medially to a narrow, blunt posterior margin. Ridged auriculae are present medially to the posterolateral curvature on the venter. The posterodorsal margin is flattened with posterolateral extensions which vary from being pointed to slightly rounded.

Scutum. The width measurements were not made since the lateral margins were indistinct. The length varies from 285 to 310 with 292 as the most common. The posterior margin is uniformly rounded. There are five pairs of scutal setae. Setae one and two, and four and five are closely grouped, with four and five situated at the posterolateral curvature. Pair three is situated medially and ranges in length from 22 to 32 with 30 as the most common.

Coxae. Coxa one has a prominent inner spur, attenuated in shape. The outer spur is about one-sixth as large as the inner spur. There are three setae present. Coxa two is oval except for the lateral margin. A small outer spur is present. There are two setae present. Coxa three lacks spurs or tubercles. The posterior margin is straight to convex. The anterior margin is straight to slightly concave. There are three setae present.

General body setae Seven pairs of marginal dorsal setae are present. Pair number one ranges in length from 52 to 74, with 55 to 66 as the most common. Two pairs of central dorsal setae are present. Pair number one ranges in length from 24 to 35, with 30 to 34 as the most common. There is one pair of supplementary setae which ranges in length from 20 to 48, with 20 to 30 as the most common. Three pairs of sternal setae are present. Pair number one ranges in length from 44 to 59 with variations equally dispersed and showing an average of 48. The setae are arranged in a triangular outline. Two pairs of pre-anal setae are present. Pair number one ranges in length from 32 to 44 with variations equally dispersed and showing an average of 36. Four pairs of pre-marginal setae are present. Pair number one ranges in length from 30 to 44 with variations equally dispersed and showing an average of 36. Four pairs of marginal ventral setae are present. Pair number one ranges in length from 24 to 48, with 36 to 42 as the most common. Two pairs of post-hypostomal setae are present.

Biology

Host preference. Larvae of *spinipalpis* were found more frequently on deer mice than on other species of animals. The few nymphs taken were found most commonly on the pika, *Ochotona princeps*. The single collections of adult males and females also were taken from pikas.

Cooley and Kohls(1945) listed five genera of hosts for this tick from the western United States.

Geographical and ecological distribution. This species of tick probably is statewide in its distribution. It was collected about equally from desert shrub and coniferous forest areas, although in Utah it likely is more common at higher elevations.

Seasonal activity. Seasonally, larvae were collected from April through September, nymphs from April through December (except August), an adult male in September and an adult female in July. Ticks were taken from deer mice in April, June, August and October. from pikas in July, September and November, and from all other hosts only from April to June.

Cooley and Kohls (1945) listed records of larvae in February, nymphs from February to October (except March, June and July), females from April to December (except July), and males in February, April, August, September and October.

Habits of infestation. Seldom was more than one specimen of the same stage of this species found on a single host animal. However, a deer mouse, *Peromyscus maniculatus*, was infested with 19 larvae, and two pikas with 10 and 16 larvae, respectively.

Larvae and nymphs were found together on the same animal in July.

Collection Records

Dipodomys merriami ssp.: Beaver Dam Wash, Washington Co., 21 Dec. 1950, 1 N
Neotoma lepida ssp.: Marysvale, Piute Co., 27 June, 1952, 3 L
Ochotona princeps ssp.: Baldy Lake, Duchesne Co., 7 Sept. 1952, 5 L, 1 N, 1 F
Cedar Breaks Nat. Mon., Iron Co., 20 July 1953, 16 L, 2 N, 1 F
Mt. Timpanogos, Utah Co., 8 Nov. 1958, 1 N
Wolfcreek Summit, Wasatch Co., 7 Sept. 1953, 10 L, 1 N
Peromyscus maniculatus ssp.: Callao, Juab Co. 12 Aug. 1953, 1 L
Palmyra Forest Camp, Diamond Fork Canyon, Utah Co., 26 June 1951, 4 L
Provo Canyon, Utah Co., 26 Apr. 1951, 1 L
Peromyscus truei ssp.: Beaver Dam Wash. Washington Co., 27 June 1952, 3 L
Marysvale, Piute Co., 27 June, 1952, 3 L
Rock Canyon, Utah Co., 22 May 1952, 7 L
Sorex vagrans monticola: Provo Canyon, Utah Co., 26 Apr. 1951, 11 L

Edmunds (1951) listed a Utah record, host unknown, collected near Ouray, Uintah Co., in 1946.

Additional records for Utah are listed by Beck (1955) as follows:

Onychomys leucogaster: Kanab (50 mi. E). Kane Co., 8 May 1952, 1 N
Perognathus formosus: Beaver Dam Slope, Washington Co., 17 Apr. 1952, 3 N
Peromyscus eremicus: Beaver Dam Slope, Washington Co., 15 Apr. 1952, 2 N
Peromyscus maniculatus: Marysvale, Piute Co., 27 June 1952, 21 L. 4 N
Provo, Utah Co.. 14 Oct. 1949, 1 N

Ixodes texanus Banks, 1908
(Figs. 28, 29, 30, 56)

Description of the Larva

Specimens examined. Eighteen specimens were analyzed. Of these, sixteen were lab-reared and received from C. M. Clifford, University of Maryland. The remaining two were collected by R. B. Eads from a red fox in Limestone County, Texas.

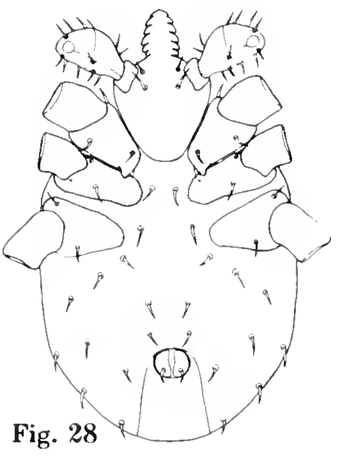


Fig. 28

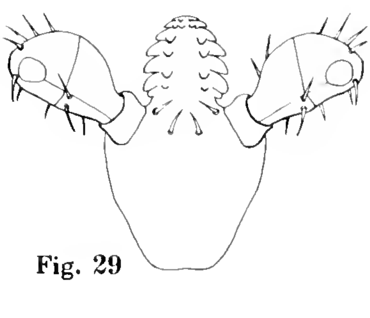


Fig. 29

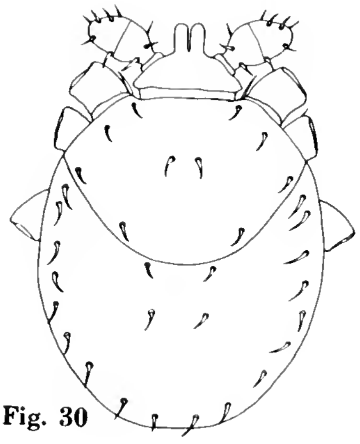


Fig. 30

Hypostome. The width varies from 45 to 60, with 54 to 58 as the most common. The length varies from 55 to 108 with 60 as the most common. The hypostome is slightly oval in outline. The denticles are separated with only slight overlapping, and are moderately pointed. Denticles of files one and two are arranged 2/2 to the base. Files one, two and three usually possess seven, six and one denticles, respectively. Sometimes there is one tooth more or less per file.

Palpi. The width at the widest point varies from 48 to 72 with 66 as the most common. The length from the base of article two to the tip of article three varies from 102 to 116 with variations equally dispersed and showing an average of 111. The width of article two at its base varies from 28 to 42 with 42 as the most common. Article one has neither anterior nor posterior projections and is about one-third as large as the hypostome. The inner margins of articles two and three are strongly convex, while the outer margins are straight. Article four is sub-terminal.

Basis capituli. The ventrolateral margin tapers medially to a narrow, blunt posterior margin. The posterodorsal margin is flattened with a small, round to pointed posterolateral extension.

Scutum. The width varies from 292 to 335 with variations equally dispersed and showing an average of 311. The length varies from 252 to 319 with 270 as the most common. The posterior margin is rounded. There are five pairs of setae present. Setae one, two, four and five are equally spaced along the lateral and posterolateral margin. Pair three is situated medially and slightly anteriorly, and ranges in length from 24 to 37, with 30 to 31 as the most common.

Coxae. Coxa one has a sightly rounded, inner spur. There are three setae present. The anterior and posterior margins of coxa two are straight. There are two setae present. Coxa three lacks spurs or tubercles. The anterior and posterior margins are straight to slightly concave. There are two setae present.

General body setae. Nine (sometimes eight) pairs of marginal dorsal setae are present. Pair number one ranges in length from 30 to 40 with 30 as the most common. Two pairs of central dorsal setae are present. Pair number one ranges in length from 25 to 42 with 30 as the most common. The setae are arranged in a triangular outline. Two pairs of pre-anal setae are present. Pair number one ranges in length from 19 to 28 with 24 as the most common. Four pairs of pre-marginal setae are present. Pair number one ranges in length from 22 to 36, with 24 to 26 as the most common. Two pairs of post-hypostomal setae are present.

Biology

Host preference. Rarely collected in our surveys, this species was found only on predatory animals: long-tailed weasel, *Mustela frenata*, mink, *M. vison*, *Martes* sp., and the western spotted skunk, *Spilogale gracilis*.

Cooley and Kohls (1945) listed eight genera of hosts for this tick.

Seasonal activity. Nymphs were found in July and August, and adult females in May, June and August. Larvae were found only in August, and no adult males were collected.

Cooley and Kohls (1945) listed collections of larvae in April, nymphs in January, March, April and December, females from January to July and in December, and males in March.

Habits of infestation. A marten was infested with 107 larvae, and one skunk was infested with 11 nymphs. All other collections consisted of only one tick per host. Nymphs and adults were found on the same host animal in August.

Collection Records

Martes sp.: Bald Mtn., Summit Co., 8 Aug. 1957, 107 L

Beck (1955) listed several Utah records as follows:

Mustela vision: La Sal Mtns., San Juan Co., 6 May 1949, 2 F

Mustela frenata: Cedar Breaks Nat. Mon., Iron Co., 18 July 1953, 2 N

Spilogale gracilis: Callao, Juab Co. 12 Aug. 1953, 11 N, 1 F

Kingston, Piute Co., 26 June 1952, 1 F

Ixodes sp.

In our collections were a number of specimens that were mutilated too severely to be identified. There were also several specimens which were sufficiently different morphologically that some question exists as to their specific placement. These records are listed below as *Ixodes* sp.

Cynomys leucurus: Roosevelt, Duchesne Co., 21 Aug. 1952, 3 L

Dipodomys microps ssp.: Beaver Dam Slope, Washington Co., 22 Apr. 1955, 1 L

Chimney Rock Pass, Utah Co., 23 Apr. 1953, 1 L

Dipodomys ordii ssp.: Cedar Valley, Utah Co., 28 Feb. 1953, 1 L

Chimney Rock Pass, Utah Co., 23 Apr. 1953, 2 L

Lucin, Box Elder Co., 11 Oct. 1952, 7 L; 14 Feb. 1953, 3 L; 23 May 1953, 1 L

Eutamias minimus ssp.: George Creek, Box Elder Co., 9 July 1957, 1 L

Microtus longicaudus ssp.: Aspen Grove, Utah Co., 22 June 1951, 1 L

Mustela frenata nevadensis: Cedar Breaks Nat. Mon., Iron Co., 18 July 1953, 2 N

Onychomys leucogaster ssp.: Lucin, Box Elder Co., 14 Feb. 1953, 2 L

Onychomys torridus longicaudus: Beaver Dam Wash, Washington Co., 17 Apr. 1952, 3 L

Onychomys sp.: Toquerville, Washington Co., 5 Sept. 1951, 1 L

Perognathus formosus ssp.: Grafton, Washington Co., 5 Apr. 1952, 6 L

Perognathus longimembris ssp.: Beaver Dam Wash, Washington Co., 17 Apr. 1952, 2 L

Perognathus parvus ssp.: Cedar Valley, Utah Co., 1 Nov. 1952, 2 L

Perognathus sp.: Beaver Dam Wash, Washington Co., 15 Apr. 1952, 1 L

Peromyscus crinitus ssp.: Fairview, Sanpete Co., 14 Nov. 1953, 1 L

Genola, Utah Co., 13 Jan. 1952, 1 L

Wild Mtn., Uintah Co., 3 May, 1953, 1 N

Peromyscus eremicus eremicus: Beaver Dam Wash, Washington Co., 17 Apr. 1952, 2 L

Grafton, Washington Co., 5 Apr. 1952, 2 L

Peromyscus maniculatus ssp.: Castledale, Emery Co., 22 May, 1952, 1 L

Chimney Rock Pass, Utah Co., 28 Mar. 1953, 1 L; 23 Apr. 1953, 7 L; 28 May 1953, 1 L

Desert Range Exp. Sta., Millard Co., 12 Sept. 1950, 1 L

Grafton, Washington Co., 5 Apr. 1952, 5 L

Joy, Juab Co., 1 June 1951, 1 N

Kanab (25 mi. E), Kane Co., 9 May 1952, 5 L

Lucin, Box Elder Co., 14 Feb. 1953. 1 L; 24 May 1953, 1 L

Marysvale, Piute Co., 27 June 1952, 3 L

Reithrodontomys megalotis ssp.: Pink Dunes, Kane Co., 11 July 1953, 1 F

Sorex vagrans monticola: Aspen Grove, Utah Co., 26 Apr. 1951, 1 L

Spermophilus armatus: Strawberry Reservoir, Wasatch Co., 28 June 1951, 1 L

Spermophilus lateralis ssp.: Delano Ranger Sta., Beaver Co., 25 June 1957, 1 L

Thomomys talpoides ssp.: Delano Ranger Sta., Beaver Co., 25 June 1957, 1 L

DISCUSSION

Larval Intraspecific Morphological and Anatomical Variations

With the exception of the setae, all major intraspecific differences observed were between specimens from different geographical areas. Of the specimens analyzed in this study, there was a direct correlation between intraspecific morphological and anatomical differences and geographical distribution. For example, with reference to specimens of *ochotonae* from Utah and Canada, those specimens which possesed similar characteristics were from the same geographic area. The same condition was also observed with *texanus* from Texas and the eastern United States, and *sculptus* from Utah and Canada.

There was little difference between the limits of variation of certain structures of specimens from a single parent reared in the laboratory and those specimens from several different areas.

Setae. Some variation in the numbers and lengths of setae and in the dimensions of other structures between specimens of the same species were observed. In only a few cases were there extremes in numbers or dimensions.

The brief description and sketch of the larva of *angustus* taken from *Sciurus hudsonicus douglasi* by Nuttall *et al.* (1911) showed marked differences from specimens observed in this study. These differences were in the number of setae and the presence or absence of coxal spurs. In his sketch, Nuttall showed five marginal dorsal setae, one central dorsal, no pre-marginal, no pre-anal, two sternal, and two ventral setae. No coxal spurs were indicated. Of the specimens examined in this study, seventeen possessed eight marginal dorsal setae, and three had seven marginal dorsal setae. All twenty specimens possessed two central dorsal setae, four pre-marginal, one pre-anal, three sternal, and three marginal ventral setae. Coxal spurs occurred on all three legs. Lack of detail in the sketch by Nuttall may indicate that setal details were never intended to be accurately shown. However, the absence of coxal spurs was cited by Nuttall as a taxonomic characteristic. Statements made by Nuttall indicate that some adults were reared from nymphs and that all stages were found at the same time on the host. However, no specific mention was made that the larvae that were studied were reared from eggs deposited by an identifiable adult. Bequaert (1946) indicated that the nymphal drawings and descriptions by Nuttall *et al.* (1911) were erroneous. Since the larva was of the same source as the nymphs, it seems probable that the larval sketch was also erroneous. However, in the present study, *angustus* was also identified on the basis of its presence with two identified nymphs taken from *Peromyscus crinitus.* Because of the lack of study of laboratory reared specimens, identity of these larvae as *angustus* is still open to question.

Analysis of the number of setae for each of the nine species of *Ixodes* larvae revealed only slight variations. When setae were absent on the specimens studied, the absence occurred most frequently with the marginal ventral setae, marginal dorsal and scutal setae. It seems probable that the setae of the marginal and scutal areas are those which are most exposed to damage through handling and manipulation. Although the setal bases of missing setae could usually be seen, inadequate clearing and occasional folding of the body margin made an accurate count of the marginal setae or their bases difficult.

The marginal dorsal setae were more variable in number than any other group of setae. *Ixodes muris, pacificus* and *spinipalpis* showed no intraspecific variations. One specimen of *kingi* possessed seven pairs of marginal dorsal setae as contrasted to eight pairs for the other specimens. *Ixodes texanus* showed equal variation between eight and nine pairs of marginal dorsal setae with one specimen having seven pairs. A few specimens of *marmotae* possessed marginal dorsal setae which varied in number from six to nine pairs. Variations from seven to eight pairs of marginal dorsal setae were observed on *ochotonae. Ixodes angustus* possessed eight pairs of marginal dorsal setae except for three specimens which possessed seven pairs. The marginal dorsal setae of *sculptus* ranged between six and eight pairs.

The central dorsal setae of *kingi, texanus, spinipalpis, ochotonae, angustus* and *sculptus* showed no intraspecific variation. Three specimens of *muris* possessed three pairs of central dorsal setae, whereas all others possessed four pairs. One specimen of *pacificus* possessed three pairs of central dorsal setae; all others possessed four pairs One specimen of *marmotae* possessed three pairs of central dorsal setae, whereas all others had two pairs.

The supplementary setae were present only on specimens of *muris, pacificus* and *spinipalpis.* Only *spinipalpis* showed variation. The supplementary setae of two specimens apparently were missing. This variation may be the result of broken setae whose bases were not discernable due to inadequate clearing.

Intraspecific variations of the marginal ventral setae were observed with *texanus* and *sculptus.* Two specimens of *ochotonae* also showed intraspecific variations.

Only one specimen of *sculptus* showed variation of the pre-marginal setae. Four pairs were common, but one specimen possessed three pairs.

The marginal ventral setae of *kingi, muris, pacificus, spinipalpis, marmotae* and *angustus* showed no intraspecific variations. *Ixodes texanus* showed equal variations between three and four pairs of setae. *Ixodes ochotonae* possessed three pairs of marginal ventral setae except for two specimens which had two and four pairs, respectively. Half of the specimens of *sculptus* observed possessed three pairs of marginal ventral setae, whereas the other half possessed four pairs.

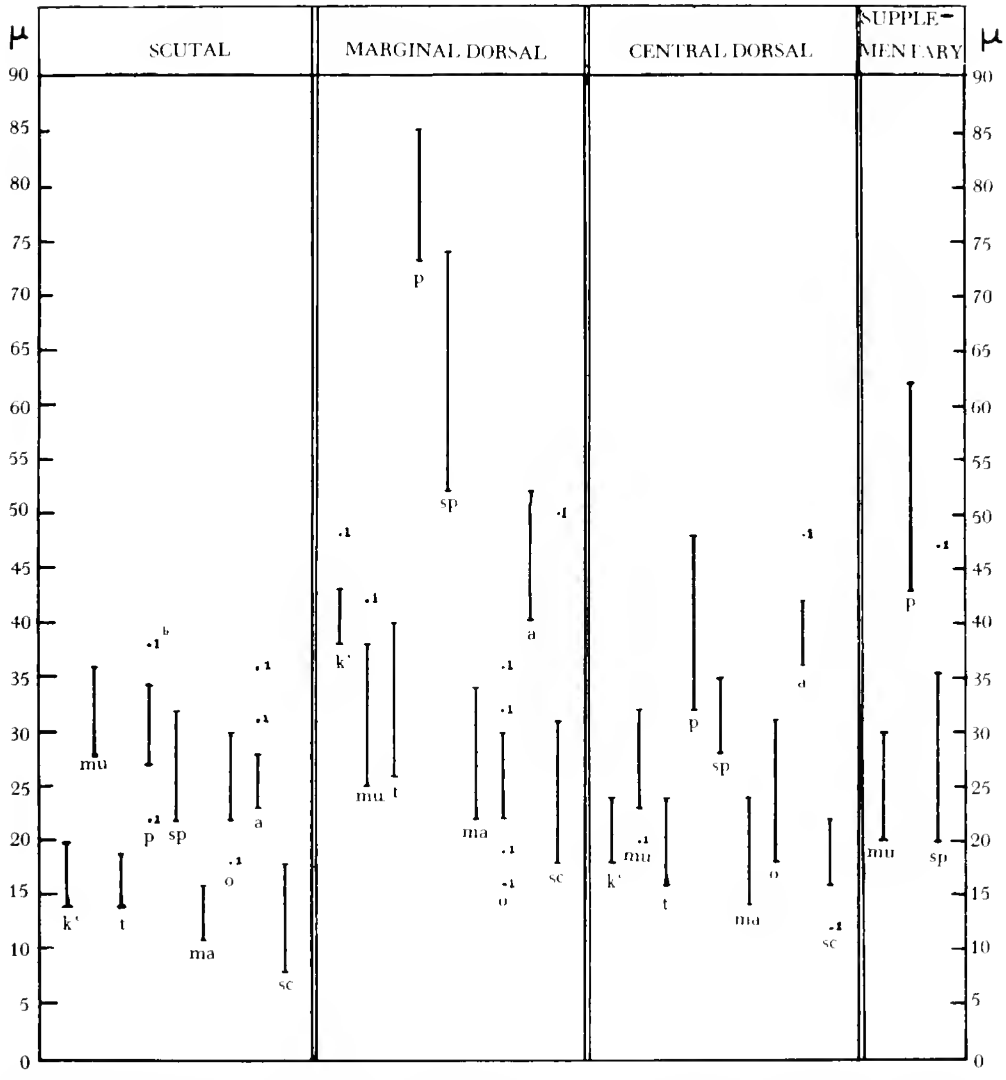
The total percentage of setae found missing on all specimens examined was only 4.4 percent. Occasionally extra setae were observed, but of the total number of setae examined on all specimens, extra setae were observed in only 0.4 percent of the cases.

Intraspecific variation with regards to the minimum lengths of setae was found to differ considerably in some cases (Tables 1 and 2). The range of variation of the scutal setae of *texanus* was 6 microns, whereas with *spinipalpis* the range was 20 microns. The length of the marginal dorsal setae of *kingi* varied 5 microns (except for one extreme), whereas those of *spinipalpis* varied as much as 22 microns. The range of variation of the central dorsal setae of *kingi* was only 6 microns, whereas *pacificus* varied as much as 16 microns. The supplementary setae of *muris* varied within 10 microns, whereas those of *pacificus* varied up to 19 microns. The sternal setae of *marmotae* differed by 4 microns, whereas those of *texanus* differed by 18 microns. The range of variation of the pre-anal setae of *marmotae* was 6 microns, whereas in *pacificus* the range was 15 microns. The pre-marginal setae of *spinipalpis* varied by 6 microns (with two extreme measurements), whereas those of *pacificus* varied by 14 microns. The marginal ventral setae of *kingi* differed as little as 5 microns (with one extreme measurement), whereas those of *pacificus* varied as much as 28 microns.

Hypostome. The length-width ratio of the hypostome of two specimens of *texanus* removed from a red fox from Texas was approximately two to one. Laboratory reared specimens from the eastern United States (host of parent unknown) had a length-width ratio of one to one.

Table 1

Length comparison of certain setal measurements[a]



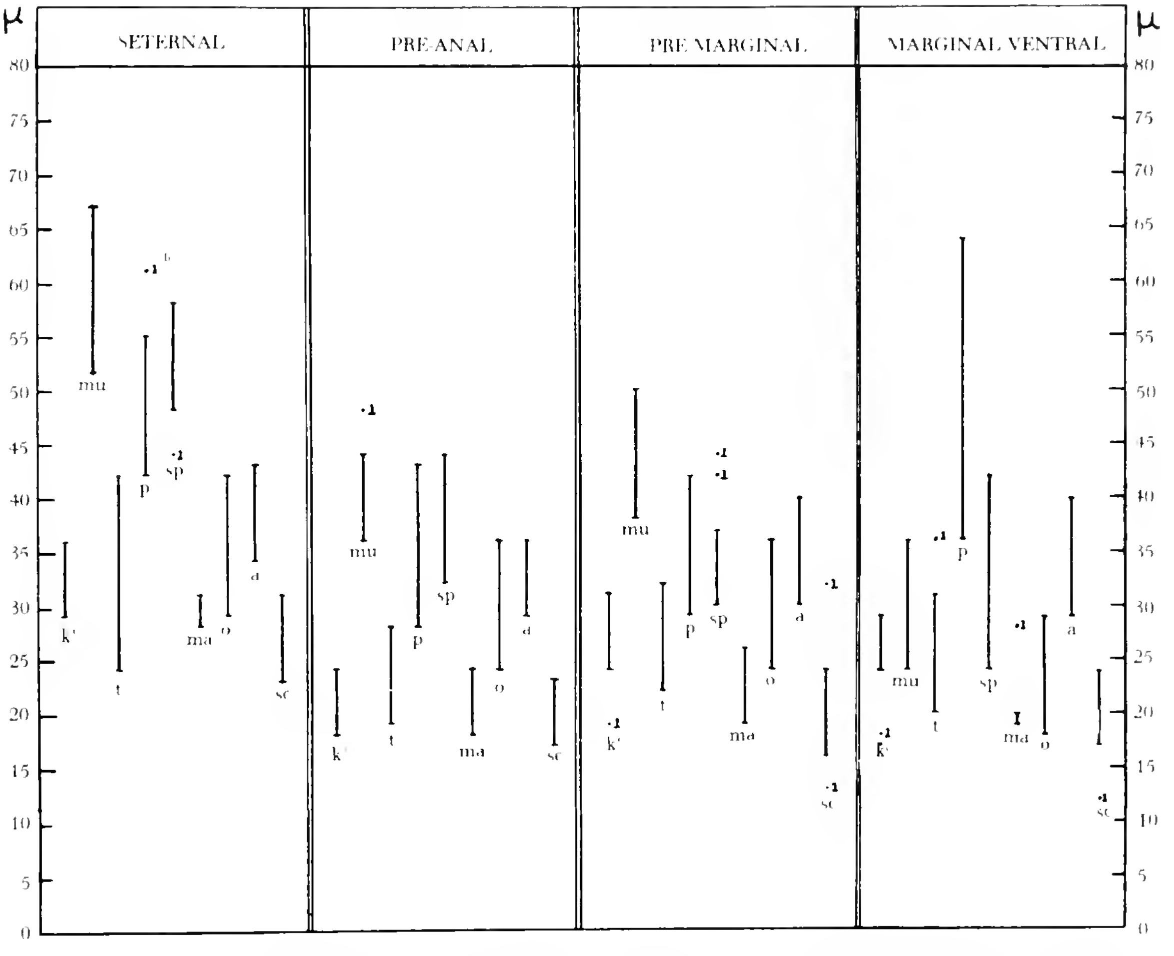
[a]The number of specimens examined is the same as those indicated under the section Analysis of Species.

[b]The number "1", etc. represent the number of specimens with measurements as indicated by the dot.

[c]k-*kingi*; mu-*muris*; t-*texanus*; p-*pacificus*; sp-*spinipalpis*; ma-*marmotae*; o-*ochotonae*; a-*angustus*; sc-*sculptus*.

Table 2

Length comparison of certain setal measurements[a]



[a]The number of specimens examined is the same as those indicated under the section Analysis of Species.

[b]The number "1", etc. represent the number of specimens with measurements as indicated by the dot.

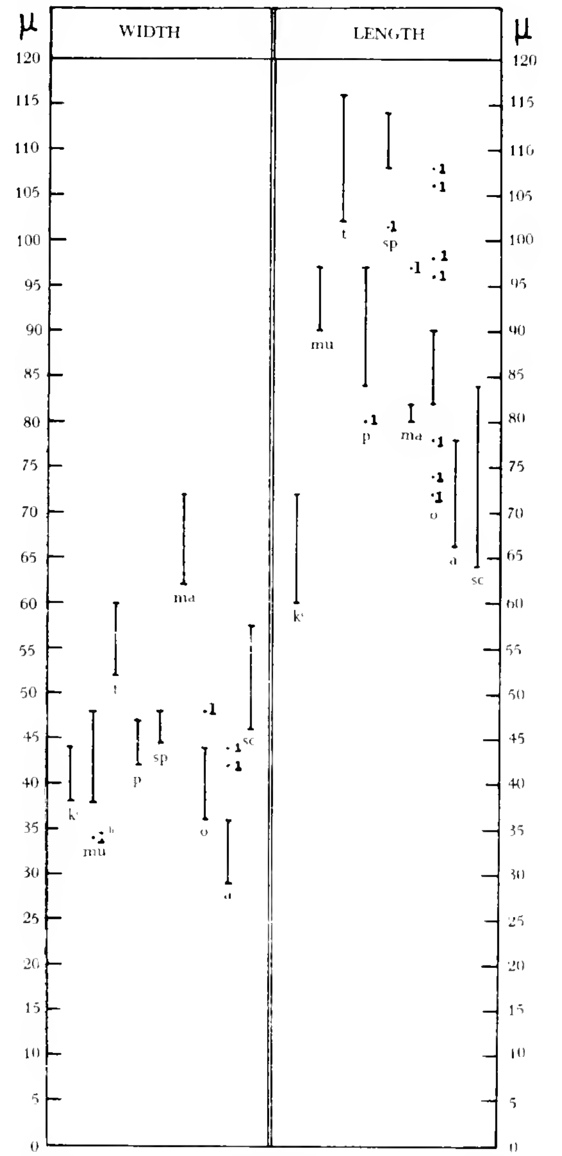
[c]k-*kingi;* mu-*muris;* t-*texanus;* p-*pacificus;* sp-*spinipalpis;* ma-*marmotae;* o-*ochotonae;* a-*angustus;* sc-*sculptus.*

The ranges of variation observed for the hypostome width were from 3 microns in *spinipalpis* to 11 microns in *sculptus* (Table 3). The ranges of variation for the hypostome length were from 2 microns (with one extreme variation) in *marmotae* to 20 microns in *sculptus*.

Palpi. Specimens of *texanus* from Texas showed a marked deviation from those of the eastern United States in the basal width of article two. The width of the Texas forms was approximately twenty-five percent (10 microns) narrower than the width of those from the eastern United States. The ranges of variation observed for the basal width of article two were from 6 microns in *marmotae* to 25 microns in *sculptus* (Table 4). The ranges of variation for the maximum width of the palps were from 6 microns (with one extreme) in

Table 3

Width and length comparisons of the hypostome[a]



[a]The number of specimens examined is the same as those indicated under the section analysis of Species.

[b]The number "1", etc. represent the number of specimens with measurements as indicated by the dot.

[c]k-*kingi;* mu-*muris;* t-*texanus;* p-*pacificus;* sp-*spinipalpis;* ma-*marmotae;* o-*ochotonae;* a-*angustus;* sc-*sculptus.*

angustus to 20 microns in *sculptus*. The ranges of variation of the palpal length (excluding article one) were from 10 microns in *angustus* to 18 microns in *ochotonae*.

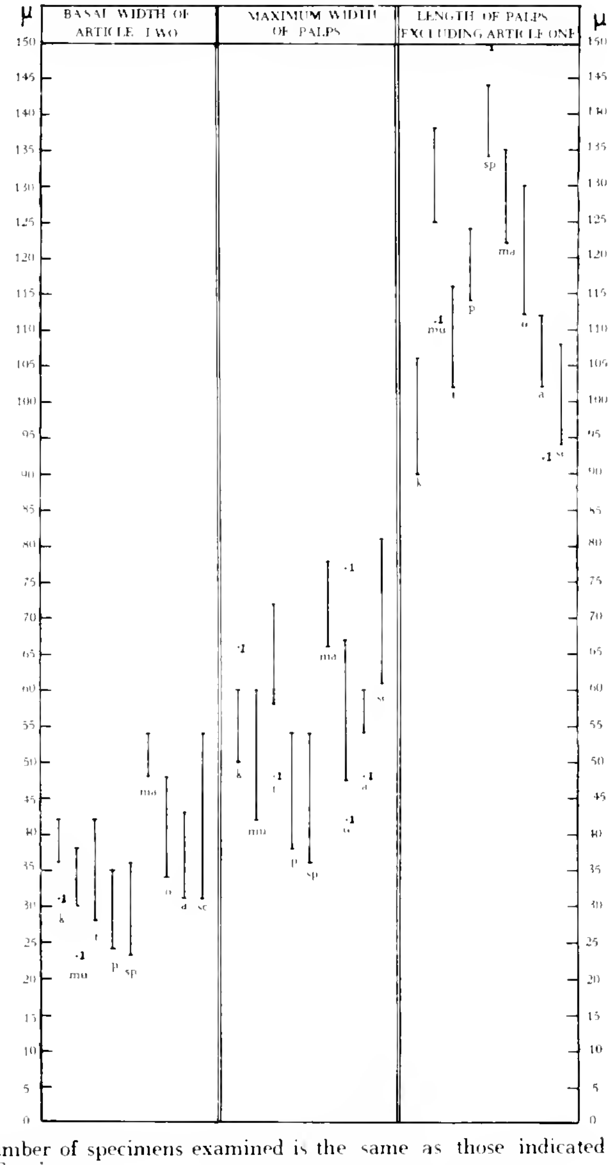
Basis capituli. Intraspecific variation of the posterolateral margin of the basis was most obvious on specimens of *ochotonae*. Of eighteen specimens of *ochotonae* taken from pikas, four specimens from Utah possessed a bluntly rounded posterolateral margin. The remaining fourteen from British Columbia, Canada, had sharply pointed lateral extensions on the posterolateral margin. Some specimens showed a tendency toward roundness but none achieved it to a degree comparable to the Utah forms.

In nineteen specimens of *sculptus* taken from *Thomomys talpoides* in Utah, the anterodorsal margin of the basis was strongly convex. In a single Canadian specimen found on *Spermophilus richardsoni*, the basis bluntly terminated at the anterodorsal margin.

Scutum. The only intraspecific scutal variation observed was between four specimens of *ochotonae* collected from *Ochotona princeps* in Utah, and fourteen specimens from the same host species in British Columbia, Canada. On

Table 4

Width and length comparisons of the palps[a]



[a]The number of specimens examined is the same as those indicated under the section Analysis of Species.

[b]The number "1", etc. represent the number of specimens with measurements as indicated by the dot.

[c]k-*kingi;* mu-*muris;* t-*texanus;* p-*pacificus;* sp-*spinipalpis;* ma-*marmotae;* o-*ochotonae;* a-*angustus;* sc-*sculptus*.

the Canadian specimens the lateral margin of the scutum was indistinct, appearing to blend with the lateral body margin. Four Utah specimens showed a distinct lateral margin.

The ranges of variation observed for the scutum width were from 4 microns (with three extremes) in *muris* to 46 microns in *marmotae* (Table 5). The ranges of variation observed for the scutum length were from 9 microns (with three extremes) in *kingi* to 58 microns for *angustus*.

Coxae. The inner spur on coxa I on specimens of *texanus* from the eastern United States showed a marked variation in contrast to specimens from Texas. The eastern forms possessed a small inner spur which appeared to blend in with the posteromedial margin. The spurs on the two Texas specimens were large, prominent and appeared separate from the coxal margin.

It is apparent from this study that intraspecific variation differs in degree with reference to specific structures on ticks from different geographic areas and different host animals. This follows the general pattern of geographical races (subspecies) and eventually species isolation. Obviously those structures which may be used for the separation of species must be of the least intraspecific variation and must differ considerably interspecifically.

Larval Interspecific Morphological and Anatomical Differences

Setae. The numbers of scutal setae, posthypostomal, sternal, pre-anal and pre-marginal setae, and setae of coxae I and II showed no interspecific differences.

Because of the intraspecific variation of the marginal dorsal setae (Table 6), these setae were of little taxonomic value for the separation of most species. However, they were useful to distinguish *texanus* from *muris*, *pacificus* and *spinipalpis*.

The central dorsal setae were used to separate the larvae into two groups which included those larvae with two pairs of central dorsal setae as contrasted to those with three or more pairs. One specimen in each of the species *pacificus* and *marmotae* was observed to possess three pairs.

The presence of supplementary setae separated *muris*, *pacificus* and *spinipalpis* from the other six species which lacked them. However, two of thirteen specimens of *spinipalpis* examined lacked supplementary setae.

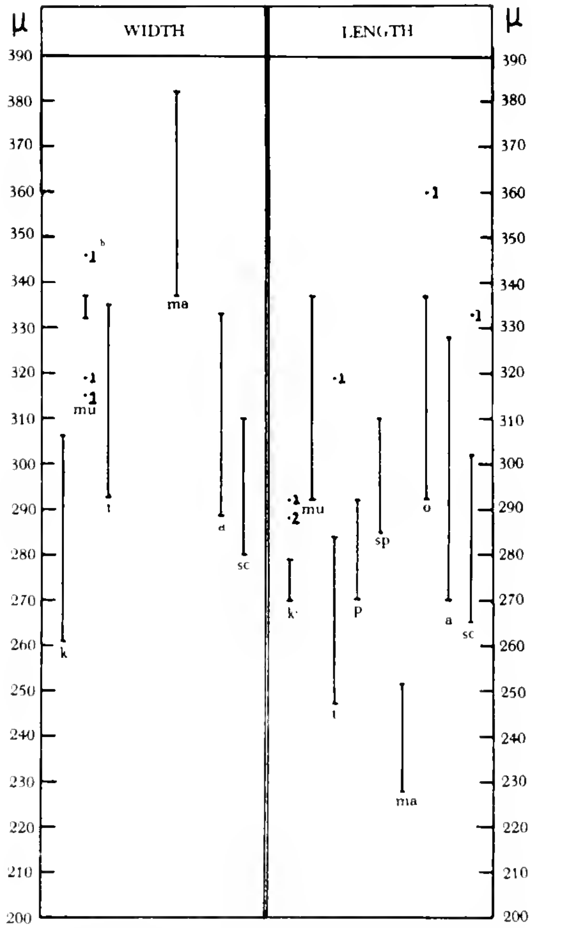
The presence of three pairs of marginal ventral setae separated *marmotae* and *angustus* from *kingi*, *muris*, *pacificus* and *spinipalpis* which possessed four pairs. Because of the variability in the number of setae demonstrated by *texanus*, *ochotonae* and *sculptus*, the marginal ventral setae were of limited taxonomic value in separating these three species.

The lengths of the scutal setae ranged from 8 to 18 microns in *sculptus* to 27 to 36 microns in *muris*. A single specimen of *pacificus* showed an extreme measurement of 38. Because of the overlapping of intraspecific variations, these setae were useful only in separating the species into major groups.

The lengths of the marginal dorsal setae varied from 18 to 31 microns in *sculptus* to 73 to 85 for *pacificus*. One specimen of *ochotonae* measured 16 microns. Interspecific overlapping of measurements of these setae limited

Table 5

Width and length comparisons of the scutum[a]



[a]The number of specimens examined is the same as those indicated under the section Analysis of Species.

[b]The number "1", etc. represent the num- of specimens with measurements as indicated by the dot.

[c]k-*kingi;* mu-*muris;* t-*texanus;* p-*pacificus;* sp-*spinipalpis;* ma-*marmotae;* o-*ochotonae;* a-*angustus;* sc-*sculptus.*

Table 6

Comparison of Numbers of Setae on the Larvae of Nine Species of *Ixodes*[1]

Species of *Ixodes*	Pairs of Setae				
	Marginal Dorsal	Central Dorsal	Supple-mentary	Marginal Ventral	Coxa III
angustus	7-8	2	0	3	2
kingi	8*	2	0	4	2
marmotae	6-9	2*	0	3	2
muris	7	3-4	1	4	2
ochotonae	7-8	2	0	3*	2
pacificus	7	4*	1	4	3
sculptus	6-8	2	0	3-4	2
spinipalpis	7	2	1*	4	2
texanus	8-9	2	0	3-4	2

[1]The scutal setae, sternal, pre-anal, pre-marginal, and post-hypostomal setae and setae of coxae I and III show no interspecific differences.

*No more than two specimens were observed to vary from this number.

the taxonomic value to the separation of major groups of species.

Length variations of the central dorsal setae ranged from 14 to 24 microns in *marmotae* to 32 to 48 in *pacificus* with one extreme of 12 microns for *sculptus* and another of 48 microns for *angustus*. These measurements were useful taxonomically only after separation of several species which showed overlapping lengths.

The supplementary setae showed measurement ranges from 20 to 30 microns in *muris* and *spinipalpis* to 43 to 62 for *pacificus*. Except for one specimen of *spinipalpis* which showed an extreme of 47 microns, these measurements were useful in separating *pacificus* from *muris* and *spinipalpis*.

The sternal setae ranged in length from 23 to 32 microns in *sculptus* to 52 to 67 in *muris*. Overlapping of lengths due to intraspecific variations allowed a separation only into two major groups.

Length variations of the pre-anal setae ranged from 17 to 23 microns in *sculptus* to 37 to 44 for *muris* and *spinipalpis* with one specimen of *muris* showing a measurement of 48 microns. An initial separation by other criteria was prerequisite for use of these measurements as taxonomic characteristics

The pre-marginal setae showed length variations from 16 to 24 microns in *sculptus* to 38 to 50 in *muris*. One specimen of *sculptus* showed a 13 micron measurement. Here again, species separation was limited to groups of species which had been separated by other criteria.

The lengths of the marginal ventral setae varied from 20 to 24 mircons in *sculptus* to 37 to 64 in *pacificus* with a single specimen of *sculptus* showing a measurement of 12 microns. An overlapping of measurements between species limited the taxonomic value of these setae.

Hypostome. Interspecific differences in the shape of the hypostome initially seemed significant. However, the intraspecific variation was so great that only limited group separation was possible. The number of denticles per file remained fairly constant within the range of one tooth. This range of variation restricted the use of the files for specific separation but provided for separation of the species into major groups (Table 7).

The width of the hypostome ranged from 28 to 36 microns in *angustus* to 62 to 73 in *marmotae* (Table 3). These measurements were useful in separating *angustus* (except for one

Table 7

Comparison of Structures of the Larvae of Nine Species of *Ixodes*

Species of *Ixodes*	Number of Denticles on Hypostome[1] File I	II	III	Posterolateral Extension of Basis Capituli	Lateral Margin of Scutum	Auriculae	Location of Palpal Article 4
angustus	8	6	2	Slight	Distinct	Absent	Subterminal
kingi	7	6	0-2	Slight to Prominent	Distinct	Absent	Subterminal
marmotae	8	7	2	Absent	Distinct	Absent	Terminal
muris	10	9	4	Slight	Distinct	Lateral	Subterminal
ochotonae	9	6	2	Prominent	Indistinct	Absent	Subterminal
pacificus	10	9	3	Prominent	Indistinct	Medial	Subterminal
sculptus	7	6	2	Prominent	Distinct	Absent	Subterminal
spinipalpis	10	8	4	Prominent	Indistinct	Medial	Subterminal
texanus	7	6	1	Slight	Distinct	Absent	Subterminal

[1]The number of denticles may vary by one more or less per file.

specimen of *muris* which overlapped *angustus*) and *marmotae* which were at opposite extremes of the range of variation for this character.

The length of the hypostome varied from 60 to 72 microns in *kingi* to 102 to 117 in *texanus*. Except for two specimens of *ochotonae* which overlapped *texanus* and *spinipalpis*, the latter two species were separated from the remaining seven species which had shorter hypostomes.

Palpi. The absence of intraspecific variations of palpal characteristics as well as constancy of some interspecific differences provided several reliable taxonomic features. Of the nine species examined, *marmotae* was the only one which showed a terminal location for article four (Table 7).

The presence or absence of anterior and posterior spurs on article one was very useful in species separation (Table 8). The presence of only a posterior spur separated *kingi* and *marmotae* from the seven other species. The species *ochotonae*, *angustus* and *sculptus* had both anterior and posterior spurs, whereas *muris*, *texanus*, *pacificus* and *spinipalpis* had neither anterior nor posterior spurs.

Measurement analyses were made to determine the variations of the palpal length excluding article one, basal (proximal) width of article two, and width of the palps at the widest point (excluding article one). The range in width of article two varied from 23 to 37 microns for *spinipalpis* to 48 to 54 in *marmotae* and 32 to 48 in *sculptus*. These measurements were of little or no taxonomic value unless certain species which showed an overlap in measurements were first separated by other criteria.

The maximum width of the palps varied from 37 to 54 microns in *spinipalpis* to 61 to 82 in *sculptus*. The overlap between species due to intraspecific variations limited the taxonomic value of these measurements.

The length of the palps excluding article one varied from 90 to 106 microns in *kingi* to 134 to 150 in *spinipalpis*. The taxonomic value of these measurements was realized only after separation of certain species such as *pacificus* and *ochotonae* by characteristics other than palpal measurements.

Basis capituli. Dorsally the presence or absence of posterolateral extensions were of some taxonomic value (Table 7). Their use was somewhat restricted due to the variable degree of size and prominence. *Ixodes marmotae* lacked the posterolateral extension while *muris*, *texanus*, and *angustus* possessed it to a slight degree. The posterolateral extension of *kingi* varied considerably. *Ixodes pacificus*, *spinipalpis*, *ochotonae* and *sculptus* all possessed prominent posterolateral extensions. Ventrally the basis of *kingi*, *texanus*, *marmotae*, *ocho-*

Table 8

Existence of Palpal and Coxal Spurs on the Larvae of Nine Species of *Ixodes*

Species of *Ixodes*	Spur of Palpal Article I		Outer Spur[1]		Inner Spur[1]	
	Anterior	Posterior	Coxa I	Coxa II	Coxa II	Coxa III
angustus	Present	Present			Present	Present or Absent
kingi		Present				
marmotae		Present			Present	
muris			Present	Present	Present	
ochotonae	Present	Present			Present	Present
pacificus			Present		Present	
sculptus	Present	Present			Present	
spinipalpis			Present	Present		
texanus						

[1]The inner spur of Coxa I and outer spur of Coxa III show no interspecific differences.

tonae, *angustus* and *sculptus* lacked auriculae. *Ixodes muris* possessed a pair of laterally situated auriculae, whereas *pacificus* and *spinipalpis* possessed medially situated auriculae.

Scutum. The scutum on all specimens of *kingi, muris, texanus, marmotae, angustus* and *sculptus* observed in this study possessed distinctly outlined lateral margins (Table 7). On four of eighteen specimens of *ochotonae* the scutum possessed a distinctly outlined lateral margin. On specimens of *pacificus* and *spinipalpis* the lateral margin of the scutum was indistinct.

The scutum ranged in width from 261 to 307 microns in *kingi*, to 337 to 382 in *marmotae*. The length ranged from 228 to 257 in *marmotae* to 222 to 338 in *ochotonae* and *muris*. One specimen of *ochotonae* showed an extreme length of 360 microns. Because of interspecific overlapping, the length and width of the scutum were useful only for separating one or two species.

Coxae. Because of the extreme intraspecific variations, the shape of the coxae were of little value as taxonomic characters. However, the presence or absence of coxal spurs was of taxonomic significance (Table 8). *Ixodes kingi, texanus, marmotae, ochotonae, angustus* and *sculptus* lacked outer spurs on coxae I and II, whereas *muris, pacificus* and *spinipalpis* possessed outer spurs.

Ixodes kingi, texanus and *spinipalpis* lacked inner spurs on coxae II and III. Only *ochotonae* possessed inner spurs on both coxae II and III. *Ixodes muris, marmotae, pacificus* and *sculptus* possessed inner spurs on coxae II, but lacked them on coxae III. *Ixodes angustus* possessed an inner spur on coxae II and III. but the inner spur on coxa III was sometimes absent.

The setae of coxae I and II showed no interspecific differences. *Ixodes pacificus* possessed three pairs of setae on coxa III whereas the remaining eight species possessed two pairs.

KEY TO THE LARVAE

As shown in the discussion on intraspecific variation and interspecific differences, most of the setal and structural characteristics which were studied were of some taxonomic significance. Although there were several characteristics peculiar to each species as shown in tables 1 to 7. all of these were not included in the following key. Only one or two of these characters which were constant or rarely variable and which were easily seen were used. In couplet 3 of the key, *ochotonae* and *angustus* were combined into a complex because of their close similarity of gross characteristics, and it was therefore necessary to use the more detailed setal measurements to separate these two species.

Key to the Larvae of Species of the Genus *Ixodes* Known to Occur in Utah

1. Posterior spur on palpal article I present (figs. 31-1, 32-1, 36-1) 2
   Posterior spur on palpal article I absent (fig. 33-1) 5

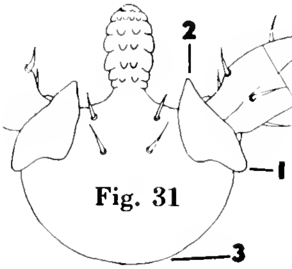


Fig. 31

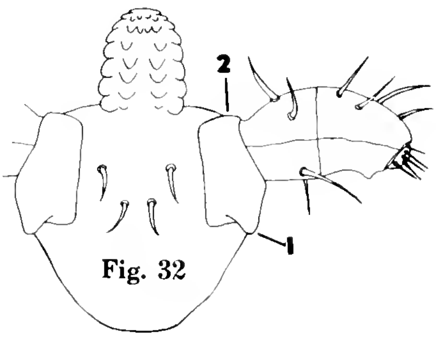


Fig. 32

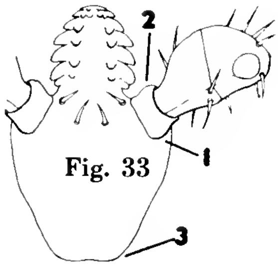


Fig. 33

2. Anterior spur on palpal article I present (figs. 31-2, 36-2) 3
   Anterior spur on palpal article I absent (figs. 32-2, 33-2) 4

3. Four pairs of MV setae (fig. 34-3); posteroventral border of basis rounded (fig. 31-3) .... *sculptus*
   Three pairs of MV setae (fig. 35-3); posteroventral border of basis angled (figs. 33-3, 36-3) (*angustus-ochotonae* complex) 8

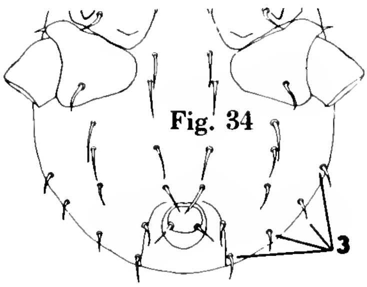


Fig. 34

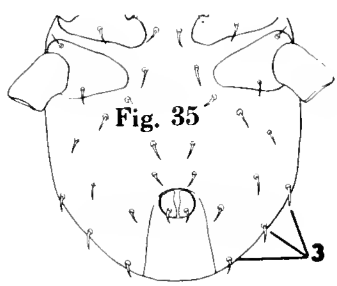


Fig. 35

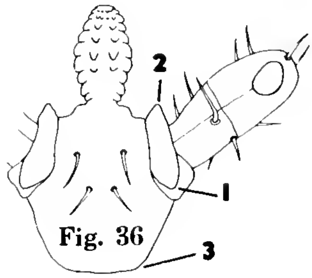


Fig. 36

4. Tip of hypostome somewhat flattened, with file 3 present as 2 teeth (fig. 37-4) .... *marmotae*
   Tip of hypostome rounded, without file 3 (fig. 38-4) (sometimes 1 accessory tooth is present) .... *kingi*

Fig. 37

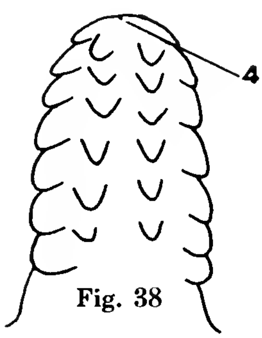


Fig. 38

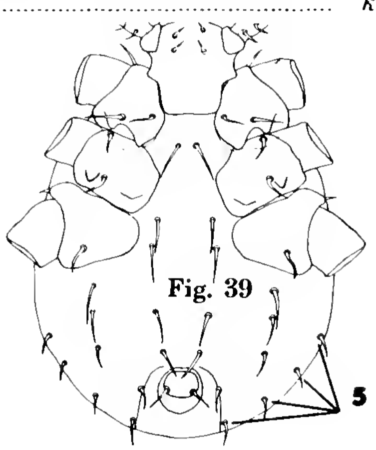


Fig. 39

5. Four pairs MV setae (figs. 34-3, 39-5); outer spurs on coxae I and II present (fig. 40-5); file 3 with at least 3 teeth (fig. 41-5); supplementary setae present (fig. 42-5) 6

Three pairs MV setae (fig. 43-5); outer spurs on coxae I and II absent (fig. 44-5); file 3 with only 1 or 2 teeth (figs. 37-4, 45-5); supplementary setae absent (fig. 46-5) .... *texanus*

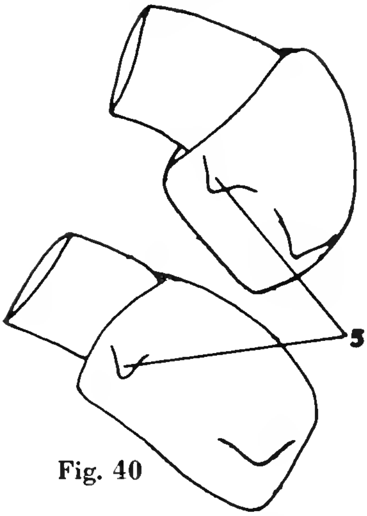


Fig. 40

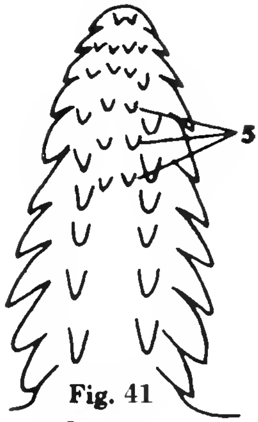


Fig. 41

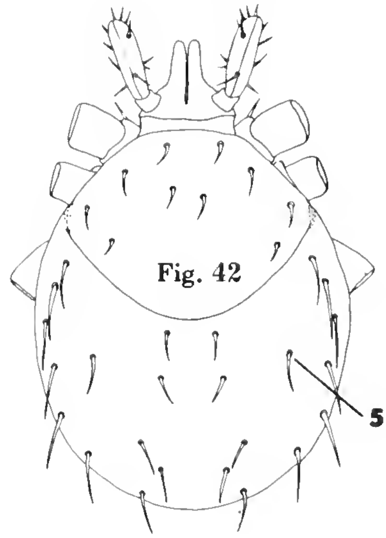


Fig. 42

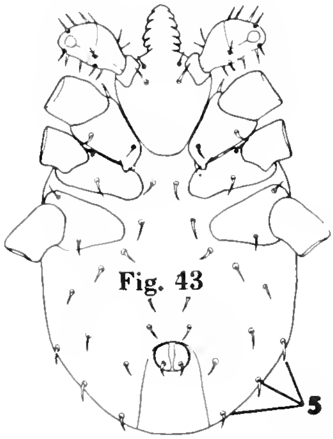


Fig. 43

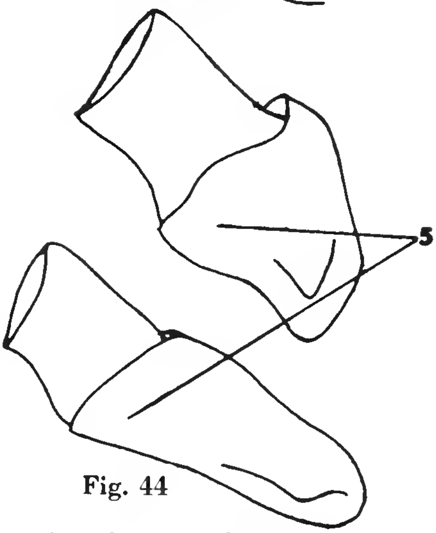


Fig. 44

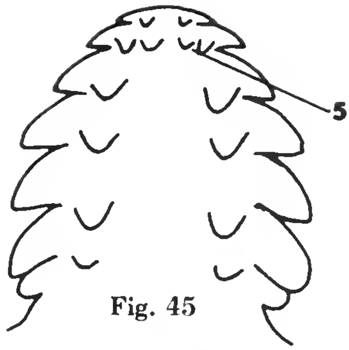


Fig. 45

6. MD setae short, subequal in length to supplementary setae (fig. 47-6); file 3 with 5 or more teeth (fig. 48-6) .... *muris*

MD setae long, half again to twice as long as supplementary setae (fig. 49-6); file 3 with no more than 4 teeth (fig. 50-6) 7

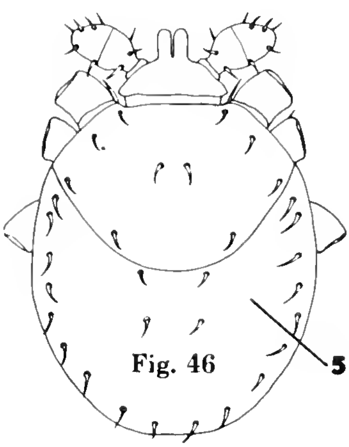


Fig. 46

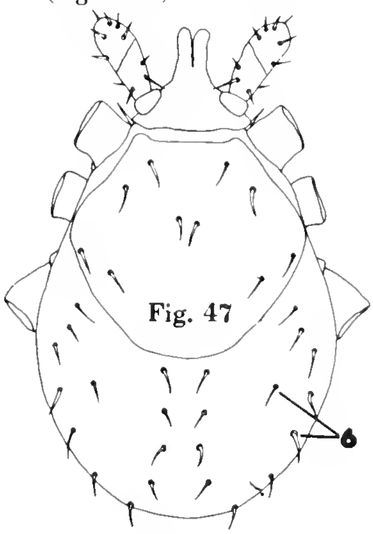


Fig. 47

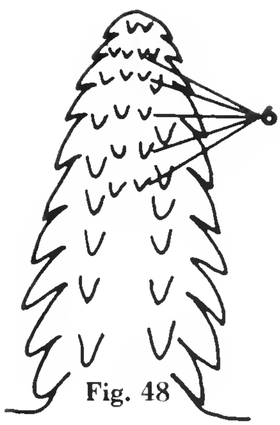


Fig. 48

7. Four pairs of CD setae (fig. 51-7) .... *pacificus*
Two pairs of CD setae (fig. 52-7) .... *spinipalpis*

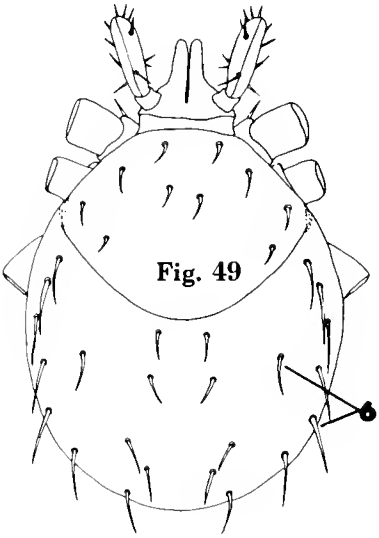


Fig. 49

Fig. 50

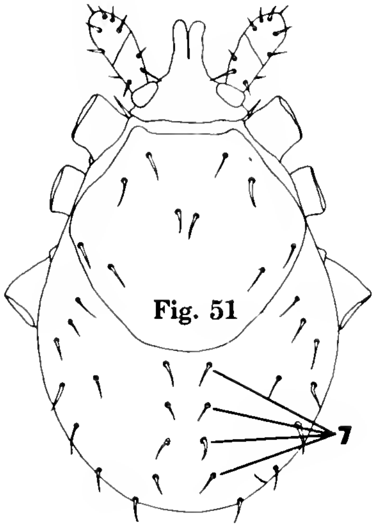


Fig. 51

8. MD setae less than 37 microns in length; CD setae less than 32 microns in length (fig. 52-8) .... *ochotonae*
MD setae more than 41 microns in length; CD setae more than 36 microns in length (fig. 53-8) .... *angustus*

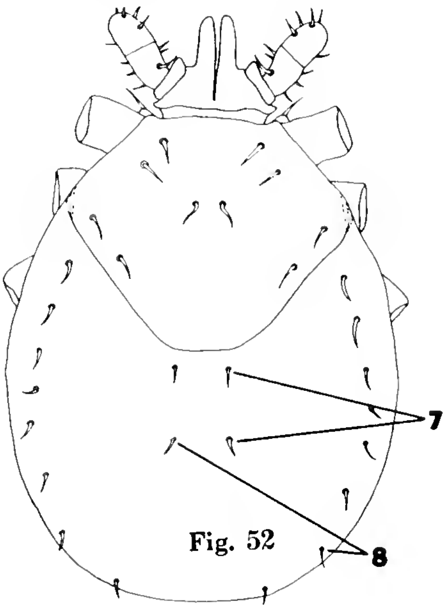


Fig. 52

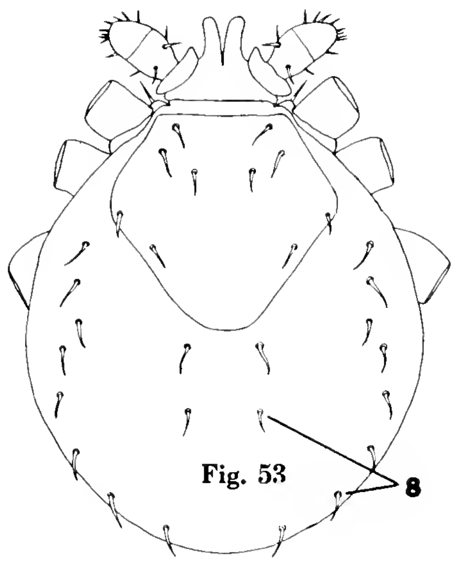


Fig. 53

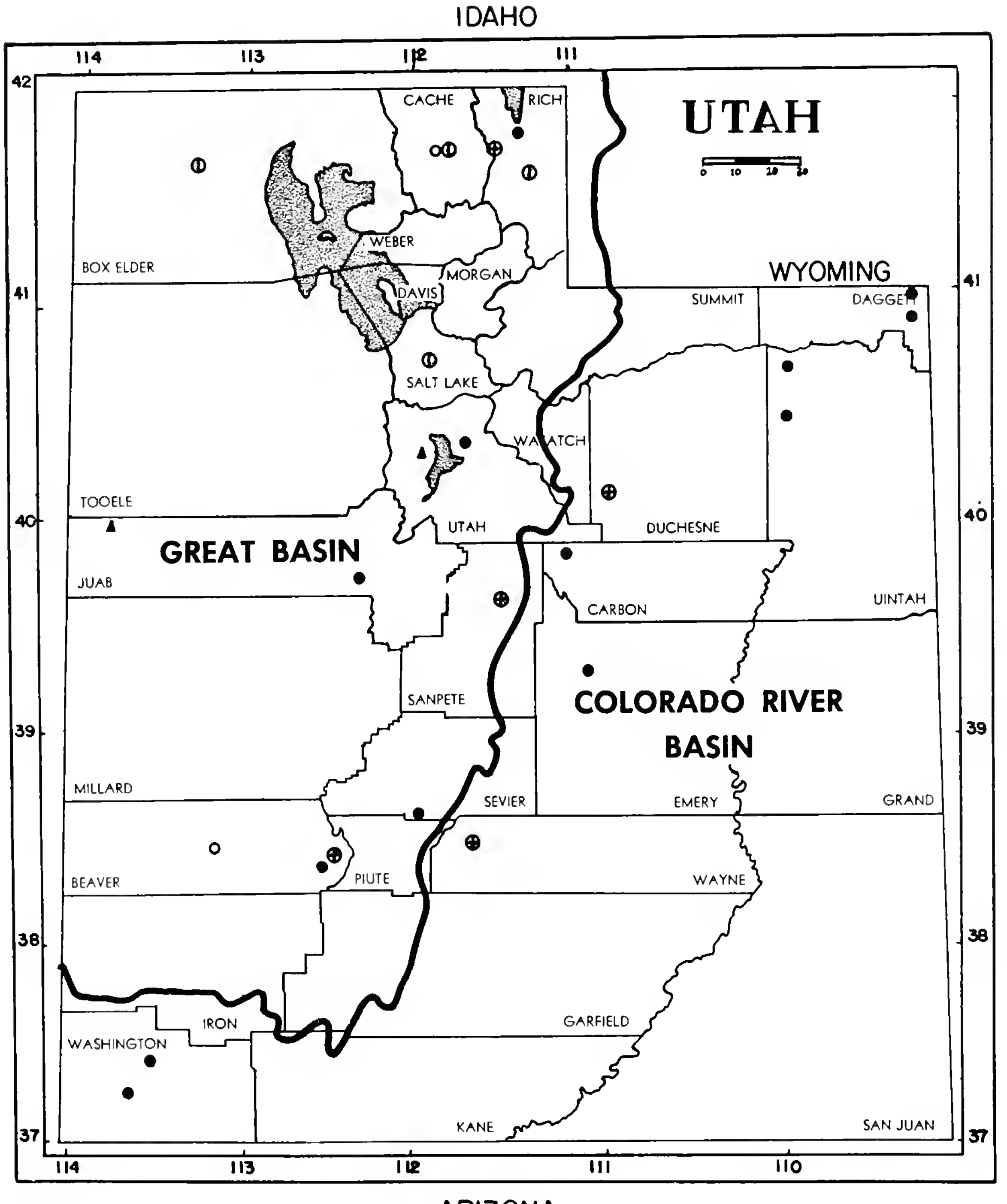


Fig. 54 ● *I. angustus*

○ *I. angustus*—specific locality unknown.

⊕ *I. marmotae*

⦶ *I marmotae*—specific locality unknown.

▲ *I. muris*

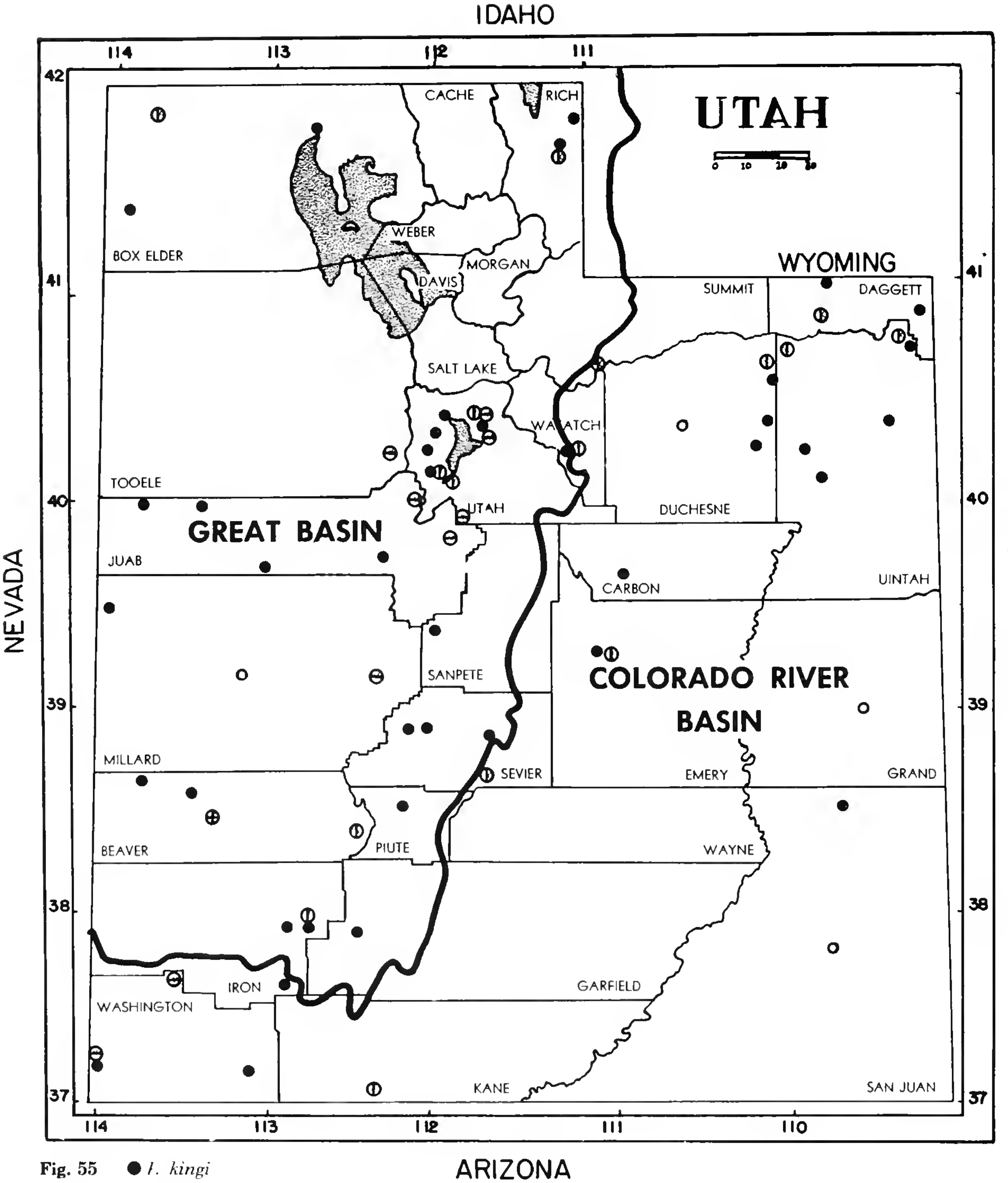


Fig. 55 ● *I. kingi*
⦶ *I. ochotonae*
⊖ *I. pacificus*
⊕ *I. pacificus*—specific locality unknown.

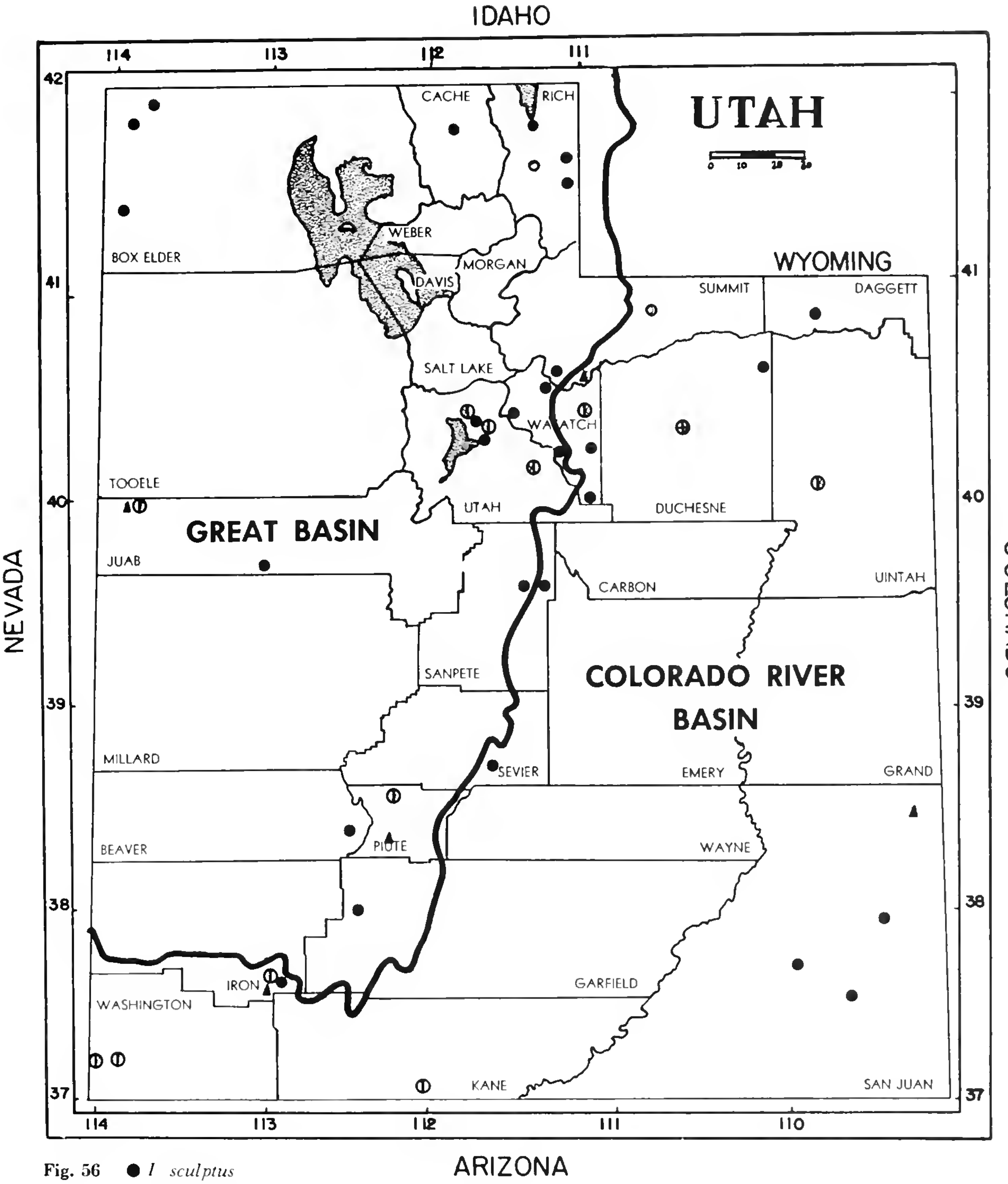


Fig. 56 ● *I sculptus*
○ *I sculptus*—specific locality unknown.
⦶ *I. spinipalpis*
⊕ *I. spinipalpis*—specific locality unknown.
▲ *I texanus*

HOST-TICK RELATIONSHIPS

It is interesting to note the apparent absence of *Ixodes* on some animals in Utah, whereas closely related species were commonly infested. In the order of bats, not a single tick of this genus was found on 651 bats representing four genera. Inasmuch as several hundred specimens of bats were collected from a single area on the same date, a broad seasonal sample was not available. The apparent absence of *Ixodes* on bats in Utah is consistent with the records of Cooley and Kohls (1945) for the western United States.

In the rabbit family, ticks of the genus *Ixodes* were found on only a few of 107 cottontail rabbits (genus *Sylvilagus*). We did not find a single animal of 404 black-tailed jack rabbits (genus *Lepus*) infested, although Cooley and Kohls (1945) listed records for *angustus*, *spinipalpis*, *pacificus* and *sculptus* from *Lepus* and *Sylvilagus* in western United States. This is interesting inasmuch as the jack rabbit lives in the same habitat with the deer mouse, *Peromyscus maniculatus*, Ord's kangaroo rat, *Dipodomys ordii*, and their common tick, *Ixodes kingi*. The pika (genus *Ochotona*), a member of a closely related family was frequently found infested.

In the squirrel family, we did not find one of 140 red squirrels (genus *Tamiasciurus*) infested by any species, although Cooley and Kohls (1945) listed *angustus* from this host. Prairie dogs (genus *Cynomys*) were commonly infested, as were yellow-bellied marmots (genus *Marmota*). Several species of the squirrel genus *Spermophilus* were found infested, yet here again there were anomalies. Not a single animal of 55 *S. variegatus* examined was found infested, nor any of 106 *Ammospermophilus leucurus*. This is consistant with findings by Cooley and Kohls (1945). Both of these animals live within the ecological range of *Ixodes kingi*, a common parasite of the deer mouse and the Ord's kangaroo rat living in the same habitat. Chipmunks were found to be infrequently infested. One specimen of 11 Least chipmunks, *Eutamias minimus*, was found infested, yet not a single animal of 81 Colorado chipmunks, *E. quadrivittatus*, was parasitized Cooley and Kohls (1945) listed records for *angustus*, *kingi*, *texanus*, *pacificus* and *sculptus* from several species of *Eutamias*.

The pocket gophers showed interesting host relationships. The northern pocket gopher, *Thomomys talpoides*, was frequently infested. Not a single specimen of 72 Botta's pocket gophers, *T. bottae*, was found infested. This animal frequently lives in the same habitat as the deer mouse, Ord's kangaroo rat and *Ixodes kingi*.

The pocket mice and kangaroo rats of the family Heteromyidae were common hosts of *Ixodes* ticks.

Native rats and mice were variable in their host relationships. Whereas the white-footed mice (genus *Peromyscus*) were frequently infested, only a few animals of 122 specimens of the western harvest mouse (genus *Reithrodontomys*) possessed ticks. The desert wood rat, *Neotoma lepida*, was occasionally infested, but not so for 29 bushy-tailed wood rats, *N. cinerea*. Cooley and Kohls (1945) listed records of *angustus* and *ochotonae* from the latter host. The meadow voles (genus *Microtus*) were commonly infested.

The non-native rats and mice (genera *Rattus* and *Mus*) were not found infested.

Few carnivores that were examined were commonly infested. Of the few ungulates examined, the mule deer was infrequently found infested.

A considerable number of lizards and birds were examined, but none was infested with *Ixodes* ticks. Cooley and Kohls (1945) listed one bird and several lizards as hosts for *pacificus*.

Following is a summary of *Ixodes* tick-host relationships known to occur in Utah.

Canis familiaris ssp.
    pacificus
Cynomys leucurus Merriam
    kingi
C. parvidens Allen
    sculptus
Dama hemionus hemionus (Rafinesque)
    pacificus
Dipodomys merriami merriami Mearns
    spinipalpis
D. microps ssp.
    kingi
D. ordii ssp.
    kingi
Homo sapiens ssp.
    pacificus
Marmota flaviventer ssp.
    marmotae
    sculptus
Martes sp.
    texanus
Microtus longicaudus ssp.
    sculptus
M. montanus ssp.
    angustus
    sculptus
Mustela frenata nevadensis Hall
    sculptus
    texanus
Mustela sp.
    kingi
Neotoma lepida ssp.
    kingi
    spinipalpis

Ochotona princeps ssp.
angustus
ochotonae
sculptus
spinipalpis
Onychomys leucogaster ssp.
kingi
spinipalpis
O. torridus longicaudus Merriam
kingi
Perognathus formosus ssp.
spinipalpis
P. longimembris ssp.
kingi
sculptus
P. parvus ssp.
kingi
Peromyscus crinitus ssp.
angustus
kingi
ochotonae
P. eremicus eremicus (Baird)
kingi
pacificus
spinipalpis
P. maniculatus ssp.
angustus
kingi
muris
ochotonae
pacificus
spinipalpis
P. truei ssp.
angustus
kingi
ochotonae
pacificus
spinipalpis
Reithrodontomys megalotis ssp.
kingi
Sorex vagrans monticola Merriam
spinipalpis
Spermophilus armatus (Kennicott)
kingi
marmotae
ochotonae
sculptus
S. beldingi crebrus Hall
sculptus
S. lateralis ssp.
kingi
marmotae
ochotonae
sculptus
S. richardsoni ssp.
kingi
sculptus
Spilogale gracilis ssp.
kingi
texanus
Sylvilagus nuttallii ssp.
kingi
Taxidea taxus ssp.
kingi
sculptus
Thomomys talpoides ssp.
kingi
ochotonae
sculptus
Urocyon cinereoargenteus scottii Mearns
angustus
Zapus princeps ssp.
sculptus

REFERENCES CITED

Anastos, George. 1957. *The Ticks, or Ixodes, of the U.S.S.R.—A Review of the Literature.* Washington: U.S. Government Printing Office, Public Health Service Publ. No. 548; 397 pp.

Anonymous (American Ornithologist's Union). 1957. *Check-List of North American Birds.* Baltimore: Lord Baltimore Press, Inc.; 691 pp.

Beck, D Elden. 1955. *Distributional studies of parasitic arthropods in Utah determined as actual and potential vectors of plague and Rocky Mountain spotted fever with notes on vector host relationships.* Brigham Young University Sci. Bulletin, Biological Series, 1 (1): 1-64.

———, 1955. *Some Unusual Distributional Records of Ticks in Utah.* The Journal of Parasitology, 41 (2):1-4.

Belding, D. L. 1942, *Textbook of Clinical Parasitology.* New York: Appleton-Century-Crofts, Inc.; 888 pp.

Bequaert, J. C. 1946. "Ticks, or Ixodoidea, of the Northeastern United States and Eastern Canada." *Entomologica Americana,* 25(2): 73:120.

Clifford, C. M. 1958. *Studies of Larval Ticks of the Family Ixodidae with Special Reference to those Species Occuring in the South eastern United States.* University of Maryland. Unpublished PhD dissertation; 144 pp.

Cooley, R.A., and G. M. Kohls. 1945. *The Genus Ixodes in North America.* Washington: U.S. Government Printing Office, National Institutes of Health Bull. No. 184; 148 pp.

Durrant, S. D. 1952. *Mammals of Utah.* University of Kansas Publications, Mus. Nat. History, 6:1-549.

Edmunds, L. R. 1951. *A checklist of the ticks of Utah.* Pan-Pacif. Entom., 27:23-26.

Hall, R. H. 1957. *Vernacular Names for North American Mammals North of Mexico.* Lawrence: Univ. of Kansas, Mus. Nat. History, Misc. Publ. No. 14; 16 pp.

Hooker, W. A., F. C. Bishopp, and H. P. Wood. 1912. *The Life History and Bionomics of Some North American Ticks*. Washington: U.S. Government Printing Office, Dept. Agric. Bull. 106; 239 pp.

Kohls, G. M. 1952. *A record of the occurence of the tick Ixodes muris Bishopp and Smith on muskrats in Utah.* Great Basin Nat , 12: 65-66.

Nuttall, George H. F., C. Warburton, W. F. Cooper, and L. E. Robinson. 1911. *Ticks, A Monograph of the Ixodidae*. London: Cambridge University Press, Parts 1-3; 550 pp.

Philip, C. B. 1939. *Ticks as vectors of animal diseases*. Canadian Entomologist, 71: 55-65.

Schmidt, Karl P. 1953. *A Check List of North American Amphibians and Reptiles*. Chicago: Univ. of Chicago Press; 280 pp.

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Many students and associates contributed to the collection and compilation of the data contained herein. Merlin Killpack and Clive Jorgensen worked as graduate student research associates on this problem during its first two years and contributed greatly with regard to specimen collections. Dr. Marvin Coffey collected many specimens of *Ixodes* during his graduate studies on related genera of ticks. Mrs. Judith Johns Braithwaite and Miss Carolyn Kitchens mounted most of the larval ticks collected during these studies.

Glen M. Kohls of the Rocky Mountain Laboratory, Hamilton, Montana, graciously loaned us specimens and identified many nymphal and adult ticks sent to him from this project. Others who have loaned specimens and kindly contributed information are Carleton M. Clifford of the University of Maryland, Richard B. Eads of the Texas State Department of Health, J. D. Gregson of the Canadian Department of Agriculture, and Allan McIntosh of the U.S. Department of Agriculture.

ADDENDUM TO COLLECTION RECORDS

Ixodes angustus

Ochotona princeps: Puffer Lake, Beaver Co., 22 July 1953, 3 L

Ixodes kingi

Perognathus parvus: Cedar Valley, Utah Co., 1 Nov. 1952, 1 L
Reithrodontomys megalotis: Chimney Rock Pass, Utah Co., 28 Mar. 1953, 2 L

Ixodes ochotonae

Ochotona princeps: Baldy Lake, Duchesne Co., 7 Sept. 1952 5 L
Wolf Creek Summit, Wasatch Co., 6 Aug. 1953, 9 L

Ixodes pacificus

Perognathus formosus: Fish Springs, Juab Co., 15 July 1951, 1 L

Ixodes spinipalpis

Peromyscus maniculatus: Marysvale ,Piute Co., 27 June 1952, 12 L
Reithrodontomys megalotis: Provo Canyon, Utah Co., 26 Apr. 1951, 10 L

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INTRODUCTION

It is becoming increasingly evident that the numerous comparative descriptions of certain saurian groups, which have been based mainly on external characters need to be supplemented by accounts of their internal anatomy, ecology, physiology, cytology, and genetics, as suggested by Huxley (1940:1), in order to fully understand the taxonomic and phylogenetic positions they hold. This need is strongly brought to mind when one considers the long confused case of the genus *Crotaphytus* Holbrook.

The purpose of this study is to describe and compare features of the anterior myology and osteology among members of the genus *Crotaphytus* for use, in addition to external characteristics, in determining if it is advisable to separate *Gambelia* Baird as a monotypic genus, as proposed by Hobart M. Smith (1946:158-166).

It is hoped that the descriptions and plates herein will also aid in, and encourage gross anatomical studies of reptiles, add to our understanding of homologies, and indicate some of the structures which are important phylogenetically and taxonomically.

ACKNOWLEDGEMENTS

We express our gratitude to Mr. James R. Dixon, Dr. Dorald M. Allred, and Dr. D Elden Beck for the specimens they so kindly supplied to add to the material examined in this study. We are also indebted to Dr. C. Lynn Hayward, Dr. Vasco M. Tanner, Dr. Stephen L. Wood, Dr. Howard C. Stutz, and Dr. Kent H. McKnight for their having examined and criticized the manuscript.

MATERIALS AND METHODS

The principal subspecies used for this study have been *Crotaphytus wislizeni wislizeni* Baird and Girard and *Crotaphytus collaris baileyi* Stejneger. However, four specimens of *Crotaphytus collaris auriceps* Fitch and Tanner from Grand County, Utah, and three of *Crotaphytus collaris collaris* Say from Anderson County, Kansas, and Stephens County, Texas, were dissected.

A male and a female of *Crotaphytus reticulatus* Baird from Webb and Dimmit Counties, Texas (snout to vent lengths 115 and 110 respectively) were the only representatives of this species examined.

The sixty-nine lizards of *Crotaphytus w. wislizeni* included in this study came from Navajo County, Arizona; Owyhee County, Idaho; Clark, Lander, Lincoln, Nye, Storey, and White Pine Counties, Nevada; and from Beaver, Emery, Garfield, Grand, Iron, Juab, Kane, Millard, Sanpete, San Juan, Tooele, Utah, Washington, and Wayne Counties, Utah.

The seventy-eight members of *Crotaphytus c. baileyi* used were collected in Coconino, Gila, and Navajo Counties, Arizona; Chihuahua, Mexico; Ada and Owyhee Counties, Idaho; Clark County, Nevada; and Emery, Garfield, Grand, Juab, Kane, Millard, Tooele, Utah, Washington, and Wayne Counties, Utah.

The majority of specimens was well preserved in formalin. However, a few were killed freshly by injecting water into the abdomen and the subcutaneous sinuses. This caused an expansion of the muscles as a result of osmotic pressure, thus permitting the recognition of aspects which are not so evident in preserved material. Other specimens were injected or subcutaneously painted with 45% aceto-carmine to make the thin, superficial layers of muscle opaque enough to be seen clearly.

Skeletons were prepared by bacterial action or by an overnight soaking of a fresh, skinned lizard in 50% ammonium hydroxide, with a subsequent 1-10 minute period of boiling in water. The later method gave better results.

It should be mentioned that the skull measurements included in the statistical analysis section were made from preserved specimens, carefully dissected, and not from skulls distorted by the cleaning techniques. All the measurements are in millimeters and were made with the aid of a hand micrometer and a dissecting microscope.

REVIEW OF LITERATURE

The genus *Crotaphytus* was first proposed by John H. Holbrook (1842:79-83), although the type species was collected and described earlier by Thomas Say (James, 1823:252) as *Agama collaris*. In April of 1852 Spencer F. Baird and Charles Girard (1852a:69)* added *Crotaphytus wislizeni* to the genus. A third species, *Crotaphytus reticulatus*, was named by Baird (1858:253).

The status of the species *Crotaphytus insul-

*We follow Taylor (1935 411 412) in considering this manuscript to have been published before Stansbury's report (Baird and Girard, 1852b).

aris Van Denburgh and Slevin (1921:96) and that of *Crotaphytus dickersonae* Schmidt (1922: 638) have been questioned by Burt (1928b:6-10) and Allen (1933:7), but these species are retained as full species by Smith and Taylor (1950:93).

Hobart M. Smith (1946:158-166) separated the species *wislizeni* into the genus *Gambelia*, having obtained this name from Baird (1859: 7), who used it while describing *Crotaphytus reticulatus*, as follows: "More closely related to *Crotaphytus collaris* than to *Crotaphytus* (*Gambelia*) *wislizenii*." This, however, is not the original usage of the word, since an identical statement was published a year earlier by the same author in his original description of *Crotaphytus reticulatus* (Baird, 1858:253).

Robert C. Stebbins (1948:219) and Karl P. Schmidt (1953:3) did not accept the division of *Crotaphytus*, as proposed by Smith (1946: 158-166).

A complete list of the synonymy of this genus and its species is too long and involved to be included here, but can be obtained by reference to Boulenger (1885:203-204), Cope (1900:245-261), Van Denburgh (1922:104-131) and Smith and Taylor (1950:91-94).

Crotaphytus is mentioned in a minority of anatomical publications and, in them, is given only superficial treatment. The only one devoted solely to this genus or any of its members is that by Dwight D. Davis (1934). Unfortunately his descriptions are superficial and in many cases incorrect.

It appears that Cope (1892:246-247) was the first to do extensive osteological studies on the North American genera of lizards. Later studies are those by Camp (1923), Williston (1925), Goodrich (1930), George (1955), Oelrich (1956), and Romer (1956). Two helpful statistical studies of the osteology of related genera are those by Phleger (1940) and Lundelius (1957).

One of the best early studies of lizard myology is that of Mivart (1867), while probably the most extensive comparative work on American lizards was done by Camp (1923). Other related studies are those by Adams (1919), Romer (1924), Edgeworth (1935), Olson (1936), Brock (1938), Evans (1939), George (1948), Kesteven (1944), Watson (1954), Oelrich (1956), and Sathe (1959). Other works available on related forms, which are pertinent, are mentioned in their respective sections.

MYOLOGY

The literature to date reveals no account of the myology of *C. wislizeni* and only Davis (1934) has published on that of *C. collaris*. We have therefore prepared the following description of their anterior musculature as a prerequisite to its use for comparative purposes.

The two forms are similar except in the few cases mentioned and explained separately for each. Notes are also made on certain aspects of the myology of *C. reticulatus*.

The axial musculature was compared in *C. wislizeni* and *C. collaris* and found to be similar. However, no description of these muscles has been included.

THROAT MUSCULATURE

Intermandibularis (posterior and anterior profundus; Plates 1, 7, and 8) is one continuous sheet of thin muscle with various points of origin, which lies superficial to the majority of the throat musculature and just deep to the skin. Posteriorly it is of a single muscle fiber in thickness, becoming increasingly thicker anteriorly.

Although not separable, it is convenient to consider this muscle as being of two parts: 1) intermandibularis posterior and 2) intermandibularis anterior profundus. The intermandibularis has been found to be separable into these two parts in *Ctenosaura* by Oelrich (1956).

The intermandibularis anterior profundus portion of this muscle lies just anterior to the intermandibularis posterior part, and is separable from it, only by having a more dorsal origin. The two become continuous mesially. This anterior profundus part arises from the mesial surfaces of the splenial and coronoid bones and by a tendon along the crista dentalis. Its anterior fibers traverse the throat anteromesially to insert on the ventral mid-line raphe with its partner, deep to the intermandibularis anterior superficialis. Its posterior fibers emerge to the ventral surface by means of three or four interdigitations with the first mandibulohyoideus muscle and then pass transversely to insert on the mid-line raphe.

The intermandibularis posterior part of this muscle may be delimitated anteriorly by the most posterior interdigitation of the anterior profundus section with which it becomes continuous mesially. Posteriorly, this muscle is separated from the constrictor colli by a narrow area of aponeurosis lacking muscle fibers It arises from the lateral surface of approximately the posterior one-half of the mandible. The margin of its origin begins at the retroarticular process of the articular and passes anteroventrally across the supra-angular and angular and then anteriorly on the ventral surface of the dentary. A few of its fibers pass dorsally just posterior to the pterygomandibularis and mesial to the depressor mandibularis, to take origin from the deep fascia of the latter. Its fibers pass transversely and slightly anteriorly to insert on the ventral mid-line raphe which widens into an aponeurotic sheet pos-

The drawings were made from adult specimens of *Crotaphytus wislizeni* and are shown enlarged to approximately four times the actual lizard size.

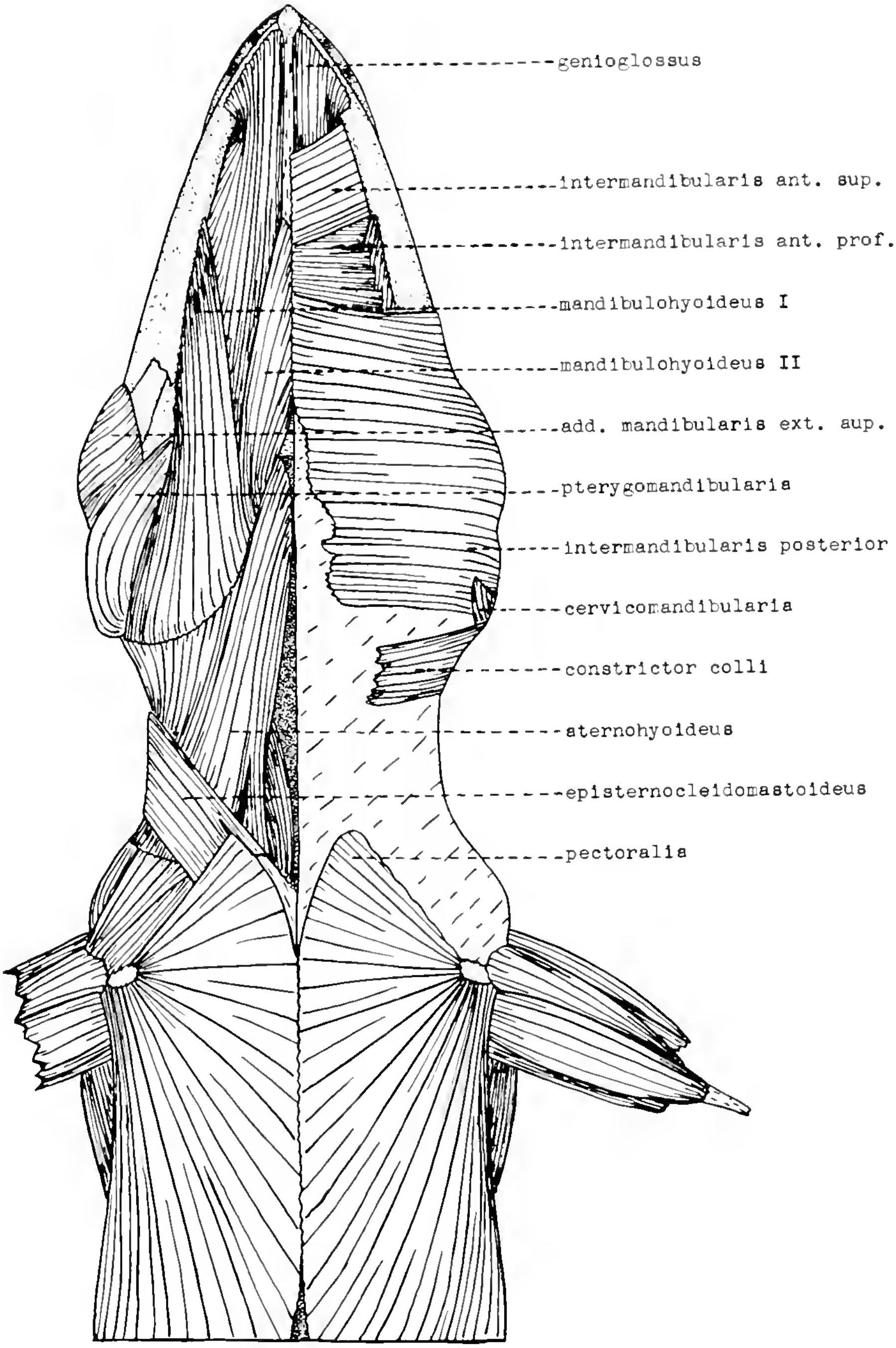

Plate 1.—Ventral view of head and thorax; superficial layer shown at right and first depth at left.

teriorly, leaving a broad gap between the insertions of the partners from opposite sides. A posterolateral part of this muscle is overlain by the insertion of the posterior bundle of the depressor mandibularis in *Crotaphytus wislizeni*.

The posterior division of the intermandibularis posterior which was reported for *Ctenosaura pectinata* by Oelrich (1956:48-49) was not observed in these species.

Intermandibularis anterior superficialis (Plate 1) is a short, band-like muscle connecting the mandibular rami in the area between the origins of the genioglossus and the first mandibulohyoideus. It lies superficial to the intermandibularis anterior profundus, the second mandibulohyoideus, and the genioglossus muscles. It is deep only to the skin.

Arising from the oral membrane, the anterior fibers of the intermandibularis anterior profundus, and the ligament along the crista dentalis, its fibers pass posteromesially to insert with those of its fellow on the ventral mid-line raphe.

Posteriorly its fibers blend into those of the intermandibularis anterior profundus.

Mandibulohyoideus I (Plate 1) is a long, slightly triangular muscle, extending two-thirds of the length of the mandible. It lies lateral to the second mandibulohyoideus muscle, mesial to the mandibular rami, and anterior to the insertion of the sternohyoideus. It runs deep to the intermandibularis muscle and superficial to the genioglossus, hyoglossus, third mandibulohyoideus, and the pterygomandibularis muscles. Anteriorly its fibers interdigitate three or four times with those of the intermandibularis anterior profundus.

The first mandibulohyoideus originates along the ventromesial surface of the dentary and a small part of the angular, from the posterior border of the intermandibularis anterior superficialis, posteriorly to the mass of the pterygomandibularis. It passes posteromesially to insert just posterolateral to the insertion of the second mandibulohyoideus, along the anterolateral border of the distal three-fourths of the first ceratobranchial.

Mandibulohyoideus II (Plate 1) is a narrow, elongate muscle which is pointed at both ends and lies mesial to the first mandibulohyoideus and closely alongside its fellow on the ventral mid-line. It is deep to the intermandibularis muscle, superficial to the tongue, the genioglossus, and the hyoglossus.

This second mandibulohyoideus muscle originates by a narrow tendon which is possibly an anterior etxension of the mid-line raphe, from the capsule of cartilage overlying the mandibular symphysis. It takes origin on this tendon at about the level of the inferior alveolar foramen and runs posteriorly to insert on the anterior border of the proximal end of the first ceratobranchial, anteromesial to the insertion of the first mandibulohyoideus.

Mandibulohyoideus III (Plate 2) is a thick band-like muscle running almost parallel to the mandibular ramus, across the mass of the pterygomandibularis and more or less attached to it by connective tissue. It lies dorsal to the first mandibulohyoideus and ventral and lateral to the genioglossus and the hyoglossus.

The third mandibulohyoideus arises from the ventromesial surface of the dentary and the angular between the anterior and the posterior mylohyoid foramina, dorsal to the origin of the first mandibulohyoideus. It passes posteriorly to insert narrowly on the lateral surface of the ceratohyal, distal to its midpoint.

Genioglossus (Plates 1 and 2) is a thick, band-like muscle occupying, with its partner, all of the space between the mandibular rami, just ventral to the tongue and anterior to the basihyal. It is located dorsal to the first, second, and third mandibulohyoideus, and the intermandibularis muscles.

This muscle takes origin along the ventral and mesial surfaces of the anterior one-sixth of the mandibular ramus, bordering Meckel's canal dorsally. Its mesial fibers run directly posteriorly, while the lateral ones turn dorsally and somewhat laterally and then pass posteriorly. However, the genioglossus in these species is not clearly divisable into a medialis and a lateralis as in *Ctenosaura pectinata* (Oelrich, 1956:55). The fibers of this muscle insert on the lateral surface of the tongue and, by interdigitations, into the body of the hyoglossus.

Hyoglossus (Plate 2) is a thick, broad muscle lying lateral to the basihyal and the second ceratobranchial, and mesial to the mandible, the third mandibulohyoideus, and the pterygomandibularis. It is dorsal to the first and second mandibulohyoideus muscles and the anterior portion of the third mandibulohyoideus. It lies ventral to the ceratohyal and the oral membrane.

The hyoglossus muscle originates along the anterolateral face of the distal two-thirds of the first ceratobranchial, just dorsal to the insertion of the first mandibulohyoideus muscle. It passes anteriorly to interweave with the genioglossus near the proximal end of the hypohyal and to form the main body of the tongue.

Branchiohyoideus (Plate 2) is a thin, narrow muscle, lying dorsal to the hyoglossus between the ceratohyal and the first ceratobranchial of the hyoid bone. Dorsally it contacts the oral membrane which, in turn, lies ventral to the massive pterygomandibularis muscle.

The branchiohyoideus arises from the posteromesial surface of the posterior two-thirds of the ceratohyal, including its mesial process.

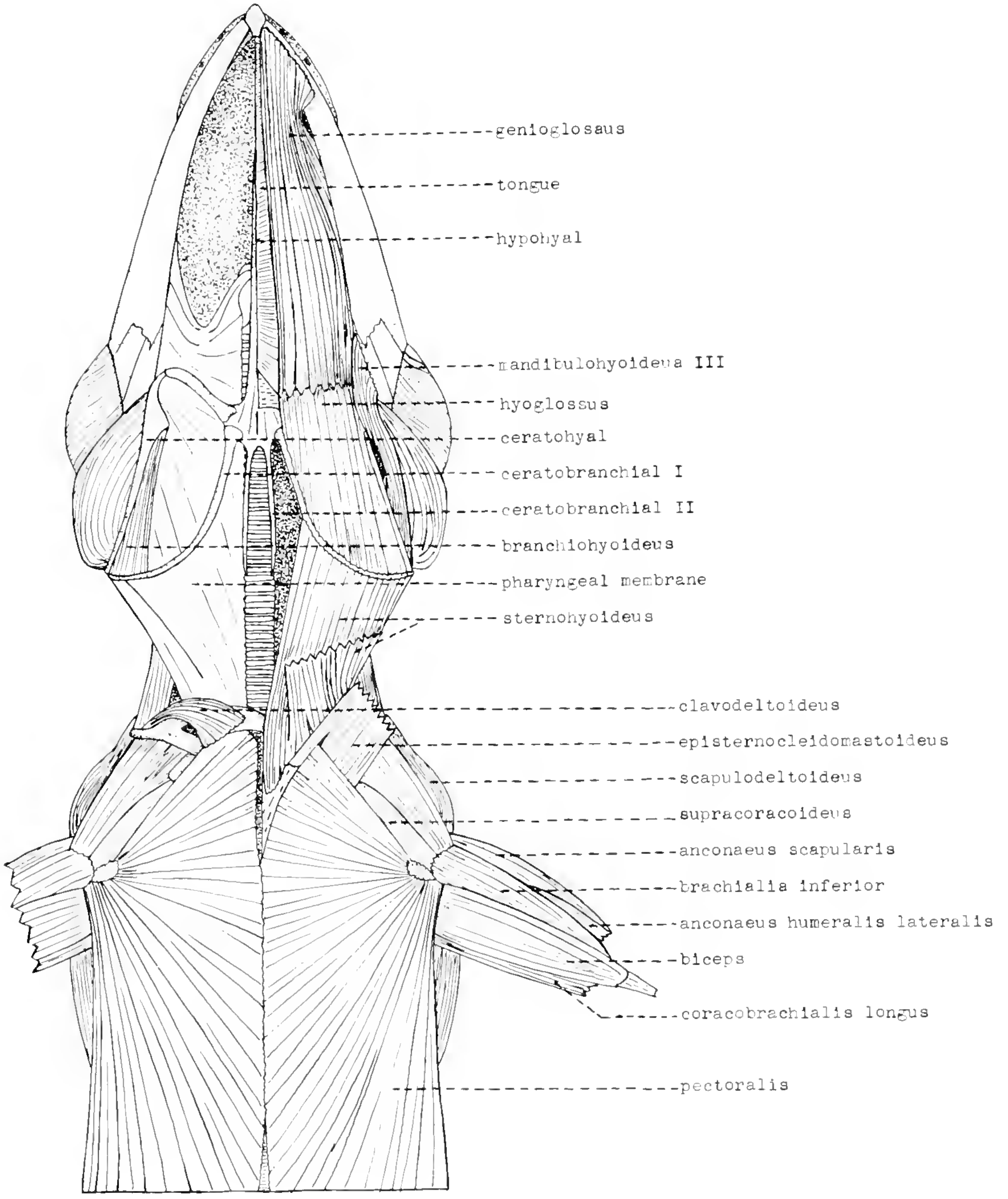

Plate 2—Ventral view of head and thorax, second depth on the right and third depth on the left.

It passes posteriorly, somewhat parallel to the two hyoid limbs, to insert near the distal end of the first ceratobranchial.

Sternohyoideus (Plates 1, 2, 7, and 8) is an extensive muscle sheet occupying the area posterior to the first ceratobranchial bone and anterior to the sternum and clavicle. It lies deep to the intermandibularis and the constrictor colli, anteriorly, and to the episternocleidomastoideus, the trapezius, and a small part of the levator scapulae superficialis, posteriorly. It is superficial to the levator scapulae profundus, the pharyngeal membrane, the trachea, the clavicle, and the clavodeltoideus.

This muscle folds back upon itself to result in superficial and deep layers. The fold is along the midventral line, leaving the lateral margins and the main bodies of the two depths easily separable from one another. The lateral fibers of the superficial sheet run anteromesially and those of the deep group pass anterolaterally. However, mesially the fibers of both layers become increasingly anteriorly directed until all are running parallel and become continuous in the area of the fold. Because of the divergent origins and directions of the fibers, and the increased thickness of the mesial portion, both sheets appear separable into several different muscles. Nevertheless, the two layers of muscle can be removed intact, laid on a flat surface, and separated to open the mesial fold; thus demonstrating a continuous muscle sheet. Lateral stretching and teasing do not reveal natural divisions. This technique and others were used on a series of ten specimens of both species measuring from 43 to 60 snout to vent (Fitch, 1956:238 reports hatchlings to measure 41), as well as older ones. The results were the same in all cases.

Davis (1934:19), in the same lizard, considers the superficial layer as divisable into three parts, one of which he calls omohyoideus. He fails to mention the deep layer. Oelrich (1956:51-52) finds the two layers to appear continuous, but because of their different origins and directions, treats them as being separable into omohyoideus and sternohyodeus in *Ctenosaura pectinata*. Kesteven (1944:245-246) in studying *Physignathus* finds enough suggested separation in young specimens to treat these layers as consisting of three parts; and he considers these to represent the similar, though more distinct, divisions observed in *Varanus*.

We have found several heads of origin and a diversity of fiber direction in both layers. It therefore seems unwise to make any division, even on the basis of apparent homology, without a careful embryological study.

The sternohyoideus arises by various heads from the suprascapula, clavicle, sternum, and interclavicle. One of its many heads originates with the episternocleidomastoideus from the tough fascia which extends between the lateral process of the interclavicle and the sternum. Another head takes tendinous origin, mesially, from the mid-point of the interclavicle. Its fibers run anteriorly, obliquely crossing each other in many instances, and insert on almost the entire posterior surface of the first ceratobranchial and a proximal portion of the second ceratobranchial.

NECK MUSCULATURE

Constrictor Colli (Plates 1, 4, and 7) is the most superficial muscle of the cervical region and is overlain only by the connective tissue of the skin and a few scattered fat pads. Dorsally it lies on parts of the depressor mandibularis and episternocleidomastoideus and ventrally on the sternohyoideus. It is of only one muscle fiber in thickness.

This muscle arises from the superficial dorsolateral fascia of the neck extending almost as far as the posterior margin of the depressor mandibularis. It passes ventrally, just posterior to the retroarticular process of the articular bone, to insert on the extensive ventral aponeurosis which shortly anteriorly serves for the insertion of the intermandibularis. Its insertion is widely separated from that of its partner across the mid-line of the throat.

Episternocleidomastoideus (Plates 1, 2, 5, 7, 8, and 9) is a thick, ribbon-like muscle obliquely crossing the lateral surface of the cervical region. Anterodorsally it is deep to the depressor mandibularis. Otherwise it lies superficial to the sternohyoideus, the tympanic membrane, the distal ends of the ceratohyal and the ceratobranchial bones, and to the two levator scapulae muscles. It arises just anterior to the pectoralis and borders the trapezius posteriorly.

In *Crotaphytus wislizeni* this muscle originates by a single head, along with a bundle of the sternohyoideus, from the lateral process of the interclavicle and a tough fascia which extends from the main body of the sternum to that process. In *Crotaphytus collaris* the episternocleidomastoideus has two heads of about equal size. The lateral one arises as does the single head in *Crotaphytus wislizeni*, whereas the mesial one takes tendinous origin, with some fibers of the sternohyoideus, from the central column of the interclavicle. Several specimens of *Crotaphytus wislizeni* have a small mesial sliver of muscle fibers which takes origin similarly to the mesial head in *C. collaris*, but which could hardly be considered as a true mesial head, due to its size. In both species the episternocleidomastoideus runs anterodorsally, deep to the depressor mandibularis and constrictor colli, to insert on the distal half of the

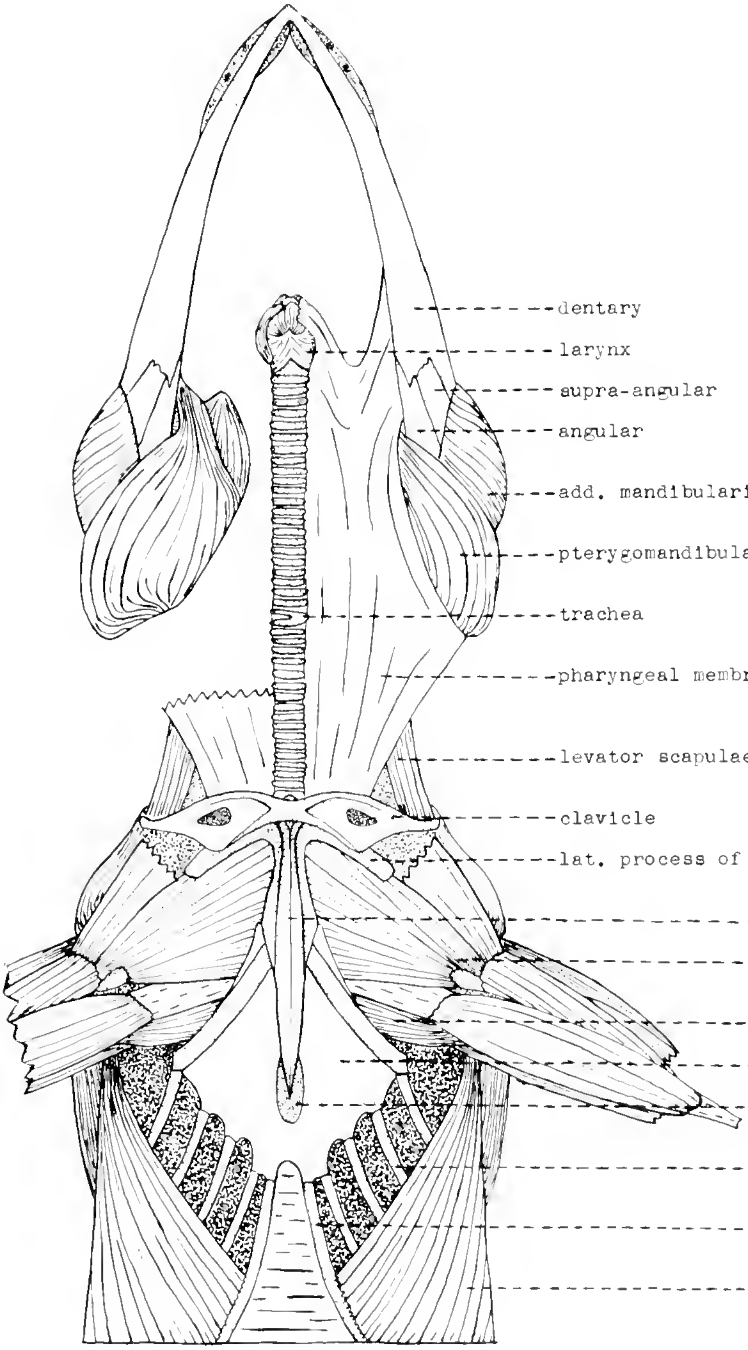

Plate 3 Ventral view of head and thorax; foruth depth on the right and fifth depth on the left

parietal crest, the lateral surface of the para-occipital process of the exoccipital bone, and on the fascia of the dorsolateral angle of the neck.

The origin of this muscle in *C. reticulatus* is similar to that described for *C. collaris.*

Depressor Mandibularis (plates 4, 7, and 8) is a massive muscle lying on the lateral surface of the cervical region and bordering the auditory meatus anteriorly. The constrictor colli overlies most of its body. Anteriorly it is superficial to some of the posterior fibers of the adductor mandibularis externus medius and the posterior border of the tympanus. Posteriorly it passes superficial to the anterior fibers of the trapezius, and those of the episternocleidomastoideus, the distal ends of the ceratohyal and ceratobranchial bones, and the tympanic membrane.

Three bundles of the depressor mandibularis are recognizable in *Crotaphytus wislizeni* (anterior, lateral, and posterior) but only the posterior one is distinctly separable in its body from the others.

The anterior bundle takes origin from the anterolateral surface of the posterolateral parietal wing and the parietal crest. It passes posteroventrally to become continuous laterally with the body of the lateral bundle and insert with it, by a strong tendon on the retroarticular process of the articular bone.

The lateral bundle arises posteriorly from the fascia along the dorsolateral angle of the neck, approximately in the region of the first three cervical vertebrae, and deep to the origin of the constrictor colli. Anteriorly the bundle originates from the entire posteromesial surface of the parietal wing and part of the parietal crest, which it traverses to pass ventrally and lie lateral to, and unite with, the anterior bundle. The anterior and posterior fibers of this entire bundle converge ventrally to insert with those of the anterior bundle, on the retroarticular process.

The posterior bundle (cervicomandibularis) is separable in its entirety from the others, except in extremely old (large) specimens in which it becomes somewhat attached, near its origin, to the lateral bundle. Its origin is from the superficial dorsal fascia of the mid-line of the neck just posterior to that of the lateral bundle, and deep to the origin of the constrictor colli. It passes anteroventrally along the posterior border of the lateral bundle and continues past the insertion of the anterior and lateral bundles to insert ventrolaterally on the superficial fascia of the intermandibularis and the skin.

Only two bundles of the depressor mandibularis can be distinguished in *Crotaphytus collaris*, and these are not separable from one another. The anterior group of fibers arises from the parietal and the anterior part of the superficial dorsal fascia, while the posterior group originates, just posterior to it, by the same fascia. The muscle fibers of both bundles converge ventrally, the posterior ones coming to lie lateral to the anterior group. All insert by a common tendon on the retroarticular process of the articular bone.

The character of this muscle in *C. reticulatus* is the same as that explained for *C. wislizeni.*

TEMPORAL MUSCULATURE

Pterygomandibularis (Plates 1 and 3) is an extremely large muscle which covers almost the entire posterior half of the mandible and has its main mass between the mandibular rami, just lateral to the trachea. It is overlain by the intermandibularis posterior, laterally, and the oral membrane, ventromesially. It lies dorsal to the third mandibulohyoideus and the hyoglossus muscles.

The pterygomandibularis originates, by a heavy tendon, from the ventral projection of the ectopterygoid, and part of the transverse process of the pterygoid. It also originates by a tendinous sheath from the remaining part of the transverse process, and the ventrolateral border of the quadrate process of the pterygoid, as well as from the ventral border of the basipterygoid process of the basisphenoid in the region of its articulation with the pterygoid.

Its fibers run posteriorly and then posterodorsally, to cover the ventral and lateral surfaces of the angular, the articular, and the supra-angular bones. Most of the fibers insert on the dorsal, mesial, and ventral surfaces of the articular, including its retroarticular and angular processes. A line of inserting fibers passes posterodorsally across the lateral surfaces of the angular and the supra-angular, continuing posteriorly along the condyle of the quadrate and the insertion of the depressor mandibularis, leaving only the posterior supra-angular foramen between it and the adductor mandibularis externus superficialis. A tendon, serving for the insertion of many of its fibers, runs lengthwise through the muscle mass in a posterior direction, and attaches to the angular process of the articular.

Levator Angularis Oris (Plate 7) is the most superficial muscle of the infratemporal fossa. It is overlain only by the extensive infratemporal fascia and the skin, and covers more than half of the lateral surface of the adductor mandibularis externus superficialis.

This thin muscle arises from the mesial surface of the superficial infratemporal fascia, the ventrolateral surfaces of the squamosal and the posterior part of the jugal, and from the anterodorsal angle of the tympanic crest. Its fibers

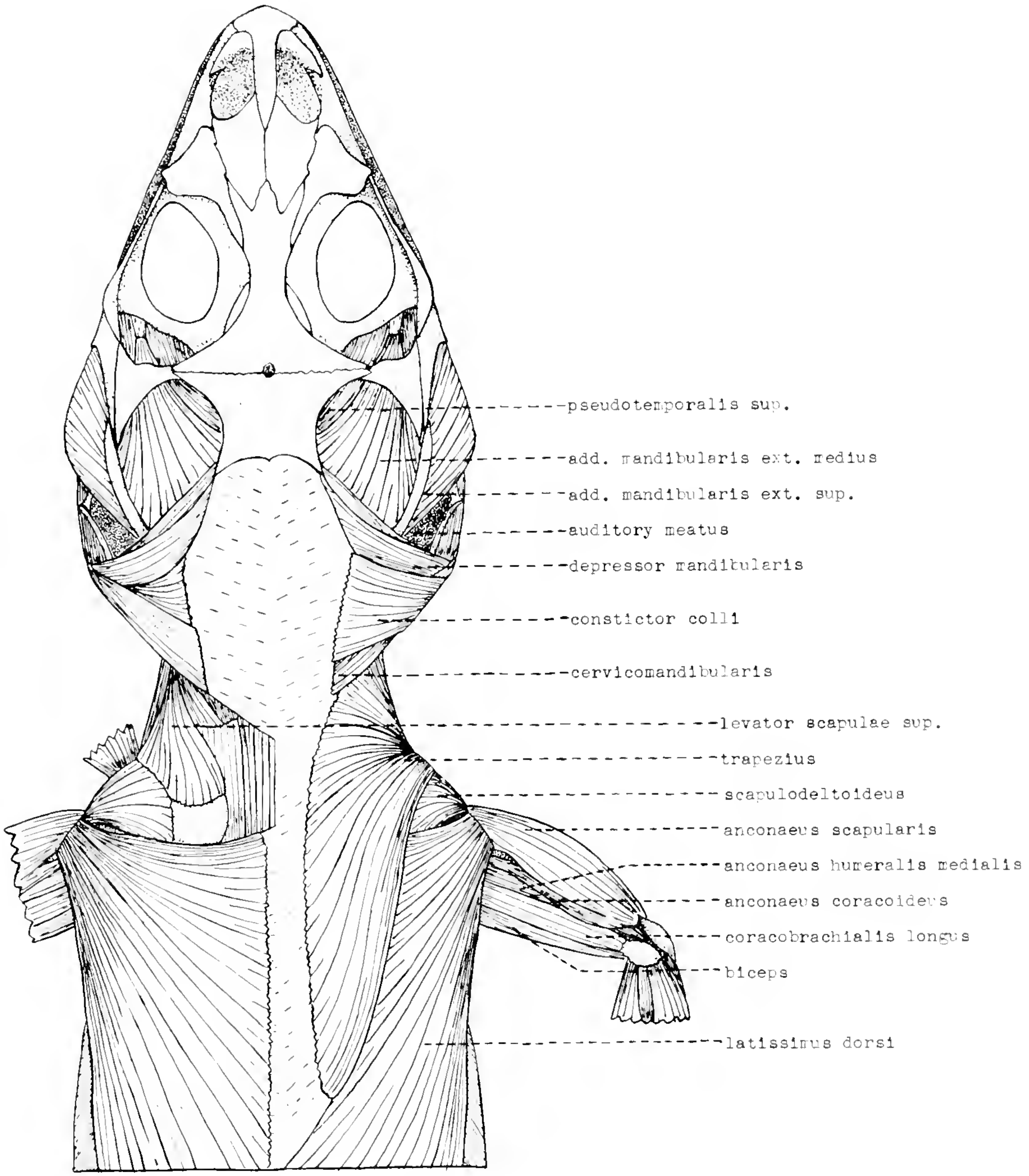

Plate 4.—Dorsal view of head and thorax, superficial layer show at right and first depth at left.

run anteroventrally and inset on the dorsomesial surface of the mundplatt near the posterior border of the coronoid.

Adductor Mandibularis Externus Superficialis (Plates 1, 3, 4, 7, and 8) is an extensive muscle of the infratemporal fossa, which mesially is scarcely distinguishable from the adductor mandibularis externus medius. It is deep to the levator angularis oris anterodorsally, and to the superficial infratemporal fascia posteroventrally.

It takes origin from the ventral surfaces of the postorbital, squamosal, and a portion of the jugal; and from the dorsal and anterior surfaces of the quadrate, as well as the lateral surface of the tympanic crest. Its fibers run anteroventrally, somewhat more ventrally than those of the levator angularis oris. They insert along the beveled, dorsolateral surface of the supra-angular, just dorsal to the posterior supra-angular foramen and covering the anterior supra-angular foramen. The more anterior fibers insert on the lateral and posterolateral surfaces of the coronoid and the lateral surface of the bodenaponeurosis.

Adductor Mandibularis Externus Medius (Plate 4, 7, 8, and 9) is a massive muscle which lies immediately mesial to the adductor mandibularis externus superficialis and dorsolateral to the adductor mandibularis externus profundus, from which muscles, it is only faintly separable. It also lies posterolateral to the pseudotemporalis superficialis, except for a few of its anteromesial fibers which are dorsal to the same.

The fibers of this muscle take origin from the mesial surface of the squamosal, the anterolateral surfaces of the supratemporal and the posterolateral parietal wing, the dorsolaterally beveled surface of the parietal, and from the anterior and dorsal surfaces of the quadrate bone. The fibers run anteroventrally, the dorsal ones being more anteriorly directed, and insert along the dorsomesial surface of the supra-angular, the posterior surface of the coronoid, and the lateral, posterior, and mesial sides of the bodenaponeurosis.

Adductor Mandibularis Externus Profundus (Plate 10) is a massive muscle and is not clearly separable from the adductor mandibularis externus medius dorsolaterally. It is located ventrolateral to the pseudotemporalis superficialis, dorsal to the prootic, and lateral to the brain case and the supraoccipital.

This muscle originates from almost the entire posteromesial border of the posterolateral wing of the parietal, from the paraoccipital process of the exoccipital, and from the dorsolateral surface of the posterior process of the prootic bone. From its parietal origin this muscle turns ventrally and then anteroventrally to enter the infratemporal fossa, passing ventral to the supratemporal and the posterolateral parietal wing and dorsal to the exoccipital and the posterior process of the prootic. Here it joins with another head from the prootic and then continues anteroventrally to insert by the bodenaponeurosis to the posterior surface of the coronoid, and separately to the base of the coronoid.

The adductor mandibularis externus group is treated as three separate muscles only for convenience. Perhaps it should be considered a single mass (Adams, 1919) with slips as described above.

Pseudotemporalis Superficialis (Plate 10) is a divergent, massive muscle which lies ventromesial to the adductor mandibularis externus medius, posterior to the orbit, anterolateral to the cranial cavity, lateral to the epipterygoid, and lateral to the pseudotemporalis profundus. Some of its posterior fibers are sandwiched between the adductor mandibularis externus profundus and the adductor mandibularis externus medius.

The pseudotemporalis superficialis originates from the dorsolaterally beveled lateral margin of the parietal, part of the anterolateral surface of the parietal wing, the lateral surfaces of the anterior semicircular canal, and the alar process of the prootic, and all but the internal surface of the dorsal one-third of the epipterygoid. The anterior fibers of this muscle run ventrally while the posterior ones pass anteroventrally. They insert, with the pseudotemporalis profundus, on the mesial surface of the bodenaponeurosis, the posteromesial border of the coronoid to its base, and then posteriorly along the dorsal border of the articular to about its mid-point.

Pseudotemporalis Profundus (Plate 11) is an almost pyramid shaped muscle just posteromesial to the pseudotemporalis superficialis. It is lateral to the epipterygoid bone and to the levator pterygoideus muscle.

This muscle arises from the anterior, lateral, and posterior sides of the ventral two-thirds of the epipterygoid bone. It runs ventrally and inserts, in common with the pseudotemporalis superficialis muscle, on the posteromesial border of the coronoid and along the dorsal surface of the articular bone to its mid-point.

Adductor Mandibularis Posterior (Plate 11) is a broad, thin muscle, lying lateral to the tympanic cavity and the protractor pterygoideus muscle, and mesial to the mandible and to the adductor mandibularis externus muscles.

Some of its fibers arise from the lateral and mesial surfaces of an aponeurosis which runs between the mesial crest of the quadrate and Meckel's cartilage. Other fibers take origin from the posterior process of the prootic bone. They all pass anteroventrally and insert on the

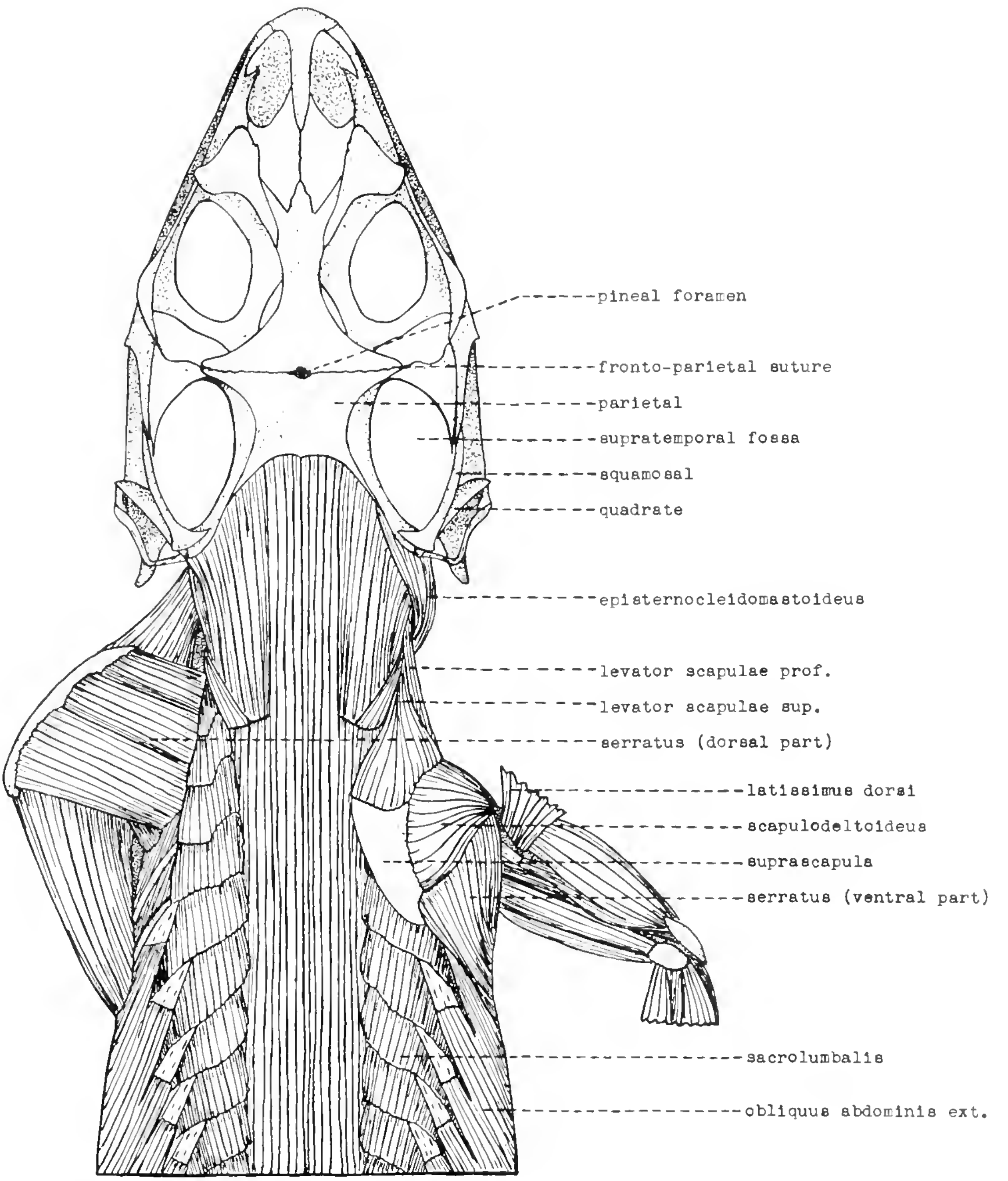

Plate 5.—Dorsal view of head and thorax, second depth on the right and a view of the left side with the suprascapula pried away from the body

dorsal surface of the articular bone with some of the fibers of the pseudotemporalis muscles, and on Meckel's cartilage.

Levator Pterygoideus (Plates 11 and 12) is a triangular shaped muscle which lies just posteromesial to the epipterygoid bone and the pseudotemporalis profundus muscle. It is anterolateral to the protractor pterygoideus and lateral to the prootic membrane of the cranial cavity.

This muscle takes origin by a flat tendon from the ventral surface of the parietal, just mesial to the epipterygoid, and posteriorly along the lateral margin of the parietal to its midpoint. Additional fibers arise from the dorsolateral surface of the prootic membrane. Its fibers fan out posteroventrally and insert, with a few anterior fibers of the protractor pterygoideus, on the proximal dorsal surface of the quadrate process of the pterygoid, beginning somewhat posterolateral to the fossa columella and extending anteromesially, to end just mesial to the epipterygoid.

Protractor Pterygoideus (Plates 11 and 12) is a broad, fairly short muscle which forms the anterolateral wall of the tympanic cavity. It ties posteromesial to the levator pterygoideus and lateral to the basisphenoid and the anterior parts of the prootic.

This muscle arises from the lateral surface of the anterior inferior process of the prootic, the posteroventral end of the pila antotica, and from the posterior and lateral surfaces of a tendon which runs from the anterior inferior process of the prootic to the region of the condyle on the anterior tip of the basipterygoid process of the basisphenoid. The fibers of the protractor pterygoideus fan out, running posteroventrally, and insert on the dorsal and mesial surfaces of the quadrate process of the pterygoid. This insertion runs from just posteromesial to the fossa columella, posteriorly, almost to the mesial crest of the quadrate. Some of its anterior fibers insert with those of the levator pterygoideus, but the majority remain posteromesial to this muscle.

PECTORAL GIRDLE AND BRACHIAL MUSCULATURE

The descriptions of the brachial muscles were made with the arm stretched out laterally and the palm of the hand down for the dorsal view, and up for the ventral view.

Trapezius (Plates 4, 7, 8, and 9) is an extensive, superficial muscle located on the dorsolateral surfaces of the cervical and thoracic regions. It is the most superficial muscle of the area with the exception of the depressor mandibularis and the constrictor colli.

It arises from the dorsolateral fascia of the neck from the axis posteriorly to about the seventh thoracic vertebra* and then posteriorly to the seventh, by the dorsal aponeurosis of the midline of the neck The anterior fibers of this muscle pass posteroventrally along the border of the episternocleidomastoideus, and the posterior ones, anteroventrally, somewhat dorsal to the scapula. Thus, they converge to insert on the crest of the anterior margin of the suprascapula, and on the superficial fascia along the clavicle and the anterior margin of the pectoralis to the origin of the episternocleidomastoideus.

This muscle varies greatly in thickness throughout its extent. Posteriorly it is considerably developed, this being the major part to insert on the suprascupula. However, anteriorly it comes to be only one muscle fiber in thickness. In many specimens an anterior slip was observed to be separate from the main sheet, in its body, and to become more or less associated with the episternocleidomastoideus.

Latissimus dorsi (Plates 4, 5, 7, 8, 9, and 10) is a sheet-like muscle which covers an extensive portion of the lateral body surface. Its anterodorsal fibers are overlain by the trapezius muscle while the remaining ones are deep only to the skin. It is superficial to part of the scapulodeltoideus and serratus muscles, and the suprascapula.

This muscle arises from the superficial fascia of the back and the deep fascia of the dorsal mid-line, between the first and the tenth thoracic vertebrae. Its anterior fibers run posteroventrally and its posterior ones, anteroventrally. They all coverge and pass between the tendons of origin of the anconaeus coracoideus and anconaeus scapularis muscles, to insert tendinously on the processus latissimus dorsi of the shaft of the humerus.

Levator Scapulae Superficialis (Plates 4, 5, 8, 9, 10, and 11) is a broad, fan-shaped muscle which lies mostly anterior, but partly superficial, to the suprascaupla. It is dorsal to the levator scapulae profundus, and superficial to the axial musculature and the posterodorsal fibers of origin of the sternohyoideus.

It lies deep to the constrictor colli, the trapezius, the episternocleidomastoideus, the depressor mandibularis, the tympanic membrane, and the distal ends of the ceratohyal and the first ceratobranchial.

The levator scauplae superficialis originates, by means of a tendon, common to it and the levator scapulae profundus, from the diapo-

*We consider six cervical vertebrae after Camp (1923 359

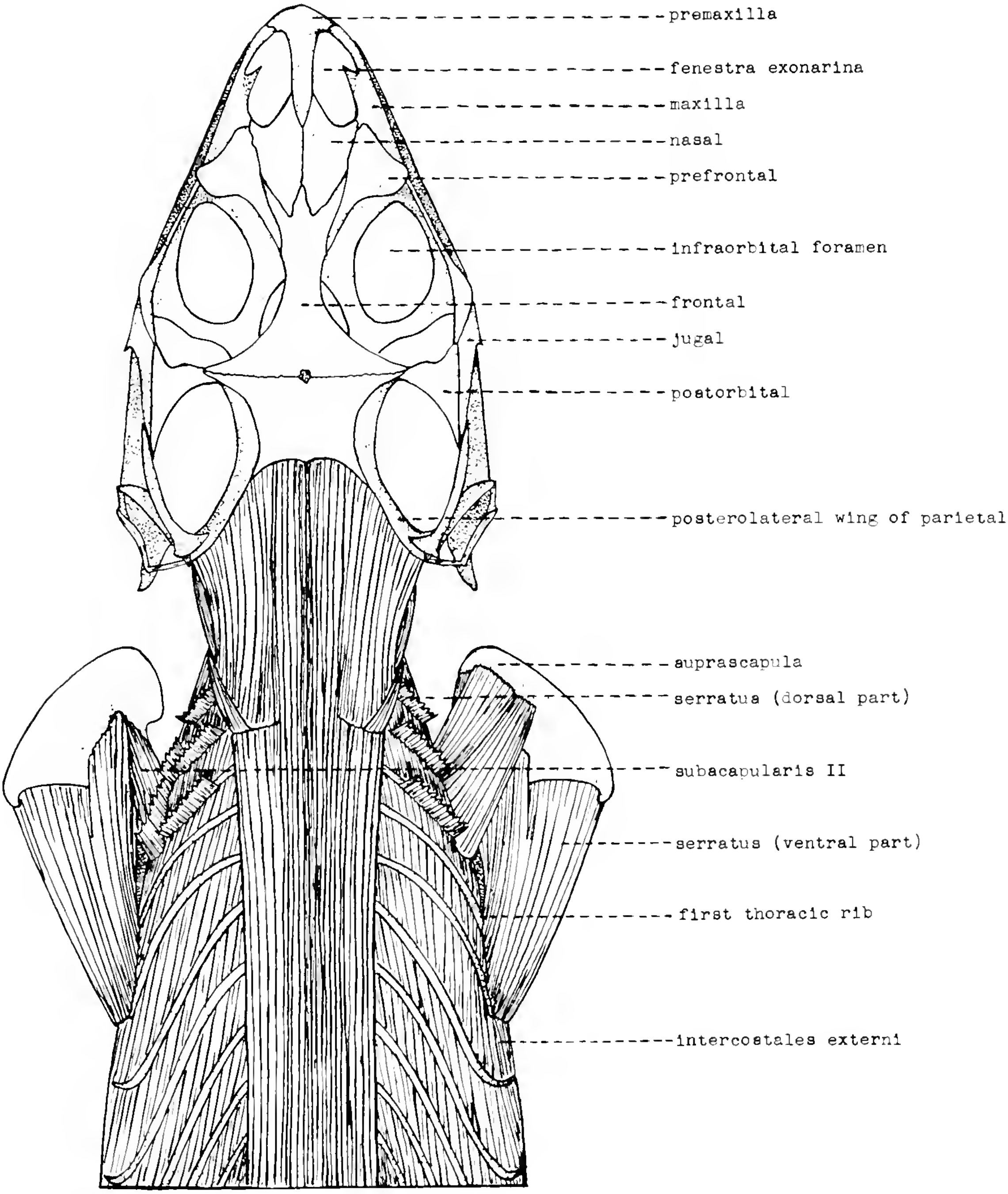

Plate 6.—Dorsal view of head and thorax; the dorsal serratus group cut on the right and the two anterior slips of the ventral group cut on the left

physis of the atlas. It runs posterodorsally and inserts on the anterior half of the lateral surface of the suprascapula.

Levator Scapulae Profundus (Plates 3, 5, 8, 9, 10, and 11) is the ventral partner of the levator scapulae superficialis, and lies in approximately the same position with relation to the surrounding muscles, except that its posterior fibers of insertion run deep to those of the sternohyoideus muscle.

It takes origin, by a common tendon with the levator scapulae superficialis, from the diapophysis of the atlas. Its fibers pass posterodorsally and insert along the anterior margin of the suprascapula just ventral to the insertion of the levator scapulae superficialis, and on the anterior surface of the acromial end of the clavicle.

Scapulodeltoideus (Plates 2, 4, 5, 7, and 8) is a heavy, somewhat triangular muscle, lying superficial to the scapula and suprascapula, posterior to the insertions of the levator scapulae muscles, and to the origin of the sternohyoideus. It is overlain dorsally by parts of the trapezius and the latissimus dorsi, and ventrally by the skin and the clavodeltoideus.

This muscle arises from the posterior one-half of the lateral surface of the suprascapula and the acromial end of the clavicle. Its fibers converge ventrally, passing mesial to the clavodeltoideus and lateral to the ligament of the anconaeus scapularis, to insert on the proximal end of the humerus.

Serratus (Plates 5, 6, 9, 10, 11, and 12) as here described may include the levator anguli scapulae and the rhomboideus (Mivart, 1867: 776-777). We have chosen to treat this complex as divisable into dorsal and ventral portions.

The dorsal part consists of three ribbon-like slips of muscle which partially overlap one another in such a way that they appear serratus-like from the dorsal view, when the suprascapula is pried away from the lizard's body. This muscle is deep to the suprascapula, and, although it is partially continuous with the ventral part, it lies mesial and somewhat dorsal to the ventral group of slips.

The dorsal part arises by fasciculae, from the lateral surfaces of the three cervical ribs. These slips pass slightly dorsolaterally, parallel to, and slightly overlapping one another, and insert, separately, along the mesial surface of the suprascapula near its dorsal border.

The ventral part has two anterior slips which are continuous with those of the dorsal part near their origins, but have their main masses lateral and ventral to them. This part also has two posterior slips which have no counterparts in the dorsal group.

The ventral part originates, by separate fasciculae, from the distal regions of the last two cervical and the first two thoracic ribs, and from the intervening intercostales externi of the area. All the slips pass anterodorsally. The two anterior ones insert on the anterior half of the inner surface of the suprascapula, just ventral to the insertions of the dorsal group. The two wider, posterior slips, from the first and second thoracic ribs, insert on the suprascapula, ventrolateral to the insertion of the slip from the last cervical rib; and along the posteroventral edge of the suprascapula, respectively.

Pectoralis (Plates 1, 2, and 7) is an extensive, superficial muscle of the breast. It overlies the sternum, sternal ribs, and the coracoid, with their attached muscles. It is posterior to the clavicle and the clavodeltoideus, and anterior to the rectus abdominis externus. The origins of the paired pectoralis muscles separate along the ventral mid-line to allow for the tendinous origin of the sternohyoideus muscle from the interclavicle.

The pectoralis muscle arises from the inner angle of the clavicle, the interclavicle, the sternum, and the ventral mid-line fascia, continuing along the xiphoid rod to the sixth sternal rib. It follows this rib, arching posterolaterally and then anterolaterally along hyaline and finally myocomatal extensions bordering the rectus abdominis externus, and traverses ventral to the fourth and third and terminates near the second sternal rib. All the fibers of the pectoralis converge to insert on the deltopectoral crest of the humerus.

Clavodeltoideus (Plates 2, 7, 8, and 9) is a heavy muscle of the anteroventral shoulder region. It is located anterior to the supracoracoideus and the pectoralis, proximal to the brachialis inferior, ventral and lateral to the scapulodeltoideus, deep to the episternocleidomastoideus, and the sternohyoideus, and superficial to the scapulohumeralis anterior. The clavodeltoideus originates from the margins and the ventral surface of the proximal half of the clavicle. Its fibers run anterolaterally across the ventral surface of the clavicle, and then turn dorsolaterally and posterolaterally, to pass mesial to the clavicle. This muscle inserts on the proximal end of the humerus.

Supracoracoideus (Plates 2, 3, and 7) is a deep chest muscle of triangular shape. It lies deep to the pectoralis muscle and the interclavicle, ventral to the coracoid and the large tendon of the biceps, posterior to the clavical and the clavodeltoideus, and anterior to the coracobrachialis brevis.

The supracoracoideus muscle originates from the ventral surface of the anteromesial region of the coracoid. Its fibers pass posterolaterally, converging to insert on the deltopectoral crest of the humerus.

Scapulohumeralis Anterior is a small, thin mus-

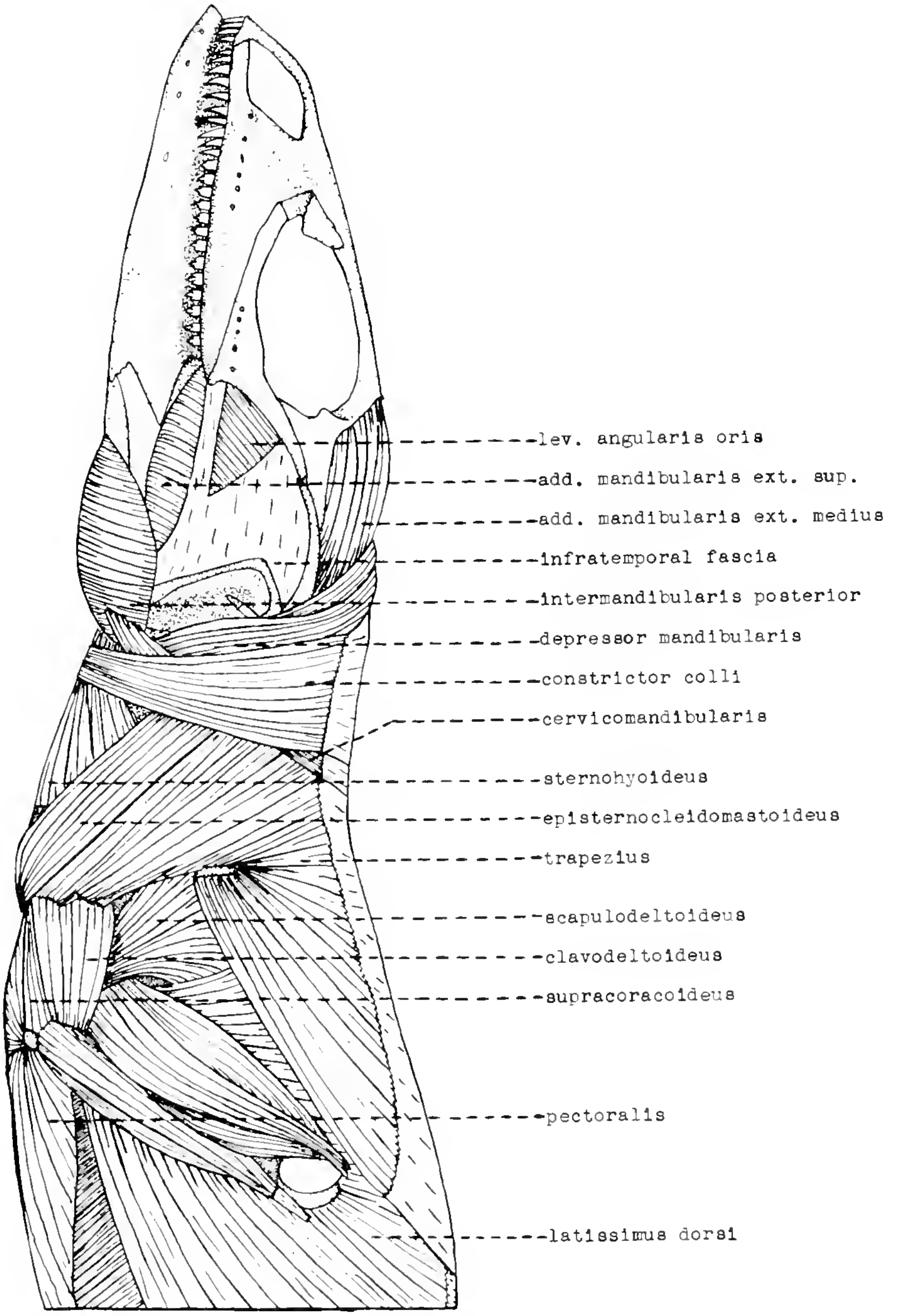

Plate 7.—Lateral view of head and thorax, superficial layer

cle located near the base of the scapula. It is anterior to the supracoracoideus, and deep to the clavodeltoideus and the inserting fibers of the scapulodeltoideus.

This muscle takes origin from the spinous process of the scapula, the anterolateral tip of the epicoracoid, the intervening membrane of the coraco-scapular fenestra, and the lateral surface of the scapula in the axillary region. The muscle runs posteriorly, lateral to the axillary region of the scapula. It then passes ventral to the tendon of origin of the anconaeus scapularis and over the margin of the glenoid fossa to insert on the distal surface of the humeral crest of the humerus, just dorsal to the insertion of the latissimus dorsi, and between the tendons of the anconaeus scapularis and the anconaeus coracoideus.

Coracobrachialis Brevis (Plate 3) is a short, stout muscle of the chest. It is located dorsal and posterior to the tendon of the biceps, and anterior to the sternal attachment of the first thoracic rib.

This muscle takes origin from the ventral surface of the posterolateral region of the coracoid. Its fibers run slightly posterolaterally and insert, shortly, on the head of the humerus in the concave region between the delto-pectoral and humeral crests, and on the proximal half of the posterior surface of the humerus.

Coracobrachialis Longus (Plates 2 and 4) forms the posterior surface of the upper arm. It is posterodorsal to the biceps and posteroventral to the anconaeus humeralis medialis.

This muscle originates from the ventral surface of the extreme posterolateral tip of the coracoid. It runs along the entire length of the humerus and inserts on the proximal surface of its ulnar process.

Biceps (Plates 2, 4, and 8) is a large ventral muscle of the upper arm. It is located posterior to the brachialis inferior, and anterior to the coracobrachialis brevis and the coracobrachialis longus muscles.

Its fibers arise near the proximal head of the humerus from a long, broad tendon which passes between the coracobrachialis brevis and supracoracoideus, to originate just dorsal to the latter, from the ventral surface of the mesial border of the coracoid. The biceps muscle passes along the ventral surface of the humerus and shortly becomes united, to some degree, with the brachialis inferior. This united body of the two muscles passes between the radial and ulnar processes of the humerus and then bifurcates to insert on the ventral (flexor) surfaces of the proximal heads of the radius and the ulna.

This muscle is single in these species. We do not consider the brachialis inferior to be its humeral head, after Mivart (1867:782-783).

Brachialis Inferior (Plates 2 and 8) is a large brachial muscle, located just anterior to the biceps and ventral to the anconaeus humeralis lateralis and the anconaeus scapularis.

This muscle arises just distal to the insertions of the clavodetoideus and supracoracoideus muscles, from the delto-pectoral crest of the humerus, and also from the entire ventral surface of its shaft. The brachialis inferior runs along the anteroventral surface of the arm, becoming somewhat united with the biceps muscle distally. However, the majority, if not all, of its fibers insert on the radius, while most of those of the biceps insert on the ulna.

Anconaeus Humeralis Lateralis (Plates 2 and 8) lies dorsal to the brachialis inferior and anterior to the anconaeus scapularis, on the anterior surface of the upper arm.

The origin of this muscle is from the proximal head and the entire anterodorsal surface of the shaft of the humerus. Its body passes along the humerus and unites with the anconaeus scapularis. It inserts with all the other anconaeus muscles, on the olecranon process of the ulna and the above sesamoid.

Anconaeus Scapularis (Plates 2, 4, and 8) is a large member of the anconaeus group, which lies posterior to the anconaeus humeralis lateralis and anterodorsal to the anconaeus coracoideus.

Its origin is by a strong tendon which passes between the latissimus dorsi and the scapulodeltoideus, and attaches to the posterior surface of the scapula. The muscle body passes dorsal to the glenoid fossa and the head and shaft of the humerus, to unit with the anconaeus humeralis lateralis and insert on the olecranon process of the ulna and the superficial sesamoid.

Anconaeus Coracoideus (Plate 4) is a small, dorsal muscle of the upper arm. It lies posteroventral to the anconaeus scapularis and anterodorsal to the anconaeus humeralis medialis.

It originates by means of a long, fine tendon which passes posterior to the inserting fibers of the lattissimus dorsi, to arise from the broad sterno-scapular ligament. The anconaeus coracoideus unites, shortly lateral to the latissimus dorsi, with the anconaeus scapularis and inserts with it on the olecranon process of the ulna and the adjacent sesamoid.

Anconaeus Humeralis Medialis (Plate 4) lies mostly deep to the anconaeus coracoideus, posteroventral to the anconaeus scapularis, and anterodorsal to the coracobrachialis longus.

This muscle arises from the humeral crest and the posterodorsal surface of the shaft of the humerus. It unites with the other anconaeus muscles to insert with them, on the ole-

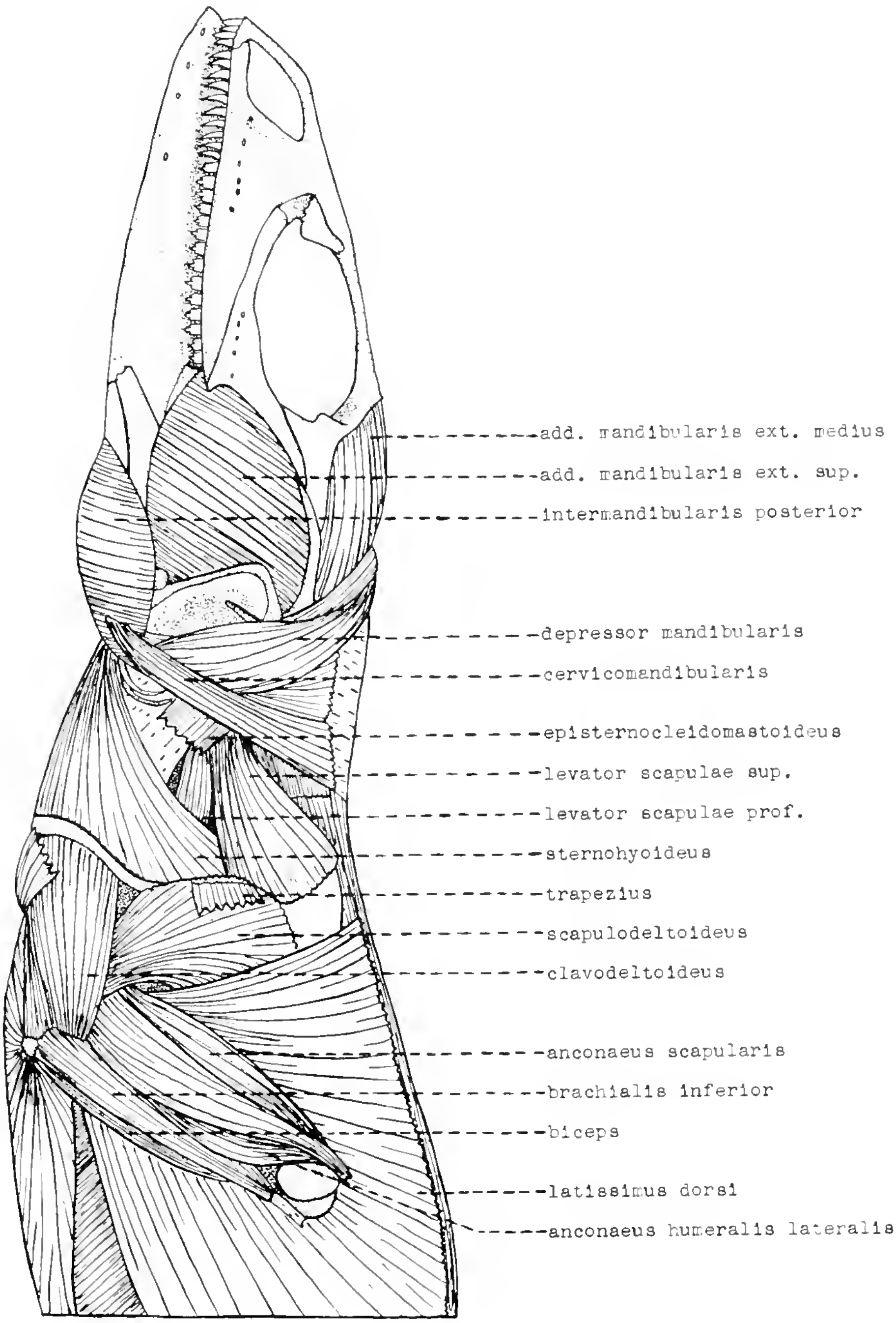

Plate 8.—Lateral view of head and thorax, first depth

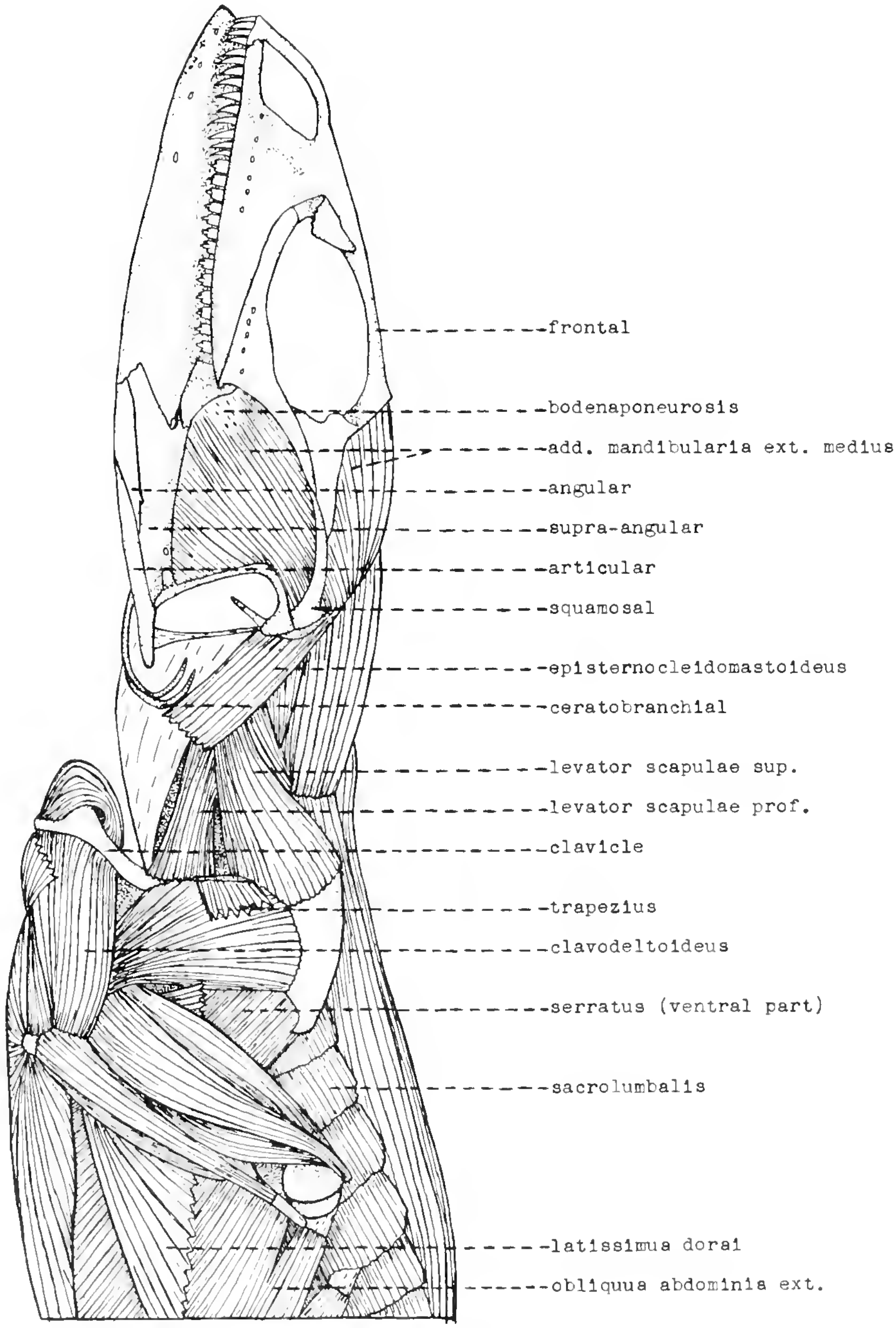

Plate 9.—Lateral view of head and thorax, second depth

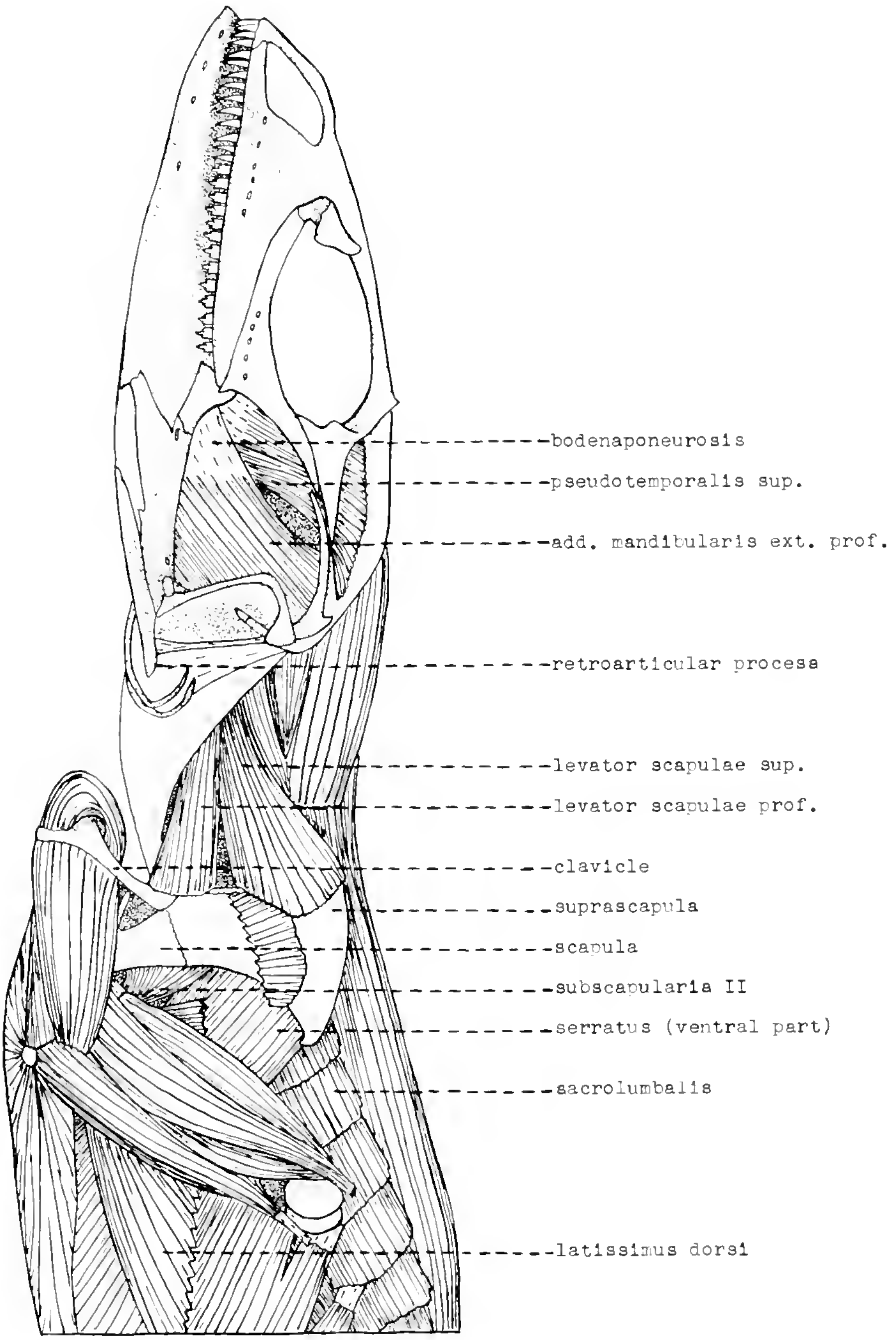

Plate 10.—Lateral view of head and thorax; third depth

cranon process of the ulna, and on the patella like sesamoid of the elbow.

Subscapularis I is a broad muscle which overlies the inner surface of the coracoid, ventrally, and borders the peritoneum dorsally. It is ventromesial to the second subscapularis and its dorsal surface is traversed near the middle by the ligament which serves for the insertion of the costocoracoid muscle.

The first subscapularis arises from the entire dorsal surfaces of the coracoid and the epicoracoid, including the membranes of all the fenestrae and of the spinous process of the scapula. Its fibers converge posteriorly and insert by a tendon, with the second subscapularis, on the humeral crest of the humerus.

Subscapularis II (Plates 6, 10, and 11) lies just dorsolateral to the first subscapularis, on the inner surfaces of the scapula and the suprascapula. It is lateral to some of the anterior fibers of the serratus, which come from the first sternal rib, and mesial to the scapulodeltoideus.

The second subscapularis originates from the scapula and suprascapula and passes posteroventrally to insert with the first subscapularis, by a tendon, on the humeral crest of the humerus.

Costocoracoid (Plates 11 and 12) is a broad, thin muscle, lying mesial to the first and second sternal ribs, some of the serratus muscles, and the scapula; and dorsomesial to the posterior portions of the first and second subscapularis muscles.

The costocoracoid arises from the anterior margin of the sternal region of the third thoracic rib. It runs anteriorly and inserts, just dorsal to the mid-region of the first subscapularis, on a ligament which extends between the inner surface of the sternum at the point of its articulation with the first sternal rib and the anterior border of the scapula, just dorsal to the spinous process.

Internal Sternocoracoid is a broad, thin muscle which lies on the inner surface of the sternum and is dorsal, in part, to the external sternocoracoid.

It arises along the dorsal surface of the posterolateral border of the sternum and from the sternal heads of the thoracic ribs. This muscle runs anterolaterally and inserts by a broad tendon on the inner surface of the mesial process of the coracoid and on part of the epicoracoid. This insertion is just anterolateral to that of the external sternocoracoid.

External Sternocoracoid is an extremely broad and short muscle which links the inner articulating borders of the sternum and the coracoid. It is ventral to the internal sternocoracoid, posteromesial to the first subcapularis, and anteromesial to the costocoracoid. Posteriorly its inner surface is traversed by the ligament of insertion of the costocoracoid.

This muscle arises from the entire anterolateral border of the sternum, just internal to its groove of articulation with the coracoid. It passes anteriorly and inserts by a flat tendon, on the epicoracoid, just posteromesial to the inserting tendon of the internal sternocoracoid.

LATERAL TRUNK MUSCULATURE

Sacrolumbalis (Plates 5, 9, 10 and 11) is an extensive muscle which parallels the longissimus dorsi over the full length of the dorsolateral surface of the body. It is dorsal to the serratus and superficial to the intercostal muscles.

The sacrolumbalis originates from the posterior end of the crest of the ilium. It passes anteriorly and inserts by tendinous bands, onto the ribs. The bands become more easily discernible anteriorly. Part of this muscle becomes continuous with the longissimus capitis, and inserts with it, by a tendon, on the sphenooccipital tubercle of the basioccipital.

Obliquus Abdominis Externus Superficialis (Plates 3, 5, and 11) is a thin, extensive sheet of muscle which covers most of the lateral surface of the body and is deep, only to the trapezius and the latissimus dorsi muscles. This muscle, with quite some difficulty, is separable into three parts. These will be discussed separately.

The first part is superficial to the second and anterior to the third part of this muscle. It is lateral and dorsal to the rectus abdominis externus, lateral and ventral to the sacrolumbalis, posterior to the scapula, and deep to the latissimus dorsi.

The majority of this part takes origin by separate heads, from aponeurotic tendons which interdigitate with the sacrolumbalis and attach to the lateral and posterior surfaces of the second through the eighth thoracic ribs near their dorsal articulations. Anteriorly, some of its fibers arise from the distal ends of the first and second thoracic ribs and from the entire posterior surface of the latter. All of its fibers run posteroventrally. The more anterior, thick, fibers from the first and second thoracic ribs insert on the xiphoid rod and the sternal part of the incomplete eighth thoracic rib, just deep to the origin of the pectoralis; and on part of the seventh thoracic rib. The remaining fibers insert along the lateral border of the rectus abdominis externus, posteriorly, to the thirteenth thoracic vertebra.

The second part lies deep to the first part, anterior to the third part, and superficial to the intercostales and the obliquus abdominis internus.

This part arises just mesial, and somewhat ventral to the origin of the first part. and in

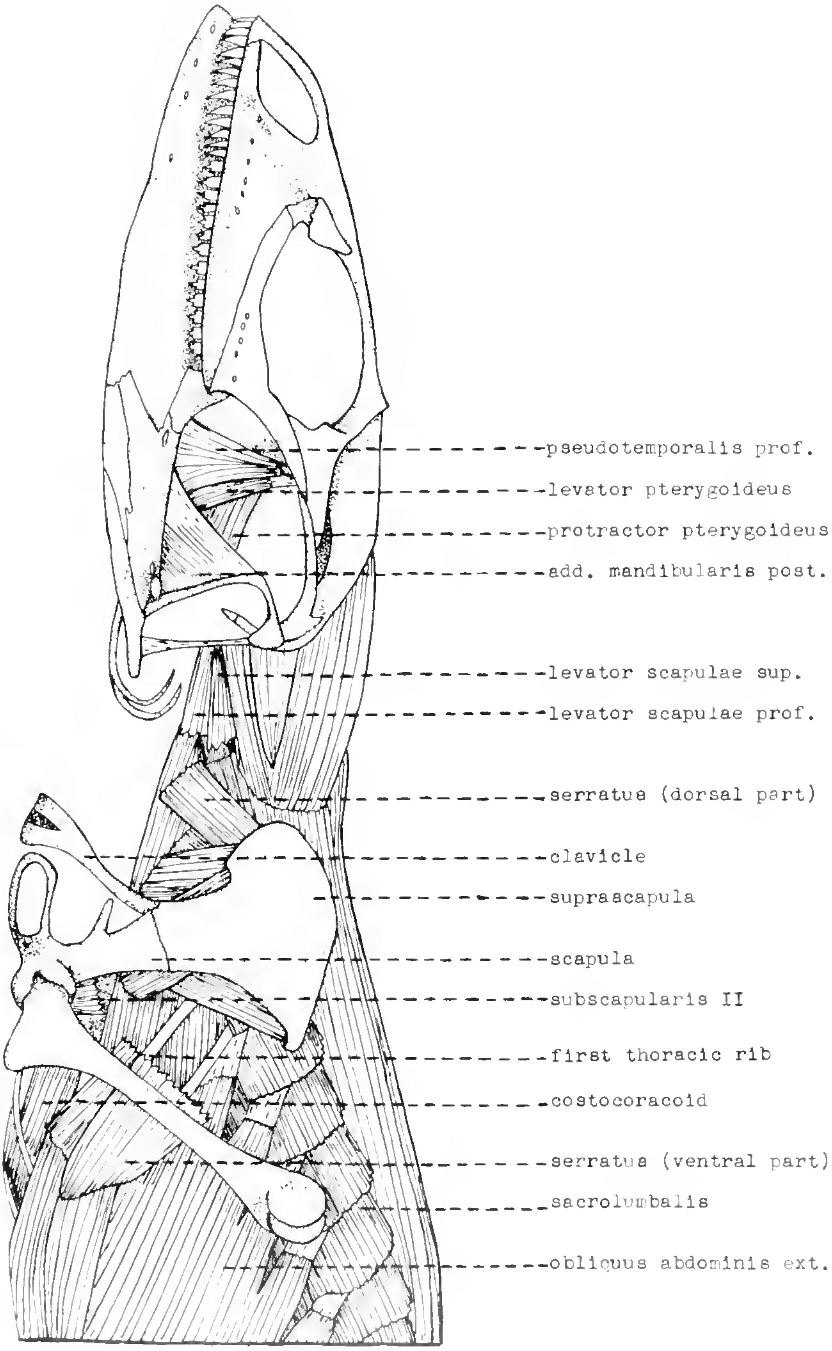

Plate 11.—Lateral view of head and thorax, fourth depth.

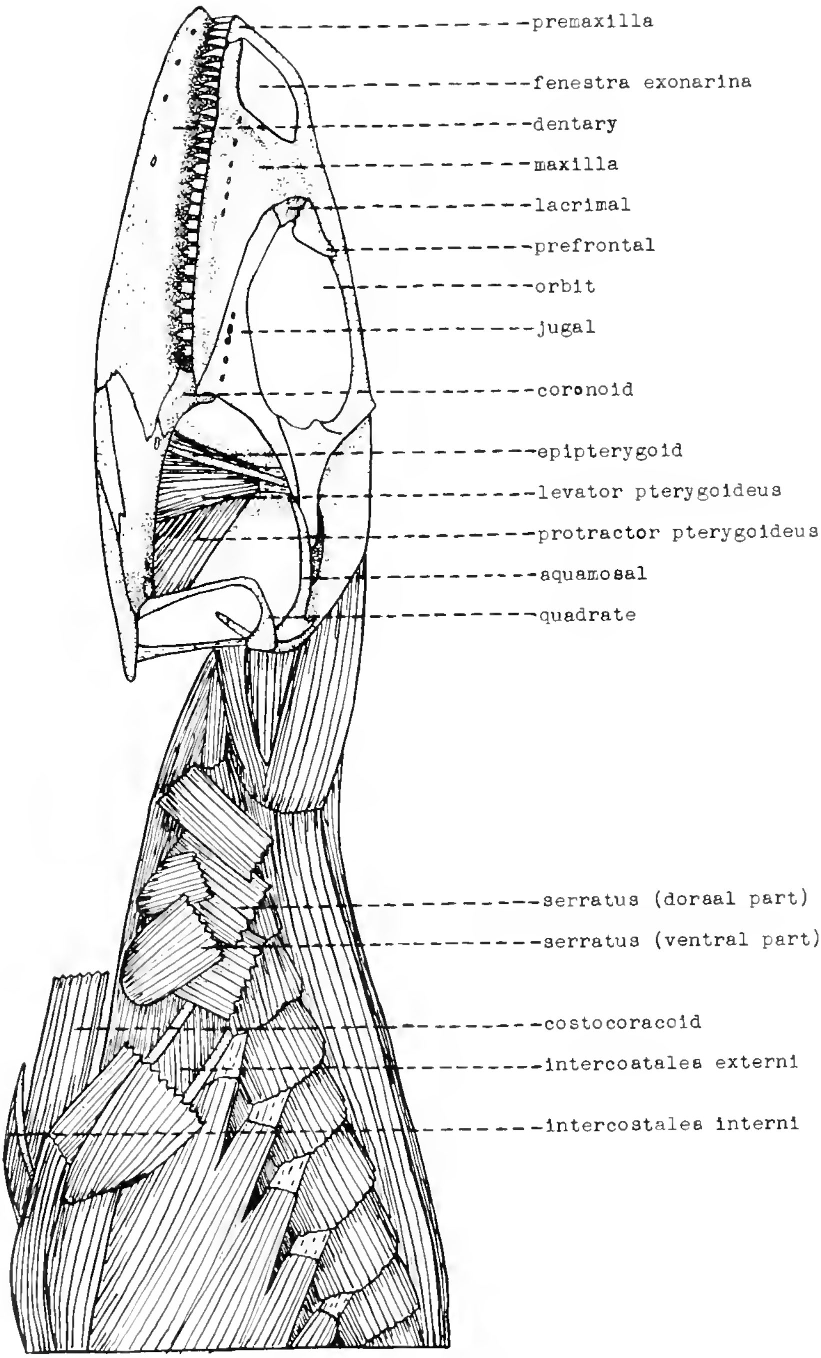

Plate 12—Lateral view of head and thorax, fifth depth

this region is not clearly separable from it. The second part originates with separate heads, by flat tendons which are attached to the lateral and posterior surfaces of the second through the eighth thoracic ribs, at the level of the lateral border of the sacrolumbalis. Some of the tendons of origin interdigitate with the sacrolumbalis. The fibers of this part run posteroventrally and insert, by means of a thin fascia, on the dorsal border of the rectus abdominis, in a jagged line which lies closer to the ventral mid-line than the insertion of the first part. The region of this insertion extends from near the posterior extent of the eighth sternal rib, posteriorly, to approximately the area of the thirteenth thoracic rib.

The third part is posterior to the first. However, a few of its anterior fibers run mesial to those of the first part. The third part lies superficial to the obliquus abdominis internus and to the intercostales externi.

This part arises by flat tendons which interdigitate with the sacrolumbalis and attach to the lateral and posterior surfaces of the eighth through the thirteenth thoracic ribs. It takes further origin from the dorsolateral fascia of the back. Its fibers run posteroventrally and insert, by a short tendon, on the tubercle of the pubis, just superficial to the origin of the intercostales externi.

Obliquus Abdominis Externus Profundus lies immediately deep to the more anterior fibers of the first part of the obliquus abdominis externus superficialis, and superficial to the intercostales interni and the sternal parts of the thoracic ribs.

This muscle takes origin from the distal ends of the first and second thoracic ribs and the intervening fascia. It runs posteroventrally and towards the ventral mid-line, to insert by separate slips, on the fourth through the sixth thoracic ribs. The posterior portion of each of these inserting fasciculae is overlain (serratus-like) by part of the next one posteriorly.

Intercostales Externi (Plates 6 and 12) lie between the three cervical ribs and ten of the thoracic ribs. They are deep to the second and third parts of the obliquus abdominis externus, the sacrolumbalis, the serratus complex, and the levator scapulae muscles; and are superficial to the intercostales interni and the obliquus abdominis internus.

Although discontinuous, due to the intervening ribs, this group may be considered as one muscle which originates by a tendon, from the tubercle of the pubis. Its fibers run anterodorsally and insert, separately, on the posterior surfaces of the tenth, ninth, and eighth thoracic ribs, and then continue anterodorsally, filling the spaces between all the remaining ribs. The fibers are attached to the entire length of the cervical ribs but extend, on the thoracic ribs, only from their dorsal heads to the articulations with their sternal components.

Intercostales Interni (Plate 12) lie immediately deep to the intercostales externi, in the spaces between the entire length of the thoracic ribs. Posteriorly they terminate, after attachment to the tenth thoracic rib, by passing dorsally, and uniting with the fascia of the mid-line of the back. They are deep to the second part of the obliquus abdominis externus and superficial to the obliquus abdominis internus.

Obliquus Abdominis Internus is a very thin, sheet-like muscle which lies deep to the ribs, the intercostales interni, the rectus abdominis externus, the costocoracoid, the sternum, and the scapula; and is superficial to the transversalis.

This muscle takes origin by means of a tendinous aponeurosis, from the inner surface of all the ribs posterior to the first thoracic; and from the lumbar fascia. Its fibers run anteroventrally and insert, with separate slips, by aponeurotic tendons, on the inner surfaces of the sternum and the ventral heads of the thoracic ribs. The insertion continues posteriorly, along the dorsal surface of the rectus abdominis, just mesial to the insertion of the second obliquus abdominis externus. A few of its anterior fibers insert on the ligament of the costocoracoid, and continue as far anterior as the second thoracic vertebra. Posteriorly, this muscle terminates in the region of the femur by attachment to a fine ligament which passes dorsally, over the femoral muscles, and becomes lost in the lumbar fascia.

Transversalis contacts the peritoneal membrane, internally, and the obliquus abdominis internus, externally.

The transversalis arises by means of a fascia which extends from the pelvis to the neck region. The muscle fibers originate along the portion of this fascia which lies between the second thoracic vertebra and the femur. They run almost vertically, but somewhat posteroventrally, and insert on the inner surfaces of the thoracic ribs, the lateral border of the sternum, and the dorsal surface of the rectus abdominis externus.

STATISTICAL ANALYSIS OF OSTEOLOGICAL AND OTHER MORPHOLOGICAL CHARACTERISTICS

Osseous elements, unlike muscles, lend themselves very well to accurate measurements. Therefore, an analysis of their size relationships has been included here, rather than a description of their structure and articulations. The detailed description of the cranial osteology of a closely related genus, *Ctenosaura*, by Oelrich (1956) is a very useful reference. Important structural differences in the bones of the two species, here studied, are mentioned in the discussion.

Other morphological features which have been thought to be of taxonomic importance are included in this analysis.

Richmond (1957) and Walker (1953) have been followed with respect to the formulas and symbols used for the *t*-test. We recognize that a certain amount of error can be expected, due to relative growth changes, when a *t*-test is used with a system of ratios (Lundelius, 1957:65). However, since the samples are reasonably large and include fair growth series, it is felt that this error is negligible. The sample sizes range from 12 to 47 and are equal to, or exceed 20 in most cases. Phleger (1940) discusses the use of a relative growth formula for such studies.

A difference in sample means is considered significant if it is too great to have happened by chance alone; therefore indicating an actual difference in the parent populations. With the exception of the egg complement and the length of the premaxilla, there are no borderline cases; thus the differences determined at the .05 level are also significant at the .01 level of significance. The actual value with which the computed *t* has been compared is 2.0 in most cases. Those cases in which the *t* value is greater than 4.0, the probability of obtaining such different sample means by chance alone, if the population means are actually equal, is less than .00006.

The measurements and counts are listed in detail below, and are repeated in abbreviated form in table 1, which summarizes the results of the analysis. Further details may be obtained from Robison (1960:38-54).

1. Total skull length taken from the tip of the snout (premaxilla) to the posterior end of the paraoccipital process of the exoccipital bone.
2. Maximum skull height taken from the ventral surface of the mandible, in the anterior region of the angular, to the most elevated point of the frontal bone, just anterior to the frontoparietal suture.
3. Width of skull at the ectopterygoid, measured from the lateral projecting tip of its lateral process to the same tip of the other ectopterygoid.
4. Width of skull at the quadrate, measured from the anterodorsal corner of the tympanic crest to the same point on the opposite side.
5. Snout to quadrate, measured from the anterior tip of the premaxilla to the posterior surface of the tympanic crest.
6. Snout to parietal, measured from the anterior tip of the premaxilla to the posterodorsal margin of the parietal proper.
7. Snout to orbit, measured from the former to the posterolateral surface of the prefrontal.
8. Parietal width measured across its narrowest part, between the dorsolateral crests which border the supratemporal fossae.
9. Length of premaxilla, measured from its anterior to its posterior tips as seen from a dorsal view.
10. Length of fronto-parietal suture, measured between the lateral tips of the frontal and parietal bones at their junction.
11. Length of the nasal bone, measured from the fenestra exonarina to its posterior tip.
12. Width of the orbit, measured across its widest part, from the frontal to the area of the transverse process of the ectopterygoid bone.
13. Length of the orbit, measured from its anterior extension between the prefrontal and the lacrimal to the notch just lateral to the dorsal process of the postorbital.
14. Greatest length of the fenestra exonarina.
15. Number of teeth or tooth sockets in the entire premaxilla.
16. Number of teeth or tooth sockets in the maxilla of both sides averaged.
17. Number of dentary teeth or indicated tooth spaces of both sides averaged.
18. Body width, measured at its widest point while pressing the specimen firmly against a flat surface.
19. Distance from snout to vent.
20. Distance between the mesial margins of the external nares.
21. External width of the temporal region, taken at its widest point.
22. Length of the rostral scale, measured from its left side to its right side.
23. Length of the labial adjacent to the rostral, measured from its anterior to posterior margins.
24. Length of the mental scale, measured from its left side to its right side.
25. Length of the labial adjacent to the mental, measured from its anteromesial to its posterolateral margins.
26. Number of scales bordering the mental posteriorly, between the infralabials.

27. Sternum width, measured across its widest point in the region of the articulation of the third thoracic rib (first one to articulate with the sternum anteriorly).
28. Sternum length, measured from the anterior point of the interclavicle to the region between the two xiphoid rods.
29. Width of the interclavicle, measured near its mid-point.
30. Width of the clavicle, measured at its widest point.
31. Length of the origin of the depressor mandibularis, measured from its beginning near the mid-point of the parietal wing, to its posterior extremity.
32. Total length of the hyoid, measured from the anterior tip of the hypohyal to the distal ends of the second ceratobranchials. The terminology of Camp (1923) has been used with respect to the hyoid.
33. Length of the second ceratobranchials of the hyoid, measured from the posterior extremity of the basihyal to their distal ends.
34. Length of the anterolateral projection of the basihyal (basal portion of ceratohyal), measured from the junction of the hypohyal with the basihyal to the proximal end of the ceratohyal.
35. Width of the ceratohyal in the region including the process which serves for part of the origin of the branchiohyoideus muscle.
36. The egg counts listed as observed by us were made from eggs measuring over four milimeters in average diameter per group, which were found in preserved specimens.

TABLE I

SUMMARIZATION OF THE STATISTICAL ANALYSIS

Ratio or Count Determined	*Computed t*	*Significance*
Depressor mand. length at origin / total skull length	5.07	sig.*
body width / snout to vent length	4.58	sig.
total skull length / snout to vent length	5.82	sig.
external temporal width / total skull length	4.46	sig.
distance between external nares / total skull length	1.35	not sig.
rostral length / length of adjacent labial	1.33	not sig.
mental length / length of adjacent labial	.27	not sig.
no. of scales post. to mental	4.81	sig.*
skull width at ectopterygoid / total skull length	1.41	not sig.
skull width at quadrate / total skull length	1.79	not sig.
maximum skull height / total skull length	1.77	not sig.
snout to quadrate / total skull length	1.09	not sig.
snout to parietal / total skull length	5.05	sig.*
snout to orbit / total skull length	11.95	sig.*
fronto-parietal suture length / total skull length	1.12	not sig.
width of orbit / length of orbit	1.63	not sig.
number of premaxillary teeth	1.35	not sig.
number of maxillary teeth	3.43	sig.*
number of dentary teeth	1.00	not sig.
parietal width / total skull length	2.92	sig.*
premaxilla length / total skull length	2.64	sig.*
nasal length / total skull length	.02	not sig.
fenestra exonarina length / total skull length	10.66	sig.*
sternum width / sternum length	6.35	sig.
clavicle width / sternum length	6.45	sig.*
interclavicle width / sternum width	.07	not sig.
second ceratobranchial length / total hyoid length	12.28	sig.
ant. projection of basihyal / total hyoid length	11.20	sig.*
width of ceratohyal at process / total hyoid length	3.33	sig.
egg complement	2.37	sig.

It appears advisable to list the data on egg counts in detail (See Table 2). Forty-one females of *C. wislizeni* ranging from 75 to 115 snout to vent measurement, and forty-two females of *C. collaris* from 75 to 105 snout to vent were dissected. The ovaries of 27 of the former and 24 of the latter contained an average of 18.3 and 17.7 eggs which were less

*In those cases where the difference in sample means is significant an asterisk indicates that the sample mean for *C. wislizeni* was the greater of the two, and likewise the lack of an asterisk indicates a greater mean for the *C. collaris* sample.

TABLE 2
Crotaphytus wislizeni

Eggs	*Size*	*Author or Locality*		*Specimen*
2	......	Richardson	1915:408	......
4	......	Richardson	1915:408	......
2	......	Richardson	1915:408	......
5	13.6x22.2	Shaw	1952:72	......
6	over 18	Johnson	1948:260	......
1	"large"	Camp	1916:522	......
6	16-20 long	Bently	1919:89	......
6	4-5	38 mi. E. Kanab, Kane, Utah		11381
5	9-9.8	5 mi. SW. Oak City; Millard, Utah		11354
7	3.8-4.2	Desert Exp. Sta.; Millard, Utah		4302
5	4.0	Battle Mt.; Lander, Nevada		2918
7	10-11x14-15	Boulder Dam; Clark, Nevada		460
9	9.5-10x11.5-12	St. George; Washington, Utah		515
4	12x17-19	Dugway; Tooele, Utah		14848
6	7	6 mi. N. Goshen; Utah, Utah		12196
8	5	Owyhee County, Idaho		2835
6	11-12	Star Spring; Garfield, Utah		12187
6	10-12x14-17.5	10 mi. S. Cisco; Grand, Utah		12857
4	5	Elberta; Utah, Utah		......
6	6-6.5x7.5-8	Temple Junction; Emery, Utah		......
3	6-8x9-11	Temple Junction; Emery, Utah		......
108				

Crotaphytus collaris

Eggs	*Size*	*Author or Locality*		*Specimen*
8	......	Anderson	1942:208	......
7	......	Burt	1928a:10	......
9	......	Burt	1928a:10	......
16	......	Burt and Hoyle	1934:198	......
10	18.3-21x12-13.1	Clark	1946:136	......
21	11.1x16	Ditmars	1907:115	......
8	......	Greenberg	1945:229	......
6	......	Greenberg	1945:229	......
6	......	Greenberg	1945:229	......
8	16.96x19.08	Hallowel	1856:239	......
2	......	Johnson, et al.	1948:259	......
7	11.4-11.7x18.4-20.3	Shaw	1952:73	......
12	......	Fitch	1956:236	......
7	......	Fitch	1956:236	......
7	......	Fitch	1956:236	......
6	......	Fitch	1956:236	......
5	......	Fitch	1956:236	......
5	......	Fitch	1956:236	......
5	......	Fitch	1956:236	......
5	......	Fitch	1956:236	......
3	......	Fitch	1956:236	......
6	......	Fitch	1956:236	......
6	......	Fitch	1956:236	......
10	......	Fitch	1956:236	......
8	......	Fitch	1956:236	......
8	......	Fitch	1956:236	......
10	......	Fitch	1956:236	......
4	......	Fitch	1956:236	......
5	......	Fitch	1956:236	......
7	4	Moab; Grand, Utah		1625
6	10-12x14-15	10 mi. S. Cisco; Grand, Utah		12855
5	9-10x10-12	Dewey Bridge; Grand, Utah		12856
4	8-9	Castair Canyon; Kane, Utah		11385
4	5-6	Adairville; Kane, Utah		14659
3	6.5	LaVerkin; Washington, Utah		444
4	10-11x12-13	Topax Mt.; Juab, Utah		9069
4	13-13.5x23-26	Lynndyl; Millard, Utah		445
6	4	Fillmore; Millard, Utah		8753
5	9-10	Fillmore; Millard, Utah		8755
8	4.5	15 mi. S. Hinckley; Millard, Utah		4310
4	4	Gold Hill; Tooele, Utah		4306
3	7	Melba; Ada, Idaho		507
11	10x14	5 mi. N Brekenridge; Stephens, Texas		13117
5	8-9	5 mi. E. Winslow; Navajo, Arizona		13573
6	7-9	5 mi E. Winslow; Navajo, Arizona		13574
5	3-4.5	Boulder Dam; Clark, Nevada		2935
5	5	Sheep Island; Clark, Nevada		4307
315				

than 3.6 in diameter, respectively. The remaining lizards contained eggs measuring 4 or more in diameter, and these cases have been listed individually in Table 2. Small eggs were also found along with these large ones. Their number averaged approximately 15 in both species.

The reports of other observers have been included; in which cases, the egg counts are indicated by the authors' names and references. Otherwise, the locality of collection and the Brigham Young University museum number, where possessing one, identify them.

Three subspecies of *C. collaris* are included, though *C. collaris baileyi* is represented by a majority of the specimens. Egg sizes are given where available. One specimen (B.Y.U. 445) laid 3 eggs prior to their being measured.

DISCUSSION AND OBSERVATIONS

MYOLOGICAL COMPARISONS

Muscles, being the most changeable of morphological structures, as pointed out by Brock (1938:736), present many problems when used for comparative purposes. Huntington (1903) comments on the difficulties involved in using muscles to determine phylogeny. The problems are augmented, on the generic level, by the limited number of myological studies available.

Episternocleidomastoideus.—The character of this muscle suggests that *C. collaris* and *C. reticulatus* are more similar than either is to *C. wislizeni*. There has been a natural selection in *C. collaris* and *C. reticulatus* for an enlargement of the mesial head which takes a more solid origin; while degeneration has left *C. wislizeni* with only a rudiment to represent it.

Accounts of this aspect of the episternocleidomastoideus in related lizards are difficult to find. However, Camp (1923:459) figures this muscle in *Gekko verticillatus* as having a single head, and Oelrich (1956, Plate 36), in his study of *Ctenosaura pectinata*, shows it with a small mesial slip of origin.

Depressor Mandibularis.—It was found to have three recognizable bundles in *C. wislizeni*, the posterior of which is easily separable; whereas only two, non-separable bundles are present in *C. collaris*. It was also found that the origin of this muscle in *C. wislizeni* covers a greater area than does that of the same muscle in *C. collaris*, with respect to the skull length. The separable, posterior bundle in *C. wislizeni* is undoubtedly the homologue of the cervicomandibularis of other lizards. This muscle is found, throughout the various genera, to be present, absent, or fused in different degrees with the remainder of the depressor mandibularis (Camp, 1923 and Kesteven, 1944). Its state in the different cases does not follow any taxonomic system, but rather, appears to be connected with a greater or lesser degree of burrowing habits (Camp, 1923:448). The presence of the cervicomanibularis in *C. wislizeni* and its absence in *C. collaris*, then, suggests greater fossorial habits for the former, but does not give a clue as to their phylogenetic relation. *C. reticulatus* shows a closer relationship to *C. wislizeni*, with respect to this muscle, than to *C. collaris*.

OSTEOLOGICAL AND GENERAL COMPARISONS

External Number, Shape, and Size Relationships.—The statistical data indicate that *C. wislizeni* has a more slender and elongated body, a shorter skull, and a narrower head, proportionately, than does *C. collaris*. The different body shapes have resulted from selection for more streamlined forms, in the case of *C. wislizeni*, which have an advantage for life on the sandy desert flats where this lizard is usually found; whereas *C. collaris* has developed a stout body, as required by its more rugged habitat on the large rocks strewn on the desert floor and at the foot of talus slopes. The narrower head, as seen by the skull width/skull length comparisons, is only an external character and therefore must be interpreted as being the result of larger temporal muscles in *C. collaris*.

No difference was found with respect to the distance between the external nares, nor in the rostral and mental sizes as related to the adjacent labials. However, it holds true that the number of postmentals is greater in *C. wislizeni* than in *C. collaris* (Smith, 1946: 158). This character, then, is important taxonomically, but doubtfully of more than specific significance.

We were unable to find any important difference in the sizes of the body and caudal scales of the two species—first suggested as a distinguishing character by Baird and Girard (1852b:340). Seventy-two per cent of the specimens of *C. wislizeni* examined have an enlarged median row of internasals (Hallowell, 1852:207), irregular in all but one specimen Thirty-eight per cent of the *C. collaris* also have an enlarged median row, which is regular in one specimen, from Castle Rock, Washington County, Utah. One individual of the latter species has two regular median rows. Equal indication of a pregular fold was found in specimens of *C. wislizeni* and those of *C. collaris*. The fringe of protruding scales bordering the ventral lamellae of the fourth hind toe, laterally, is constantly present, in varying degrees, in *C. wislizeni*; but is merely the result of an exaggerated extension of a similar border of scales in *C. collaris*.

Therefore, it is felt that all these characteristics, as well as the difference in the dorsal scale pattern of the head and the number of suboculars, fit into the category of minor or unimportant taxonomic criteria in the case of these species.

Size Relationships of Skull Parts.—No difference was found in the relative skull width as measured in two places, the skull height, the nasal bone length, the extent of the fronto-parietal suture, or in the shape of the orbit. The fenestra exonorina and associated premaxilla lengths, the snout to orbit distance, and the snout to parietal distance are greater in *C. wislizeni;* whereas, the snout to quadrate distance is not, and the total skull length is actually less, proportionately, than in *C. collaris.* These data indicate that *C. wislizeni* has a more elongated snout, and that this length advantage is carried on through to the posterior border of the parietal. However, an immediate change takes place between that point and the quadrate, which results from a proportionately greater extension of the posterolateral wing of the parietal in *C. collaris*, accompanied by an elongation of the squamosal and other bones concerned.

The longer snout of *C. wislizeni* gives this species an advantage for burrowing in its typical habitat. It is interesting to note that only the snout is elongated, proportionately, and not the entire head as reported by Baird and Girard (1852a:69). The elongation of the posterior skull region in *C. collaris*, producing a larger temporal fossa and a proportionately longer skull, is no doubt a result of correlation with the selection for larger temporal muscles in this species, as mentioned above. A similar condition was reported by Lundelius (1957) for *Sceloporus olivaceus* and *S. undulatus*.

The data show that the distance between the dorsolateral margins (crests) of the parietal proper is proportionally greater in *C. wislizeni*. It was also observed that this distance, in the species mentioned, increases slowly with age, whereas in *C. collaris* after the sub-adult or adult stage, it decreases. The decrease results from a mesial movement of the crest, by demand of the developing temporal muscles as the parietal grows upward. The fact that this crest does not move mesially in *C. wislizeni* is evidence for the lesser importance of the jaw muscles in this species.

Less obvious differences in the skulls are the more arched frontal, the less posteriorly inclined posterior margin of the fenestra exonarina as seen laterally, and the greater general bone thickness in the case of *C. collaris*. The two former characters have been modified in *C. wislizeni* for burrowing habits, while the latter is undoubtedly correlated with the greater jaw muscles of *C. collaris*. Cope (1892:202-203 and 1900:246-247) states that the pineal foramen is in the parietal in *C. wislizeni*, and in the frontal in *C. collaris*, bordering the coronal (fronto-parietal) suture in both cases. We have found this foramen present in the frontal and parietal of both species. However, it is usually found centered in the suture. Brattstrom (1953:177-178) notes some slight differences in the shape and size of the maxillae of *C. wislizeni* and *C. collaris*. George (1955) demonstrates some skull differences between *Uromastix hardwicki* and *U. aegyptia*.

Number and types of Teeth.—The number of premaxillary and dentary teeth is the same in both species, but *C. wislizeni* has more maxillary teeth, and they are narrower and slightly longer than those of *C. collaris*. The short, thick teeth of *C. collaris* are compatible with its heavier skull and more massive jaw muscles.

Both species posses pterygoid teeth, as reported for the genus by Boulenger (1885:203). It is not clear why Camp (1923:365-366) lists one species of this genus as lacking such teeth.

Sternum and Related Parts.—The sternum is proportionately narrower in *C. wislizeni*, as correlated with its elongated body and fossorial habits. In this species the clavicle is wider, proportionately, to allow for its fairly large and regular perforation which lies deep to the origin of the clavodeltoideus muscle. Twenty per cent of the specimens of *C. collaris* observed had some type of a perforation in the clavicle; usually in the form of a slit, but never large or regular. The solid clavicle of *C. collaris* provides greater support for the pectoral apparatus. No difference was seen with respect to the interclavicle width.

Boulenger (1885:203) considers *Crotaphytus* as lacking a median sternal fontanelle, and Cope (1892:203 and 1900:247) states that *C. collaris* has one, whereas, *C. wislizeni* does not. We found at least a small median fontanelle to be present in all specimens of both species examined, except two of *C. collaris* from Elberta, Utah County, Utah; and Colonia Juarez, Chihuahua, Mexico (B.Y.U. 15185).

Hyoid Character.—The hyoid is very different in these species. The second ceratobranchials are proportionately shorter as well as weaker and less closely appressed in *C. wislizeni*. The length of the anterolateral projection of the basihyal is greater in *C. wislizeni*, whereas the mesial process, serving for the origin of the branchiohyoideus muscle is narrower.

It seems logical to attribute these hyoid differences to sexual selection, in *C. collaris*, for males with larger throat fans and to assume that this was not a selective character in *C. wislizeni*. Supporting this view is the fact that the latter species has not developed a bright coloration of the gular region in correlation with the throat fan, as has *C. collaris* (Burt, 1929:418) This may be an important factor in discouraging hybridization between these sympatric species.

Egg Complement.—Unfortunately, original observations on egg clutches for *Crotaphytus* are few; and these have been repeated, often without reference, by numerous authors. The report of Ditmars (1907:115) of 21 eggs laid by a female *C. collaris* has almost become legendary; in spite of the fact that all subsequent observers have reported strikingly fewer eggs.* Those which have observed egg clutches or large eggs within females are: Bently (1919:89), Camp (1916:522), Johnson (1948: 260), Richardson (1915:408), and Shaw (1952:72), for *C. wislizeni;* and Anderson (1942:208), Burt (1928a:10), Burt and Hoyle (1934:198), Clark (1946:136), Ditmars (1907: 115), Fitch (1956:236), Greenberg (1945:229), Hallowell (1856:239), Johnson et al. (1948: 259), and Shaw (1952:73), for *C. collaris.* The details of these reports are listed in Table 2.

The high counts of small eggs within the ovaries of both species, as compared to the number of eggs finally laid, suggest a pattern similar to that found in *Eumeces skiltonianus* (Tanner, 1957:82-89). However, the fact that small eggs are still present when others are ready to be laid raises the possibility that atrophy does not take place as in the skink, but that a few eggs are induced to enlarge to laying size, while the others remain for use at a later date. The data at hand are insufficient to allow a decision.

The average number of eggs which we determined for *C. collaris* is slightly lower than that of 7.55 $\pm$ .7 found for 29 clutches by Fitch (1956:235). However, this difference is not significant ($t = .971$). Although our analysis of data suggests a borderline difference between the egg complements of the two species, if the exceptional observations of Ditmars (1907:115) and Burt and Hoyle (1934:198) are not included, this difference is not significant even at the .05 level of significance ($t = 1.86$).

There is some reason to question the validity of these extreme egg counts. Uncontrolled conditions existed in both cases, since Ditmars (1907:115) apparently had several lizards within the same enclosure, and the observation of Burt and Hoyle (1934:198) was made in the field. If the true mean of the number of eggs per clutch is around 6.7, as suggested by the present analysis, the statistical probability that a clutch with 21 eggs would occur by chance alone is so small that it can be considered extremely unlikely.

The present study is limited by the fact that we have assumed that the number of large eggs (over 4mm. in diameter) in female lizards is a good indication of the actual number laid per clutch. Also, a certain amount of bias can be expected because all of the subspecies of *C. collaris* were not represented by equal numbers. Further studies are necessary before the egg complement can be used as a taxonomic character for these species.

CONCLUSION

Smith (1946:158-159) used ten characters to distinguish *Gambelia* as a genus. Only half of these are true differences between *C. wislizeni* and *C. collaris*: 1) the external shape of the head, 2) the number of postmentals, 3) the number of suboculars, 4) the general character of the dorsal head scales, and 5) the character of the scales which border the ventral lamellae on the lateral surface of the fourth toe.

Additional differences between the two species are: 1) the character of the episternocleidomastoidous and the depressor mandibularis muscles, 2) the body proportions, 3) the relative size and shape of the skull and its component bones, 4) the number of maxillary teeth, 5) the shape of the sternum, 6) the width and character of the clavicle, and 7) the relative sizes of the hyoid parts *C. reticulatus* is intermediate between the two species of this study with respect to the episternocleidomastoideus and the depressor mandibularis.

Many of the characters found to be different are a direct result of the adaptations of these sympatric species to their respective habitats. Our data suggest that none are of generic significance.

Based on the evidences available in this study as well as those indicated in previous studies, there is no reason to separate *Gambelia* from *Crotaphytus*.

SUMMARY

The anterior musculature of *C. wislizeni* and *C. collaris* is described in detail and compared. Size and number relationships of the skull and its component bones, the sternum, the clavicle, the parts of the hyoid, the general body form, certain scales and teeth, and the eggs per clutch were determined for large samples of both species and then statistically compared. The general character of many structures is also compared and notes are made on *C. reticulatus.*

The differences encountered by this study, as well as the valid ones of those listed by Smith (1946:158-159) are not considered to be important generically and *Gambelia* is not given generic status

*We do not consider the report of Strecker (1910 b), which has also been repeated many times to have been based on an actual observation

LITERATURE CITED

Adams, Leverett Allen

1919 A memoir on the phylogeny of the jaw muscles in recent and fossil vertebrates. Ann. New York Acad. Sci., 28:51-166, 13 pls.

Allen, Morrow J.

1933 Report on a collection of amphibians and reptiles from Sonora, Mexico, with the description of a new lizard. Occ. Pap. Mus. Zool. Univ. Michigan, 11(259):1-15.

Anderson, Paul

1942 Amphibians and reptiles of Jackson County, Missouri Bull. Chicago Acad Sci., 6(11):203-220.

Baird, Spencer F.

1858 Description of new genera and species of North American lizards in the museum of the Smithsonian Institution. Proc. Acad Nat. Sci Philadelphia, 10:253-256.

1859 Reptiles of the boundary. *In* Emory, William H. United States and Mexican boundary survey. Washington 2(2):1-35, 41 pls.

Baird, Spencer F. and Charles Girard

1852a Characteristics of some new reptiles in the museum of the Smithsonian Institution. Proc. Acad. Nat. Sci. Philadelphia, 6:68-70.

1852b Reptiles. *In* Stansbury, Howard. Exploration and survey of the valley of the Great Salt Lake of Utah . . . Lippincott-Gambo; Philadelphia. p. 336-365.

Bently, George H.

1919 Reptiles collected in the vicinity of Currant, Nye County, Nevada. Copeia, 1919(75):87-91.

Boulenger, George Albert

1885 Catalogue of the lizards in the British Museum (Natural History). Second edition. Taylor and Francis; London. vol. 2, xiii, 497 p., 24 pls.

Brattstrom, Bayard H.

1953 Records of Pleistocene reptiles from California. Copeia, 1953 (3):174-179.

Brock, Gwendolen T.

1938 The cranial muscles of the Gecko.—a general account, with a comparison of the muscles in other Gnathostomes. Proc. Zool. Soc. London, series B, 108:735-761, 8 text-figs.

Burt, Charles E.

1928a The lizards of Kansas. Trans. Acad. Sci. St Louis, 26(1):1-81.

1928b The synonymy, variation, and distribution of the collared lizard, *Crotaphytus collaris* (Say). Occ. Pap. Mus. Zool. Univ. Michigan, 8(196):1-19, 7 pls.

1929 The sexual dimorphism of the collared lizard, *Crotaphytus collaris*. Pap. Michigan Acad. Sci., 10:417-421, pl 23.

Burt, Charles E. and William L. Hoyle

1934 Additional records of the reptiles of the central prairie region of the United States Trans. Kansas Acad. Sci., 37:193-216

Camp, Charles Lewis

1916 Notes on the local distribution and habits of the amphibians and reptiles of southeastern California in the vicinity of the Turtle Mountains. Univ. Calif. Pub. Zool., 12(17):503-544, pls. 19-22.

1923 Classification of the lizards. Bull. Amer. Mus. Nat. Hist., 48(11):289-481, 112 text-figs.

Clark, Hugh

1946 Incubation and respiration of eggs of *Crotaphytus c. collaris* (Say). Herpetologica, 3(4):136-139.

Cope, Edward Drinker

1892 The osteology of the Lacertilia. Proc. Amer. Philos. Soc., 30(138):185-221, pls. 2-6.

1900 The crocodilians, lizards, and snakes of North America. *In* Annual Rep. U.S. National Mus., 1898(2):151-1294, 36 pls.

Davis, Dwight D.

1934 The collared lizard, a laboratory guide Macmillan; New York. viii, 57p.

Ditmars, Raymond Lee

1907 The reptile book . . . Doubleday, Page; Garden City, New York. xxxii, 472 p., 8 col. pls., 400 photos.

Edgeworth, F. H.

1935 The cranial muscles of vertebrates. Univ. Cambridge Press; Cambridge. 493 p., 841 figs.

Evans, Francis Gaynor

1939 The morphology and functional evolution of the atlas-axis complex from fish to mammals. Ann. New York Acad. Sci., 39(2):29-104.

Fitch, Henry S.

1956 An ecological study of the collared lizard (*Crotaphytus collaris*). Univ. Kansas Pub. Mus. Nat. Hist., 8(3)213-274, pls. 3-6. 10 figs., 9 tbls.

George, J. C.

1948 The muscular system of *Uromastix hardwickii* (Gray). Journ. Univ. Bombay, 17(3):1-23.

1955 On the cranial osteology of *Uromastix Hardwickii* (Gray). Journ. Animal Morphol. and Physiol ; 1(2):23-29, 6 figs.

Goodrich, Edwin S.

1930 Studies on the sturcture and development of vertebrates. Macmillan; London xxx, 837 p., bibl. 787-828.

Greenberg, Bernard

1945 Notes on the social behavior of the collared lizard. Copeia, 1945(4):225-230, 1 pl.

Hallowell, Edward

1852 On a new genus and three new species of reptiles inhabiting North America. Proc. Acad. Nat Sci. Philadelphia, 6:206-209.

1856 Notice of a collection of reptiles from Kansas and Nebraska, presented to the Academy of Natural Sciences, by Dr. Hammond, U.S.A. Proc. Acad. Nat. Sci. Philadelphia, 8:238-253.

Holbrook, John Edwards

1842 North American herpetology or, a description of the reptiles inhabiting the United States. J. Dobson; Philadelphia, vol. 2, iv, p. 9-142, 20 col. pls.

Huntington, Geo. S.

1903 Present problems of myological research and the significance and classification of muscular variations. Amer. Journ. Anat., 2(2):157-175, 7 pls.

Huxley, Julian S.
1940 The new systematics. Clarendon; Oxford. viii. 583 p.

James, Edwin (compiled by)
1823 Account of an expedition from Pittsburgh to the Rocky Mountains, performed in the years 1819 and '20 . . . from the notes of Major Long, Mr. T. Say, and other gentlemen of the exploring party. H. C. Carey and I. Lea, Philadelphia, vol. 2 xcviii. 442 p.

Johnson, D. H., M. D. Bryant, and A. H. Miller
1948 Vertebrate animals of the providence mountains area of California. Univ. Calif. Pub. Zool., 48(5):221-375, 52 figs., 1 map

Kesteven, H. Leighton
1944 The evolution of the skull and the cephalic muscles. A comparative study of their development and adult morphology. Memoir Australian Mus., Sydney. number 8, part 3:237-269

Lundelius, Ernest L., Jr.
1957 Skeletal adaptations in two species of *Sceloporus*. Evolution. 11(1):65-83. 10 figs., 12 tbls.

Mivart, St. George
1867 Notes on the myology of *Iguana tuberculata*. Proc. Zool. Soc. London, 1867:766-797. 18 figs.

Oelrich, Thomas M.
1956 The anatomy of the head of *Ctenosaura pectinata* (Iguanidae). Misc. Pub. Mus. Zool. Univ. Michigan, (94):1-122, 59 figs.

Olson, Everett Claire
1936 The dorsal axial musculature of certain primitive permian tetrapods. Journ. Morphol., 59(2):265-311, 12 figs.

Phleger, Fred B., Jr.
1940 Relative growth and vertebrate phylogeny. Amer. Journ. Sci., 238(9):643-662, 6 figs.

Richardson, Charles Howard
1915 Reptiles of northwestern Nevada and adjacent territory. Proc. U. S. National Mus., 48(2078):403-435

Richmond, Samuel B.
1957 Principles of statistical analysis. Ronald Press; New York. xii. 491 p.

Robison, W. Gerald, Jr.
1960 A comparative study of *Crotaphytus* Holbrook (Iguanidae). Unpublished thesis. 69 p., 12 pls.

Romer, Alfred Sherwood
1924 Pectoral limb musculature and shoulder-girdle structure in fish and tetrapods. Anat. Rec., 27(2):119-143, 10 figs.
1956 Osteology of the reptiles. Univ. Chicago Press; Illinois. xxi. 772 p., 248 figs., bibl. 709-736

Sathe, Avinash M.
1959 Trunck musculature of *Chamaeleon vulgaris* (Gunther). Journ. Bio. Sci., 2(2):89-99

Schmidt, Karl P.
1922 The amphibians and reptiles of Lower California and the neighboring islands. Bull. Amer. Mus. Nat. Hist., 46(11):607-707
1953 A check list of North American amphibians and reptiles. Sixth edition. Amer. Soc. Ich. Herp. viii, 280 p.

Shaw, Charles E.
1952 Notes on the eggs and young of some United States and Mexican lizards, 1. Herpetologica, 8(3):71-78

Smith, Hobart Muir
1946 Handbook of lizards, lizards of the United States and of Canada. Comstock; Ithaca, New York. xxi. 557 p., 135 pls., 136 text-figs., 41 maps.

Smith, Hobart Muir and Edward H. Taylor
1950 An annotated checklist and key to the reptiles of Mexico exclusive of the snakes. Bull. U. S. Nat. Mus., (199):1-253.

Stebbins, Robert C.
1948 Nasal structure in lizards with reference to olfaction and conditioning of the inspired air. Amer. Journ. Anat. 83(2):183-221, 9 figs.

Strecker, John K., Jr.
1910 Notes on the fauna of a portion of the canyon region of northwestern Texas. Baylor Univ. Bull., 13(4-5):1-31, 1 pl., 2 figs.

Tanner, Wilmer W.
1957 A taxonomic and ecological study of the western skink (*Eumeces skiltonianus*). Great Basin Naturalist, 17(3-4):59-94

Taylor, Edward Harrison
1935 A taxonomic study of the cosmopolitan scincoid lizards of the genus *Eumeces* with an account of the distribution and relationships of its species. Univ. Kansas Sci. Bull., 23:1-643, 43 pls., 84 figs.

Van Denburgh, John
1922 The reptiles of Western North America. Occ. Pap. California Acad. Sci., 10:1-611, pls. 1-57.

Van Denburgh, John and Joseph R. Slevin
1921 Preliminary diagnoses of new species of reptiles from islands in the Gulf of California, Mexico. Proc. California Acad. Sci., series 4, 11:95-98.

Walker, Helen M. and Joseph Lev
1953 Statistical inference. Henry Holt; New York. xi, 510 p.

Watson, D. M. S.
1954 On Bolosaurus and the origin and classification of reptiles. Bull. Mus. Comp. Zool. Harvard Univ., 111(9):297-449, 1 pl.

Williston, S. W.
1925 Osteology of the reptiles. Harvard Univ. Press, Cambridge. xiii. 300 p., 191 figs.

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BIOLOGICAL SERIES — VOLUME II, NUMBER 2

FEBRUARY, 1963

BIOTIC COMMUNITIES OF THE NEVADA TEST SITE

by

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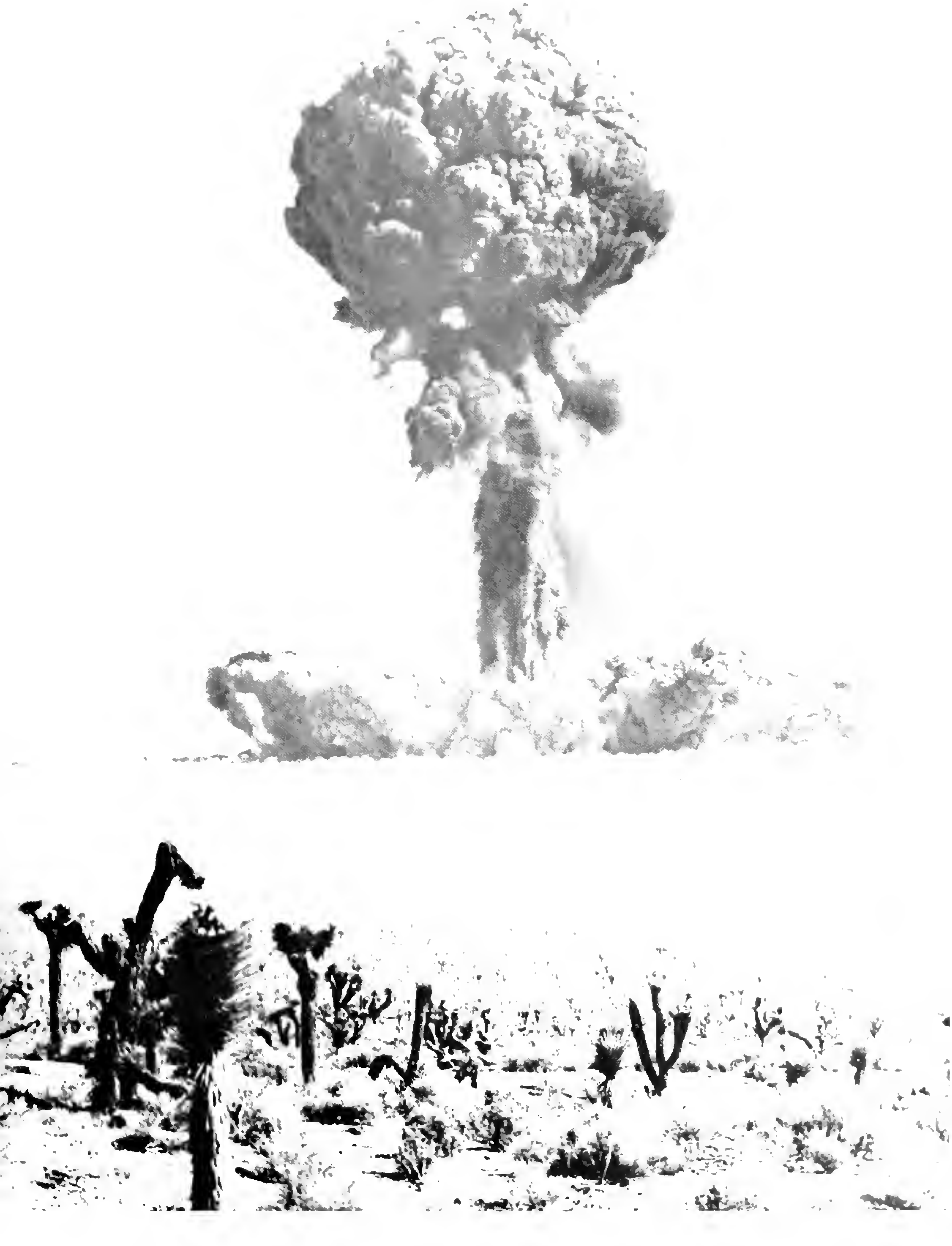
Brigham Young University

Science Bulletin



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PREFACE

This paper constitutes a terminal report to the United States Atomic Energy Commission for Contract AT(11-1)786. It provides a listing of the fauna known to occur at the Nevada Test Site, with designation of ecological distribution and relative density. It is designed to serve as the basic faunistic reference source, in subsequent studies, related to geographical and ecological features at the test site.

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BIOTIC COMMUNITIES OF THE NEVADA TEST SITE

INTRODUCTION

Since the first nuclear detonation at the Nevada Test Site in January, 1951, many weapons and experimental devices have been tested in southern Nevada. The native plants and animals have been disturbed to varying degrees by the thermal, radiation, and other physical effects of these tests.

In August, 1959, Brigham Young University initiated an ecological survey of the fauna at the Nevada Test Site to study the effects which these nuclear tests have had on the native animals. Inasmuch as no basic ecological investigations were made at the test site before nuclear testing commenced, our studies were designed to develop standards of measurement to determine past nuclear effects, so far as possible, as well as to measure the effects of future tests. Subsequently, study sites were established in (1) test areas where visible effects of nuclear detonations were obvious, (2) contiguous areas where no physical effects were evident, and (3) areas several miles distant from centers of nuclear detonations (ground zeros). Principal objectives of our project were to determine the kinds, population, seasonal occurrence, geographic and ecological distribution, migration, home range, and related habits of native animals in these areas. This would facilitate (1) selection of species of animals which would serve as standards of measurement to determine how the ecological structure in a selected community had been affected by the thermal, radiation, and other physical factors in nuclear testing; and (2) establish techniques of procedure so that studies may be made in similar ecological situations where nuclear detonations have occurred or may occur.

During the three years from 1959 to 1962 that these studies were in progress, large numbers of animals were captured and studied, and volumes of data were gathered. The initial analysis of these data was dependent upon the identification of the organisms collected. Specialists were employed to classify the many taxonomic groups. In some groups of the invertebrates specialists were not available who could identify the species. Some vertebrate animal groups were studied in detail, and some of these data have been published.

As a basis for reports which are to follow, it is the objective of this report to (1) identify, delineate, and describe the major plant communities of the Nevada Test Site, (2) include a listing of the predominant animals occurring in these communities, with a designation of their relative abundance and seasonal occurrence, and (3) list phylogenetically all the species of animals known from the test site and the communities in which they are found.

The delineation of the plant communities is rather general and does not include certain plant associations. Detailed botanical studies continued over several years will perhaps necessitate a refinement of our present plant community designation. Nevertheless, the present arrangement fits the needs of the present study.

EXTENT AND GENERAL GEOGRAPHY OF THE NEVADA TEST SITE

The Nevada Test Site (proving grounds) is situated approximately 70 miles northwest of Las Vegas, Nevada, in the southeastern part of Nye County. It lies alongside northwestern Clark County and southwestern Lincoln County (Fig. 1). It is approximately 1,300 square miles in size, extending 40 miles north to south and about 35 miles east to west. It is included in the Las Vegas Bombing and Gunnery Range which comprises approximately 4,000 square miles.

Johnson and Hibbard (1957) have given an account of the geology of the proving grounds in Nevada. Most of the descriptive information on the geographic features which follows was extracted from their report. Maps and geographic names which accompany this report are also based, for the most part, on their report. Recent United States Geological Survey maps of the test site area were also used. Figures 4, 5, and 44 are composites from these sources which show mountain ranges, valleys, and our designation of plant communities.

The geography of the test site is typical of the landscape in southwestern desert areas of the United States (Fig. 2 and 3). There are low-lying, rugged mountain ranges which are sparsely vegetated, and intervening valleys into which erosional material has been deposited over the ages, creating extensive alluvial fan-like deposits. Those deposits extending from the bases of the mountains and hills comprise the bajadas, or foothills. The composition of the bajadas is reflected in the source from which the erosional material was derived and the degree of incline and deposition. Composition of

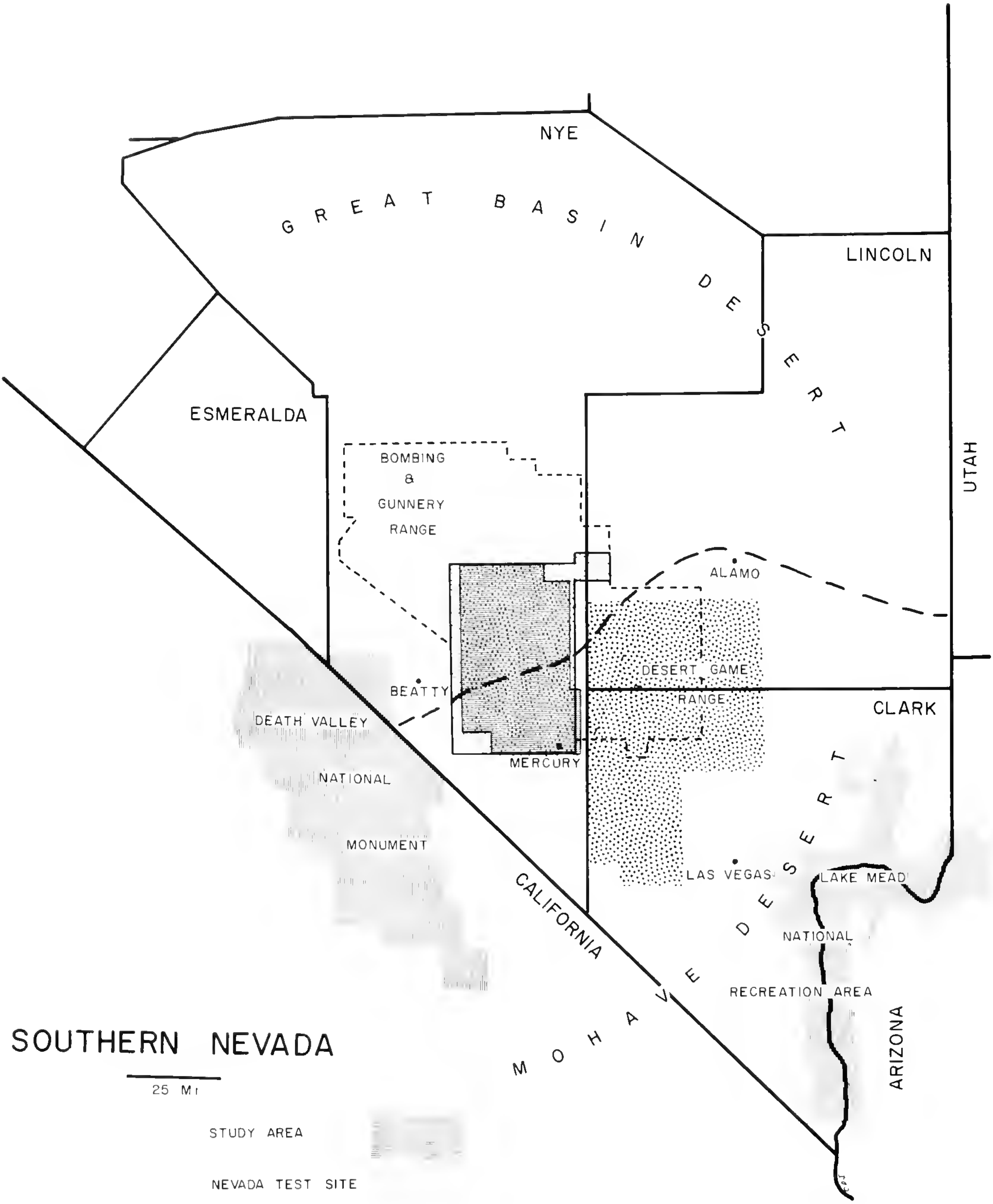


Fig. 1. Geographic location of the Nevada Test Site and the approximate boundary between the Great Basin and Mohave deserts.

Fig. 2. Typical landscape of southern Nevada.

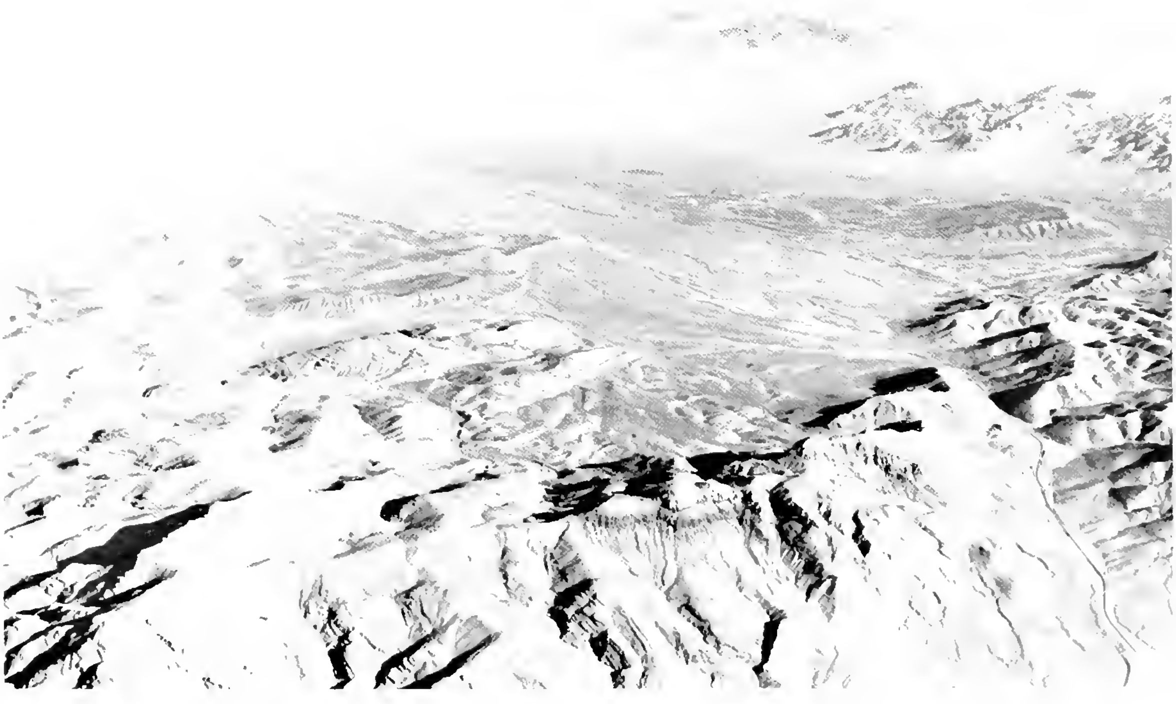


Fig. 3. Playa of Frenchman Flat.

these deposits, in part, also affects the characteristics of plant cover and faunal associates (Hardy, 1945).

Another characteristic feature of some of the southwestern desert areas of the United States are those valleys in which moisture from snow melt and rain is trapped when run-off occurs from the surrounding terrain. The silt-laden waters which eventually reach the lowest elevation in such valleys concentrate as ephemeral bodies of water which upon evaporation leave a deposit of fine silt and clay that becomes very hard when dry. These lake beds are termed playas and for the most part lack conspicuous vegetation (Fig. 3).

The principal geographic areas in which our studies were conducted are three valleys and selected areas on hills, mountains, and mesas. Two of the valleys are catchment basins in which relatively large playas exist. The northernmost is Yucca Flat, south of which is Frenchman Flat, separated from the former by a low ridge called Yucca Pass. The relative size of each valley and the positions and size of their playas are shown in Figure 44. With reference to Yucca Flat, Johnson and Hibbard state (p. 365) that "the alluvial fill thickens toward the central part of the valley to about 800-1000 feet." They state further, "Seismic surveys (Farnham, oral communication) determined a depth to bedrock of about 650 feet in the playa in Frenchman Flat." The actual thickness of the playa itself ". . . was calculated by seismic methods to be about 175 feet thick (Farnham, oral communication)."

The other valley where studies were conducted is known as Jackass Flats (Fig. 44). This is not a land-locked basin like the two above but drains south and west from the test site.

CLIMATIC CONDITIONS

Nevada lies to the east and leeward side of the Sierra Nevada mountain range which forms a massive barrier to the prevailing winds from the west. This barrier to moist air has resulted, at least in part, in a vast desert region of which the Nevada Test Site is a part. The drier air that descends the eastern slopes of the Sierras is warmed by compression so that little precipitation occurs until it moves farther east, rises and cools as it approaches other ranges where it drops precipitation on the local mountains.

During the summer moist tropical air from a southerly quadrant invades the southwestern deserts (Weedfall, 1962), whereas moisture from other directions is effectively blocked by higher mountain ranges. Summer precipitation is due primarily to convective showers associated with thunderstorms which in turn are induced by low-level humidity. This phenomenon results in considerable variation in precipitation at different positions at the test site. Rainfall was 4.42 inches at 3,356 ft. elevation and 8.75 inches at 7,480 ft. elevation at two stations in 1960, and 3.66 inches and 6.74 inches at the same stations in 1961.

Most of the precipitation occurs during the winter. From 1959-1961 36% of the rainfall was between April and September, whereas 64% occurred during the remaining months.

Snowfall is sparse in the lower valleys and usually persists for only short periods. Although the high plateaus and mesas frequently have considerable snow, it usually does not remain in sufficient amounts to continually cover the ground. This results from the fact that daily temperatures frequently rise considerably above freezing even in the winter. Consequently, there is a lack of extended periods of extreme cold which would delay snow melt.

The summers at the test site are long and hot and the winters short and mild. The highest temperature recorded at the test site was 112° F in July, 1959, at Jackass Flats. The minimum was 3° F in January, 1959, at Yucca Flat. The average maxima and minima vary with the location, from 64° to 77° F maximum and 39° to 52° F minimum. Prolonged periods of extreme cold are rare due primarily to mountainous barriers which lie to the east and north and block off the cold continental air masses. Diurnal temperature changes typical of desert regions fluctuate as much as 51° on clear days but may not differ more than 20° on cloudy, windy days. Temperature inversion zones have been demonstrated at the Nevada Test Site. Frenchman and Yucca flats are closed basins; hence, cold air drainage from the mountains frequently results in the formation of cold air pockets in the valley floors.

Relative humidity varies from near 2% to approximately 90%, the highest occurring in the pre-dawn hours and the lowest during daylight hours. The average is about 21% in summer as contrasted with 30% in winter.

Prevailing winds are westerly, although local physiographic features sometimes result in winds from a southerly direction. High winds are rare. Dust and sandstorms occur occasionally, particularly during the spring months.

HISTORY

Little is known concerning the early inhabitants and explorers in the actual area of the Nevada Test Site. According to Harrington (1930), archaeological evidence to indicate Indian inhabitants in adjacent areas was reported by Jedediah S. Smith in 1827, M. S. Duffield in 1904, A. V. Kidder in 1912, H. P. Mera in 1913, and N. C. Nelson in 1921. In the course of our studies at the test site Indian artifacts were recovered.

Early explorers to southern Nevada were Jedediah S. Smith, Antonio Armijo, and others who followed the Old Spanish Trail which passed near the present site of Las Vegas. Mining ventures which brought numerous people to contiguous areas as well as the area of the test site is evidenced by mine shafts and prospect holes.

Cane Springs at the test site is notable as a water source. Inasmuch as it is a continuous source of water, it was a likely stopping place for early travelers and explorers. Murbarger (1956) reported that in 1928 the mining town of Wahmonie in the eastern part of Jackass Flats on the test site boomed abruptly to a population of 1,500, obtaining its water supply by tank from Cane Springs. Almost as abruptly, it became one of the many typical ghost towns.

The first major biological expedition in the vicinity of the test site was the Wheeler survey of 1871-1877. Later came the Death Valley expedition of 1891-1893 led by C. Hart Merriam. There is no evidence that the Wheeler group visited the actual area of the test site, and the Death Valley expedition circumvented it entirely, although they may have visited adjacent Emigrant Valley (Palmer, 1893). John C. Fremont, who delineated the Great Basin region and gave it that name (Tanner, 1940), passed by the test site area in 1844. This was while he was enroute to Las Vegas, Nevada from Walker Pass in the high Sierra Nevada Mountains. LaRivers (personal correspondence) and his associates at the University of Nevada made several collecting trips into southern Nevada since 1948, but none of these involved the test site.

Several botanical studies were made in the Charleston Mountains southeast of the test site. Merriam (1893) reported on the vegetation of southern Nevada as observed by the Death Valley expedition. From 1909 until his retirement in 1945 Shreve (1951) was actively engaged in field studies of the vegetation in the deserts of southwestern United States including areas contiguous to the Nevada Test Site. We have no record, however, of his actually traversing the test site itself. In the summer of 1937 LaRivers (personal correspondence) collected plants in areas now involved in the test site. Clokey (1951) published the only comprehensive flora of the area and reviewed the earlier investigations of Purpus, Jones, Haller, Tidestrom, Jaegar, Hitchcock, LaRivers, Hancock, Maguire, Alexander, and Kellogg. Although Clokey spent parts of seven years in or near the Charleston Mountains, he apparently did not enter the area of the test site. Tidestrom (1925) like Clokey did not visit the test site proper; nevertheless, his published studies on the plants of the general region are an important source of reference.

Recently, between 1957 and 1961, Shields (1958, 1959a, 1959b), Shields and Rickard (1960), Shields, Rickard, and Drouet (1959), Shields, Durrell, and Sparrow (1961), Shields and Wells (1962, 1963), Rickard (1959, 1961, 1963), Drouet (1959), and Durrell and Shields (1960), associated with New Mexico Highlands University, studied the effects of nuclear detonations on plants at the test site. At present, plant studies are being conducted there by Janice C. Beatley (1962) and William E. Martin of the University of California, Los Angeles.

The first extensive work on mammals of southern Nevada was begun in 1928 by Burt (1934), but he did not study the area of the test site. Hall (1946) published the next major work in his "Mammals of Nevada" and reviewed the work on mammals covering the period from 1930 to 1946. He recorded collections from several localities on and adjacent to the test site.

Aside from the early reports by Henshaw (1875, 1877, 1880), Nelson (1875), and Fisher (1893) on the birds of Nevada, the first extensive treatise was prepared by Ridgway (1877), zoologist with the United States Geological Expedition of the 40th Parallel. Hoffman (1881) published the first comprehensive listing of Nevada birds and summarized the findings of Henshaw and Ridgway. Only isolated records of birds were published between 1881 and the more recent works of Jaeger (1927), Van Rossem (1936), and Linsdale (1936, 1951). Gullian, Pulich and Evenden (1959) studied the birds of southern Nevada and reported several species from the region of the test site. Some ornithological records have been published by members of the U. S. Fish and Wildlife Service (Anon. 1961) at the Desert Game Range which is adjacent to the eastern boundary of the test site. Rickard (1961) published on the nesting habits of several species observed at the test site.

Following the reports of reptiles by Yarrow (1875), Yarrow and Henshaw (1878), and Stejneger (1893) resulting from the Wheeler and Death Valley expeditions, Bentley (1919), Van Denburgh and Slevin (1921), and Linsdale

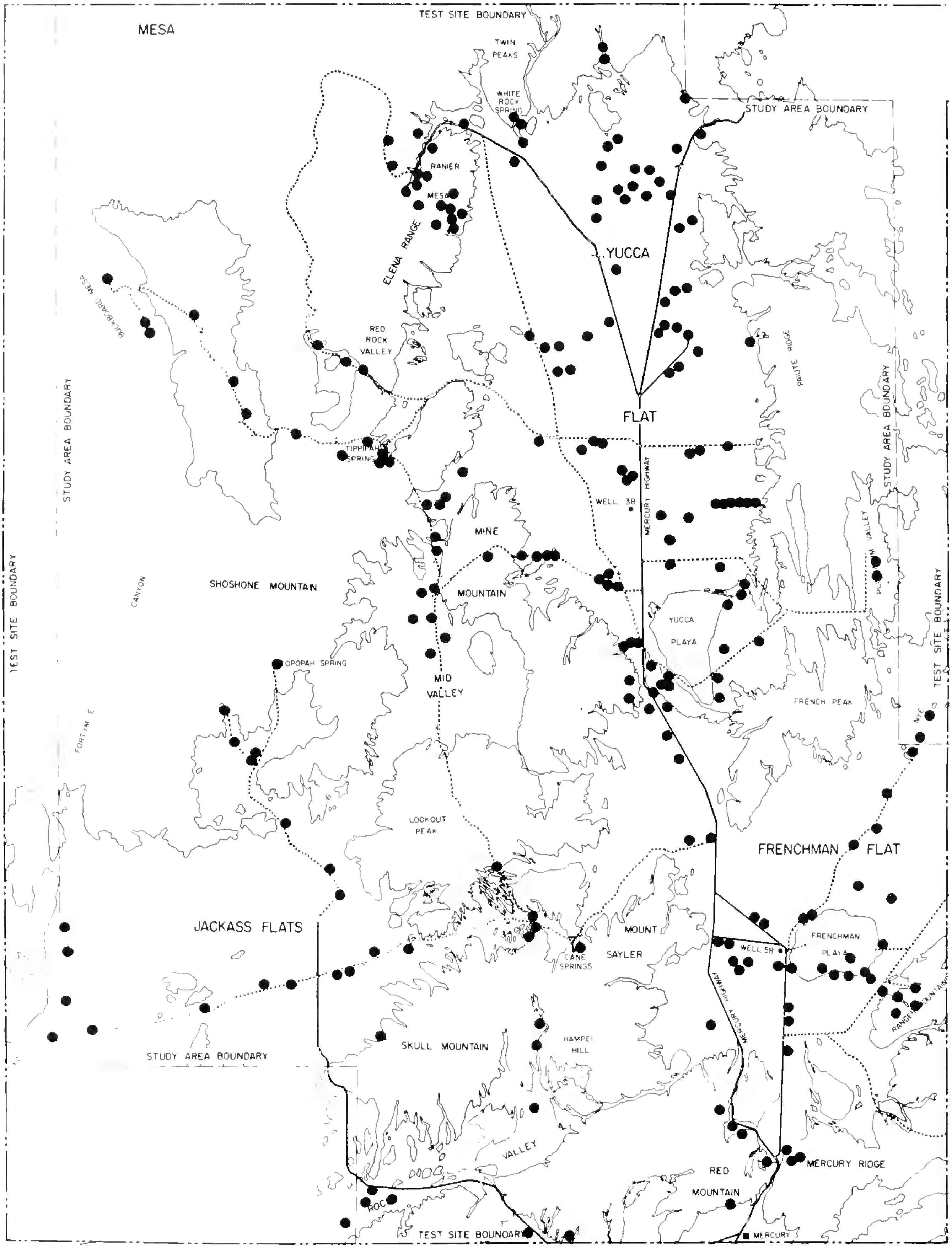


Fig. 4. Principal collecting sites of vertebrates (Sites of incidental collections are not included).

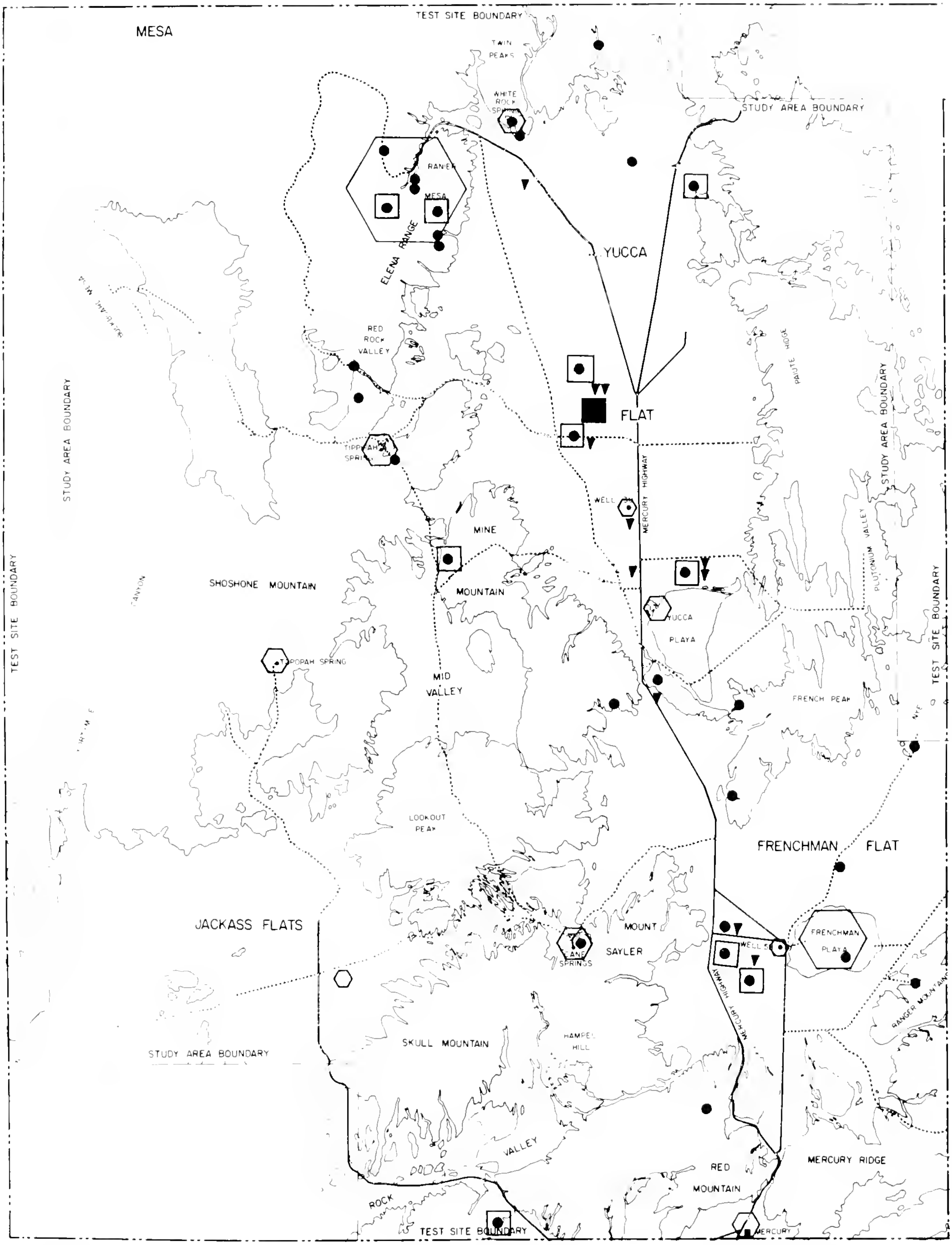


Fig. 5. Permanent sites for year-round studies of animals, and principal sampling stations of invertebrates (Open squares - permanent study sites of mammals; solid square - permanent study site of lizards; solid circles - permanent and/or principal sampling study sites of ground-dwelling invertebrates; solid triangles - permanent study sites of invertebrates associated with predominant plant species; open hexagons - general collection and study sites of all animals. Sites of incidental collections are not included).

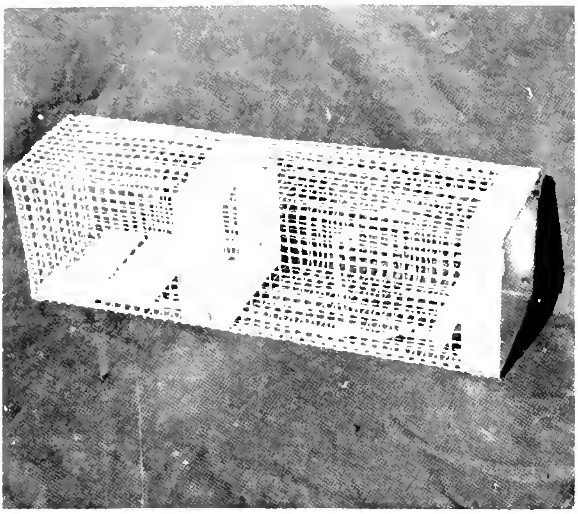


Fig. 6. Young-type rodent trap.

Fig. 7. Museum Special, break-back traps.

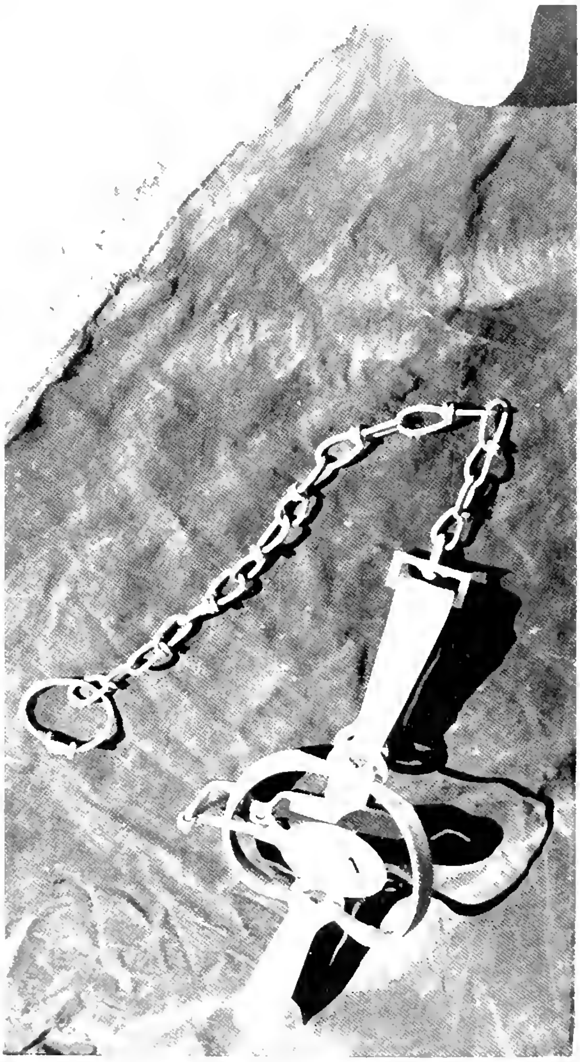


Fig. 8. Oneida-Victor carnivore trap.

Fig. 9. Can pit-trap.

(1940) published exclusively on Nevada reptiles. Linsdale (1940) first listed records obtained from the area of the test site. Other recent records for southern Nevada are listed by LaRivers (1942) and Banta (1950, 1953).

As far as is known, the invertebrate fauna of the test site and adjacent vicinity has not been studied except for incidental collections reported by various workers in their specific fields. The surveys by Rehn (1924) and his associates, and LaRivers (1938, 1943, 1948) are examples.

In 1941 an area of approximately 4,000 square miles in southern Nevada was designated as the Las Vegas Bombing and Gunnery Range. This included and surrounded the present area of the Nevada Test Site (Fig. 1). The establishment of this range essentially excluded biological surveys from that area. Following the establishment of the Nevada Test Site in 1950 and the initiation of nuclear testing in 1951, biological investigations in that specific area have been limited to those scientists closely associated with the development of nuclear devices. Since 1950 approximately 150 such devices have been detonated at the test site with varying effects on the flora and fauna. Recent faunal studies of the test site in association with the nuclear testing program were reported by Allred, Beck, and Murdock (1960), Allred (1960, 1961, 1962a, 1962b), White and Allred (1961), Allred and Beck (1962, 1963a, 1963b), White (1962), Jorgensen (1962a, 1962b), Jorgensen and Orton (1962), Chamberlin (1962a, 1962b), Richards (1962), Killpack and Goates (1963), Cole (1963), Goates (1963), and Packham (1963).

PROCEDURES AND ACKNOWLEDGMENTS

The Nevada Test Site is a security area closed to the general public. Researchers must have permission for access. Even then, restricted areas within the test site are not fully accessible.

Most of our permanent study sites were established in the valleys, although considerable sampling was done in some of the mountainous areas. Some of the mesas are of sufficient elevation that deep snows are present for several months. In those areas somewhat restricted for reasons of security, or which were only seasonally accessible, short-term studies were made as opportunities allowed. Figures 4 and 5 show the geographical locations of our study sites.

Several techniques of collecting animals were used. The principal trap used for rodents was a Young-type, wire animal trap (Fig. 6). It is 15 inches long by 4½ inches square and is made of 3-mesh hardware cloth on the sides, top, bottom, and one end. The door of galvanized sheet metal closes by gravity drop. For other rodent sampling the Museum Special, break-back trap was used (Fig. 7). Quick-cooking rolled oats was used as bait for rodents. Oneida-Victor coyote traps (Fig. 8), rifles and shotguns were used for collecting badgers, foxes, coyotes, and other carnivores. Birds were collected by use of various gauge shotguns, Japanese mist nets, and funnel traps made of hardware cloth and baited with mixed grains. Lizards were caught by hand, with nets, and by use of small caliber shot shells, but principally by use of sets of sunken cans (Fig. 9). These consist of an outer, galvanized metal case, 7 inches in diameter and 14 inches long with a stainless steel, flanged inner can slightly smaller in size. Invertebrates were collected with aerial, sweeping, and beating nets, sunken cans (same as above), and Berlese funnels 15 inches in diameter and 3 ft. in length (Fig. 10). Ectoparasites were removed from hosts by brushing and with the aid of the binocular dissecting microscope.

The application of sampling techniques to selected areas of study was principally done

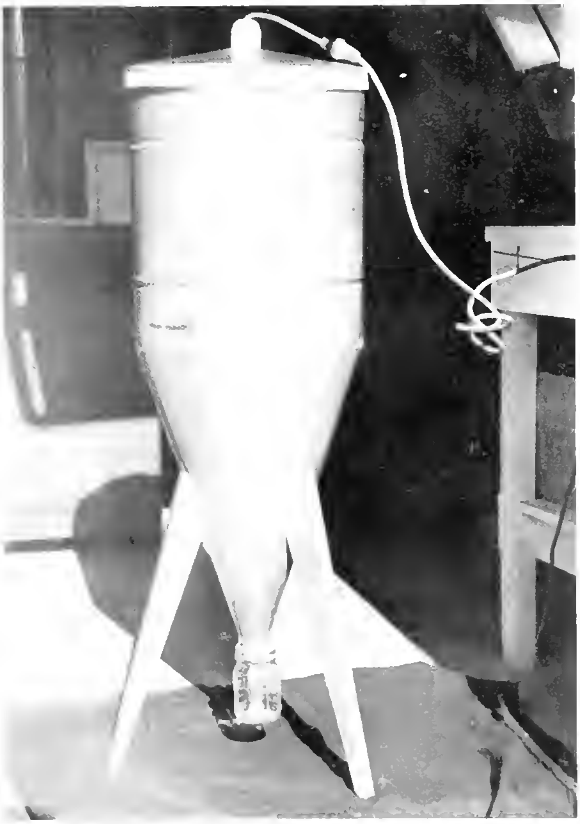


Fig. 10. Berlese funnel.

under one or more of the following plans. Grids of 15.6 acres were used with stations at 75-ft. intervals (Fig. 11). Smaller grids with collecting stations at 35-ft. intervals were also utilized. Line transects radiating from a central point were employed; some had collecting stations at 30-ft. and others at 264-ft. intervals (Fig. 12). These transects varied from 750 ft. to 1½ miles in length. A third method of sampling consisted of two parallel transects, 60 ft. apart, with traps spaced at 30-ft. intervals (Fig. 13).

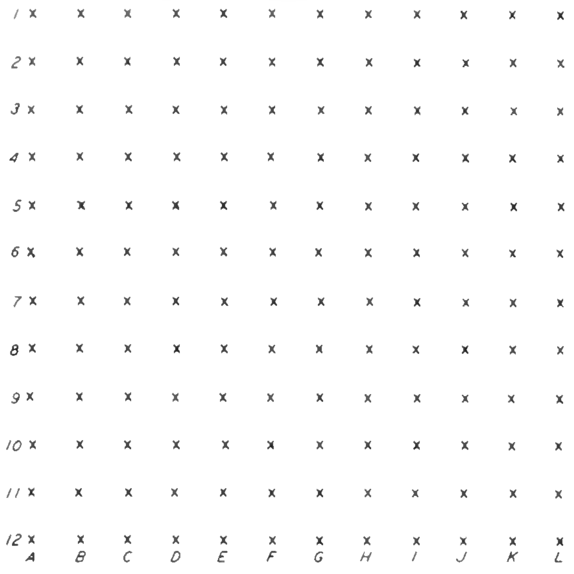


Fig. 11. Grid arrangement of collecting stations at permanent study sites.

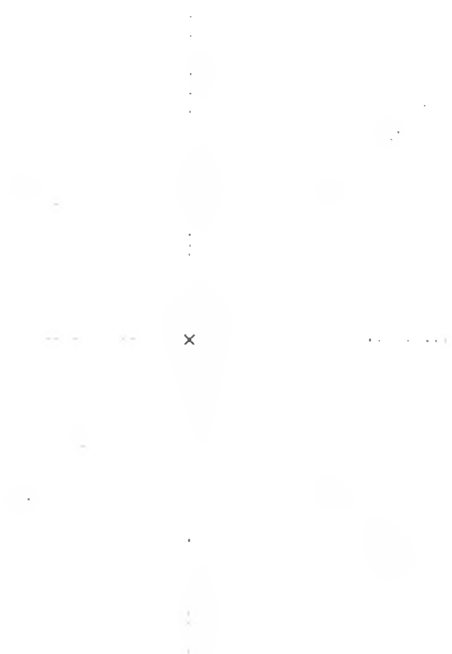


Fig. 12. Radiating transect arrangement of collecting stations at permanent study and sampling sites.

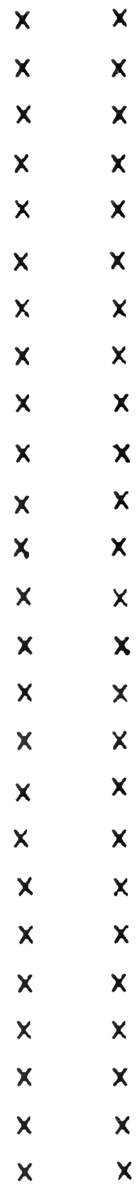


Fig. 13. Paired transect arrangement of collecting stations at sampling sites.

Sight observations of reptiles, birds, lagomorphs, carnivores, and artiodactyls were recorded, and miscellaneous collections of all animals were made as opportunity permitted.

Vegetation composition of the study sites was analyzed by the line intercept method.

All applicable data were recorded on IBM punch cards. Analyses and tabulations were made with an IBM 650 computer.

The authors express appreciation to the following agencies, institutions, contractors, and personnel for their assistance in this research project. Division of Biology and Medicine, United States Atomic Energy Commission for their financial support under contract AT(11-1)786; Civil Effects Test Operations, United States Atomic Energy Commission, especially Robert L. Corsbie and L. J. Deal; and Reynolds Electrical and Engineering Company, Inc., particularly John L. Williamson, for their support at the Nevada Test Site; Kermit H. Larsen and Janice C. Beatley, University of California, Los Angeles, for assistance in fallout and radiation evaluations and for identifications of plants and interpretation of plant communities, respectively; Lora M. Shields and Philip V. Wells, New Mexico Highlands University, and William H. Rickard, Hanford Laboratories, for identification of plants and interpretation of plant communities; and to Brigham Young University for permission to participate in the research project and for furnishing laboratory facilities and office space for personnel associated with the project on the Brigham Young University campus.

Many specialists and consultants have cooperated with us on the project. Identification and verification of specimens returned to our laboratories were made by the following personnel: Willis J. Gertsch, American Museum of Natural History, New York, scorpions, spiders, and phalangids; Martin E. Muma, University of Florida, Lake Alfred, solpugids; James M. Brennan, Rocky Mountain Laboratory, Hamilton, Montana, and Russell W. Strandtmann, Texas Technological College, Lubbock, mites; Stanley B. Mulaik, University of Utah, Salt Lake City, isopods; George F. Edmunds, University of Utah, mayflies and caddice flies; Andrew H. Barnum, Dixie College, St. George, Utah, grasshoppers, crickets, and relatives; Vasco M. Tanner and Stephen L. Wood, Brigham Young University, and Henry F. Howden, Canada Department of Agriculture, Ottowa, beetles; Arthur C. Cole, University of Tennessee, Knoxville, ants; Ralph V. Chamberlain, University of Utah, millipeds and chilopods; Wilmer W. Tanner, Brigham Young University, reptiles; and C. Lynn Hayward, Brigham Young University, birds and mammals.

Special mention is made of those who have worked full or part time for a long period and contributed considerably to the project, namely: Joseph R. Murdock and Leland D. White, who constituted our first resident field team at the Nevada Test Site and laid the groundwork for our present studies; Andrew H. Barnum, Merlin L. Killpack, Arthur C. Anderson, Gerald L. Richards, Willis A. Packham, and Arnold M. Orton who spent considerable time at the test site in addition to summers. Others who contributed a great deal while holding research assistantships are Morris A. Goates, Carl G. Ingersoll, Richard L. Richhart, Elias P. Brinton, Robert L. Amoureux, Gerald L. Hayward, and James R. Barnes. Other students, staff, and consultants spent summers, made periodic visits, or assisted with the preparation and identification of specimens. Special thanks is given Linda Ann Terry who carried much of the responsibility of the busy-work of the administrative burden, as well as the checking of data, their transfer to IBM punch cards, and arrangement for tabulation and analysis.

BIOTIC COMMUNITIES

The Nevada Test Site is situated in an interesting ecological desert area. It lies on the border of the Upper and Lower Sonoran life zones as defined by Merriam (1892, 1893, 1898), the Artemisian and Mohavian biotic provinces of Dice (1943), and the Shadscale-Kangaroo Rat (Cool Desert) and Creosote Bush-Desert Fox biomes of Shelford (1945). The boundary between the Great Basin and Mohave deserts, as defined by Jaeger (1957), crosses the Nevada Test Site (Fig. 1). The Great Basin was designated as a geographic province by Fremont (1845). The Mohavian Biotic Province was described by Dice (1943), although Shreve (1951) and Jaeger (1957) delimited approximately the same geographic area in their definition of the Mohave Desert.

Inasmuch as our studies were directed toward a detailed examination of small biotic communities, we could not apply the broad systems of community classification such as Life Zones, Biotic Provinces, or Biomes of these other workers. Consequently, we used the various vegetative complexes at the test site as a basis for community identification and comparison. This is what Shields (1958) did in her studies of the plants at the test site. At that time she defined eight vegetation zones. Subsequently, Shields, Rickard, and Drouet (1959) and Shields and Rickard (1960) redefined these zones as vegetation types. Fautin (1946) faced a similar situation in designing a workable scheme of community classification in his studies of the Northern Desert Shrub Biome in Utah. Hayward, Beck and Tanner (1958) applied a similar approach in their studies of the zoology of the upper Colorado River Basin.

We have applied the concept of Munz and Keck (1959) to the two major types of vegetation at the test site. These are the Desert Scrub and the Desert Woodland (also known as the Pigmy Forest), which we have subdivided into plant communities (Fig. 44). Under the Desert Scrub Type we have designated five communities: Larrea-Franseria, Grayia-Lycium, Coleogyne, Atriplex-Kochia, and Salsola. Under the Desert Woodland Type there is one community, the Pinyon-Juniper. This arrangement is well adapted to the type of ecological investigation conducted in our study.

Within a community plants characteristic of other communities frequently occur. However, these species are localized and are not found distributed throughout the community. These peculiar situations undoubtedly result from differing edaphic and climatic factors as discussed by Rickard and Murdock (1963). Such areas frequently are the habitats for animal species which may not occur elsewhere in the typical community. A listing of some of the more common plants found in the several communities is given in Appendix I.

Once the plant communities at the test site were delineated for our purposes, the predominant animals associated with each community were determined.

PLANT COMMUNITIES

Larrea-Franseria Community

This community is recognized as belonging to the Mohave Desert (Shreve, 1951; Jaeger, 1957). The vegetation of Mercury Valley, Rock Valley, Jackass Flats, and Frenchman Flat is predominantly *Larrea divaricata* and *Franseria dumosa* which gives these areas many of the characteristics of this southern desert (Fig. 14).

In this community there are areas where the vegetative pattern varies from the typical predominant combination of *Larrea* and *Franseria*. Around the playa of Frenchman Flat *Atriplex confertifolia* occurs as a narrow band in a relatively pure stand. It also frequently occurs in abundance on the bajadas, hillsides, and along the washes. Similarly, *Atriplex canescens* occurs between the playa and the stand of *A. confertifolia* and usually extends up the washes from the lake bed.

On the gently sloping bajadas of northern Jackass and Frenchman flats, the stands of *Larrea* and *Franseria* give way abruptly to stands of *Coleogyne ramosissima*; frequently there is an area of heterogenous vegetation between. This situation occurs along Mercury Ridge, Skull Mountain, Mine Mountain, and on the Spotted and Specter ranges.

In Jackass Flats there is an extensive area which supports an almost pure stand of *Larrea divaricata*. Although this situation is not common at the test site, it frequently occurs throughout other parts of the Mohave Desert. A stand of *Larrea divaricata* and *Lycium rickardii* is conspicuous on the bajada southeast of Frenchman Playa, an area intersected by many washes. In Frenchman Flat *Lycium pallidum* occurs in abundance as a narrow stand which extends in a southwesterly direction from the playa through an extensive area of *Larrea* and *Franseria*. In Rock Valley there are areas which are predominantly *Lycium andersonii*. Although small areas of similar vegetation occur at other parts of the test site, this particular area is appreciably larger than most.

Grayia-Lycium Community

Shreve (1951) stated that *Grayia spinosa* is occasionally found in place of *Larrea divaricata* and *Franseria dumosa* in mountainous areas of the Mohave Desert at elevations below stands of *Coleogyne*. Jaeger (1957) suggested that it coexists with *Eurotia lanata* at lower elevations in northern Utah, and Shreve (1951) added that *Grayia spinosa* and *Coleogyne ramosissima* occur in place of *Larrea divaricata* and *Franseria dumosa* at higher elevations in the northern parts of the Mohave Desert. Although *Grayia spinosa* and *Lycium andersonii* occur in varying degrees with *Larrea divaricata* and *Franseria dumosa* on the test site, the Grayia-Lycium community attains its most impressive development in Yucca Flat where it covers many square miles of the bajada (Fig. 15). At the somewhat higher elevation of Buckboard Mesa, there is a large stand of *Grayia spinosa* and *Artemisia tridentata*.

Near the edge of the Grayia-Lycium community and next to the Atriplex-Kochia community in Yucca Flat, there is a small stand of *Atriplex confertifolia* and *Eurotia lanata*. In the lower part of the valley, *Atriplex* and *Eurotia* occupy a position similar to that described by Jaeger (1957) for the Great Basin Desert.

At the east side of Yucca Flat on the sandy bajada there is an association of plants that is unique. It consists of several species, of which *Tetradymia glabrata* is one of the most prominent. This situation is also common to Plutonium Valley east of Yucca Flat.

Coleogyne Community

Coleogyne ramosissima occurs as one of the most pure stands of plants at the test site (Fig. 16). These stands may be in patches only 100 ft. in diameter on the side of a mountain or occur as belts as much as several miles in length on the gently sloping, rocky foothills.

Scattered stands of *Larrea divaricata* and *Coleogyne* occur in several areas along the upper bajadas in Yucca Flat. Wells (personal correspondence) demonstrated that one of the stands was in a temperature inversion zone. Temperature inversion may explain the existence of these localized stands of *Larrea*, but not the isolated plants in both the Coleogyne and

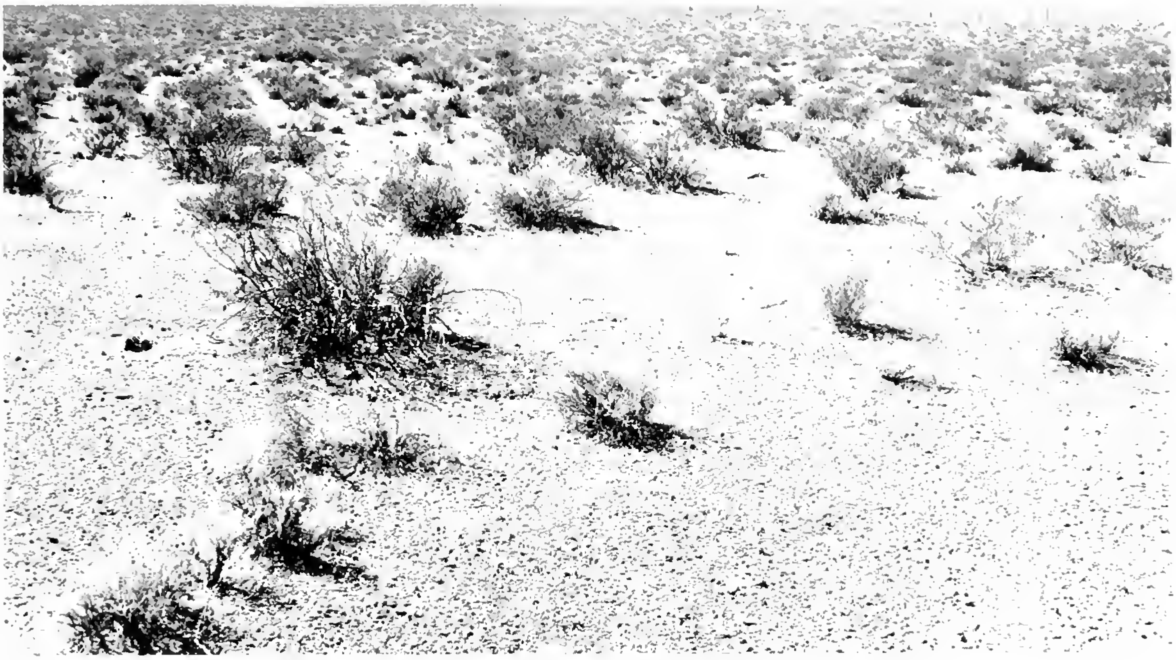


Fig. 14. Larrea-Franseria Community.

Fig. 15. Grayia-Lycium Community.

Fig. 16. Coleogyne Community.

Fig. 17. Atriplex Kochia Community.

Fig. 18. Salsola Community.

Fig. 19. Pinyon-Juniper Community.

Grayia-Lycium communities. *Franseria*, which is frequently associated with *Larrea* and *Coleogyne* in Frenchman and Jackass flats apparenly is absent in Yucca Flat.

Coleogyne exists as a complex mosaic in the northern end of Mid Valley where it occurs in small almost pure stands next to almost pure stands of *Artemisia tridentata*. These are sometimes separated from each other by narrow ecotones of less than 10 ft.

On both sides of Yucca Pass there is an association of *Yucca brevifolia* and *Coleogyne* that is found in almost every area in Yucca Flat where *Yucca* occurs in large numbers.

Atriplex-Kochia Community

This distinct community consists primarily of *Atriplex confertifolia* and *Kochia americana* (Fig. 17). It occupies an extensive area at the margin of the Yucca Playa where there is extremely shallow soil covering a nearly impervious clay substrate. An occasional wash lined with *Atriplex canescens* intersects this community.

Salsola Community

During nuclear weapons testing large areas are denuded of native vegetation. Plants on the fringes of these areas frequently are partially burned or broken by the heat and shock waves Such disturbance creates areas suitable for invasion of *Salsola kali* and ecologically related species (Fig. 18). The total area covered by these invading plants is relatively large, but pure stands are usually restricted to the areas surrounding ground zeros.

Pinyon-Juniper Community

The Desert Woodland is well developed at the northwestern corner of the test site as a *Pinus monophylla* and *Juniperus osteosperma* community (Fig. 19). This well developed community is common at higher elevations throughout the Mohave Desert and on the foothills and mountains of low elevation in the Great Basin. At the test site, stands of Pinyon and Juniper occur in various combinations with *Artemisia tridentata* and *Coleogyne ramosissima*.

Fig. 20. Cane Springs.

OTHER HABITATS

Areas that are not typical of the major plant communities occur within and adjacent to them. These areas are sometimes the permanent habitat for animals that are not frequently associated with the predominant plants typical of these major communities. For purposes of this report, mountainous areas, natural springs, reservoirs, and playas are grouped together as Mixed communities.

Mountainous areas were not included in the description of plant communities due to the diversity of plant species which occur there and because these areas are not specifically included in our overall surveys. In these areas plants occur in various combinations, and each canyon or rocky outcropping frequently has a different combination of plant species associated with it. In many cases the same species that were found in these areas were also found on the bajadas.

Several natural springs are known in the mountainous areas at the test site. Some of them have been modified to exploit the water supply. Cane Springs (Fig. 20) was developed by digging further into water producing strata and a reservoir was built to hold the constant, year-round supply of water. Tippipah, Topopah, and White Rock springs have not been so fully developed. Almost all of the shrubby species found on the bajadas occur near the springs as scattered or small clusters of plants. There are some plant species peculiar to moist habitats which are only present near the above springs. Generally, however, the vegetation about the springs differs little from that found in mesic canyons.

Several reservoirs were established at the test site as part of the testing program. Two that were studied for faunal surveys were supplied with water from Well 3B in a Grayia-Lycium community, and Well 5B in a Larrea-Franseria community. The vegetation has been essentially eliminated from the area immediately adjacent to these reservoirs, but *Chara* sp. is common in the water

The playas are considered as important habitats since they frequently hold large volumes of water for varying periods of time, although they are usually dry during the summer months. Unlike the saline playas common to much of the Mohave Desert, the non-saline playas of the test site are usually surrounded with *Atriplex canescens*, *A. confertifolia*, and other associated species. Essentially no vascular plants occur on these playas.

ANIMAL INHABITANTS

In the discussion and illustrations that follow, data are included for those groups of animals which were studied systematically for at least one year. These data show plant community distribution, seasonal occurrence, and relative population density.

Although Hardy (1945) and Allred and Beck (1963b) discussed the effects of edaphic factors on the distribution of mammals in southwestern Utah and at the Nevada Test Site, we have not included such data in this paper. Soil textures vary so greatly within the different plant communities that it was not practical to attempt to relate these to each systematic group

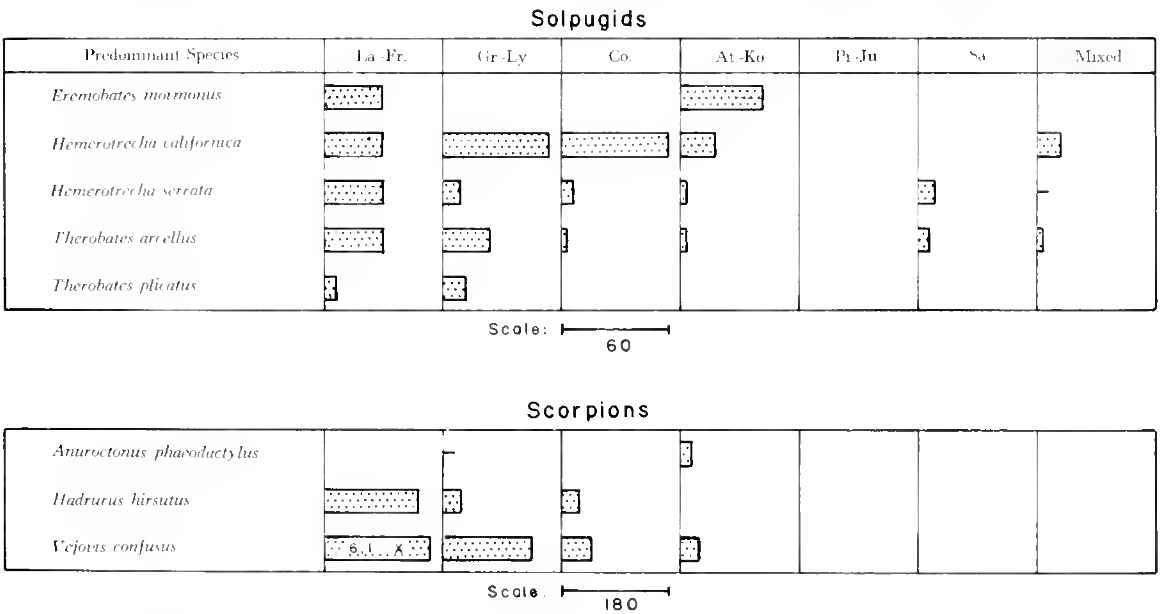


Fig. 21. Distribution by community and relative abundance of predominant species of solpugids and scorpions.

of animals for their broad community distribution. Only the predominant species of each group were selected. A complete listing of all the identified species and their known ecological distribution at the test site is included in Appendix II.

In the figures which show the seasonal distribution for each of the predominant species (e.g. Fig. 22), relative abundance is indicated by the vertical diameter of the symbol. Relative abundance of each species in its taxonomic group is proportional only within the plant community indicated. For example, in Figure 24 the relative abundance of *Psilochorus utahensis* in the Larrea-Franseria community cannot be compared with the same species in the Coleogyne community. Relative abundance, however, can be compared in each case with other species in the same community.

In the figures which show community relationships only, relative abundance of each species is shown in direct proportion, regardless of community and taxonomic group. In these figures a median, single line opposite each species indicates that it was present in numbers too small to plot with the scale used.

SCORPIONS

These animals were found in only four communities (Fig. 21). They were most abundant in numbers of individuals in the Larrea-Franseria, although the greatest number of species was found in the Grayia-Lycium. The most widely distributed of the five known species was *Vejovis confusus*. The scorpions were evident during late summer and early autumn (Fig. 22).

SPIDERS

All communities were inhabited by these animals (Fig. 23). They were most abundant in numbers of individuals in the Larrea-Franseria, although the greatest number of species was found in the Grayia-Lycium. *Gnaphosa hirsutipes* and *Psilochorus utahensis* were the most widely distributed of more than 80 species known for the test site. The spiders as a group were evident every month of the year, although individual species were seasonally restricted. They were most abundant during the summer (Fig. 24).

SOLPUGIDS

These arachnids were found in five communities (Fig. 21). They were most abundant in numbers of individuals in the Larrea-Franseria, although the greatest number of species was found in the Grayia-Lycium community. The most widely distributed of approximately 30 species were *Hemerotrecha serrata* and *Therobates arcellus*. Solpugids were most obvious during summer (Fig. 25).

PHALANGIDS

Only one species, *Globipes spinulatus*, was found at the test site. It was collected in five of the communities and was most abundant in the Coleogyne community (Fig. 23). Phalangids were evident principally during late winter and early spring (Fig. 26).

ISOPODS

Although these crustaceans were found in four communities, they were rarely collected in communities other than Larrea-Franseria at the test site (Fig. 27). *Armadillo arizonicus* was the more widely distributed of the two species recorded. Isopods were evident principally during summer and early autumn (Fig. 26).

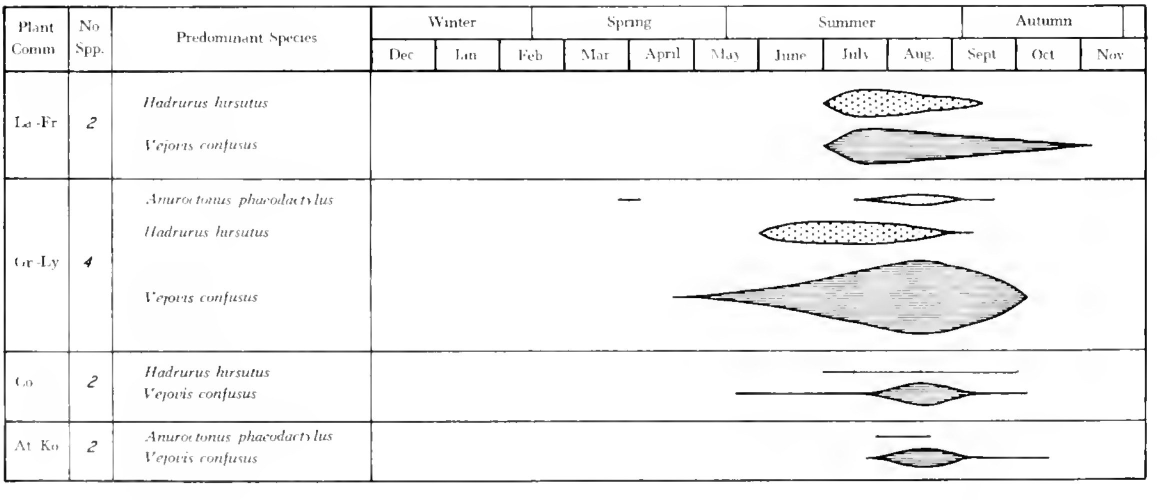


Fig. 22. Seasonal occurrence and relative abundance of predominant species of scorpions.

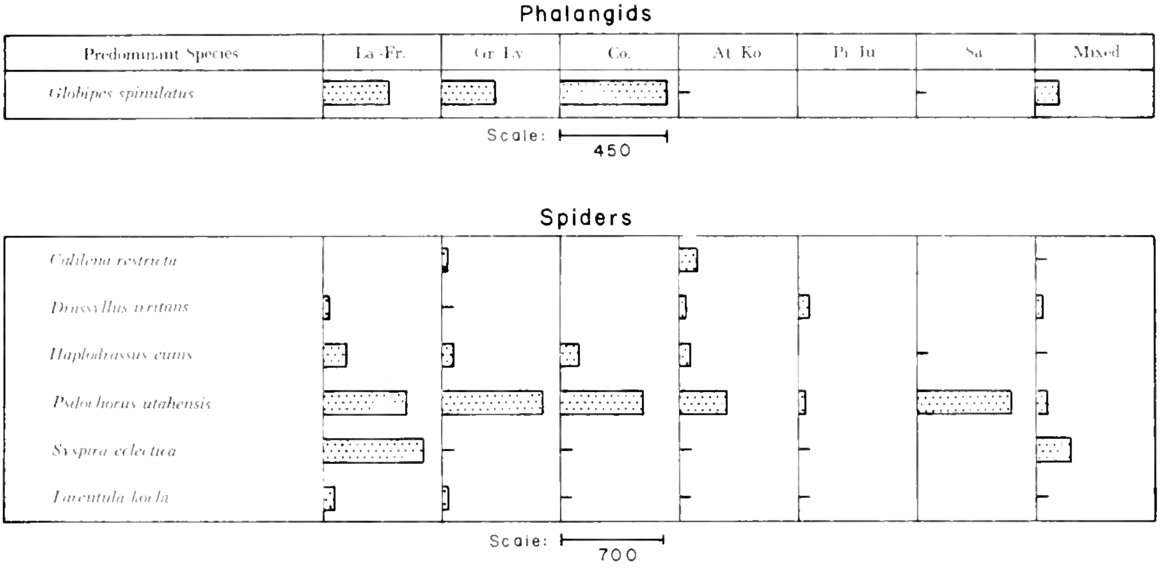


Fig. 23. Distribution by community and relative abundance of predominant species of phalangids and spiders.

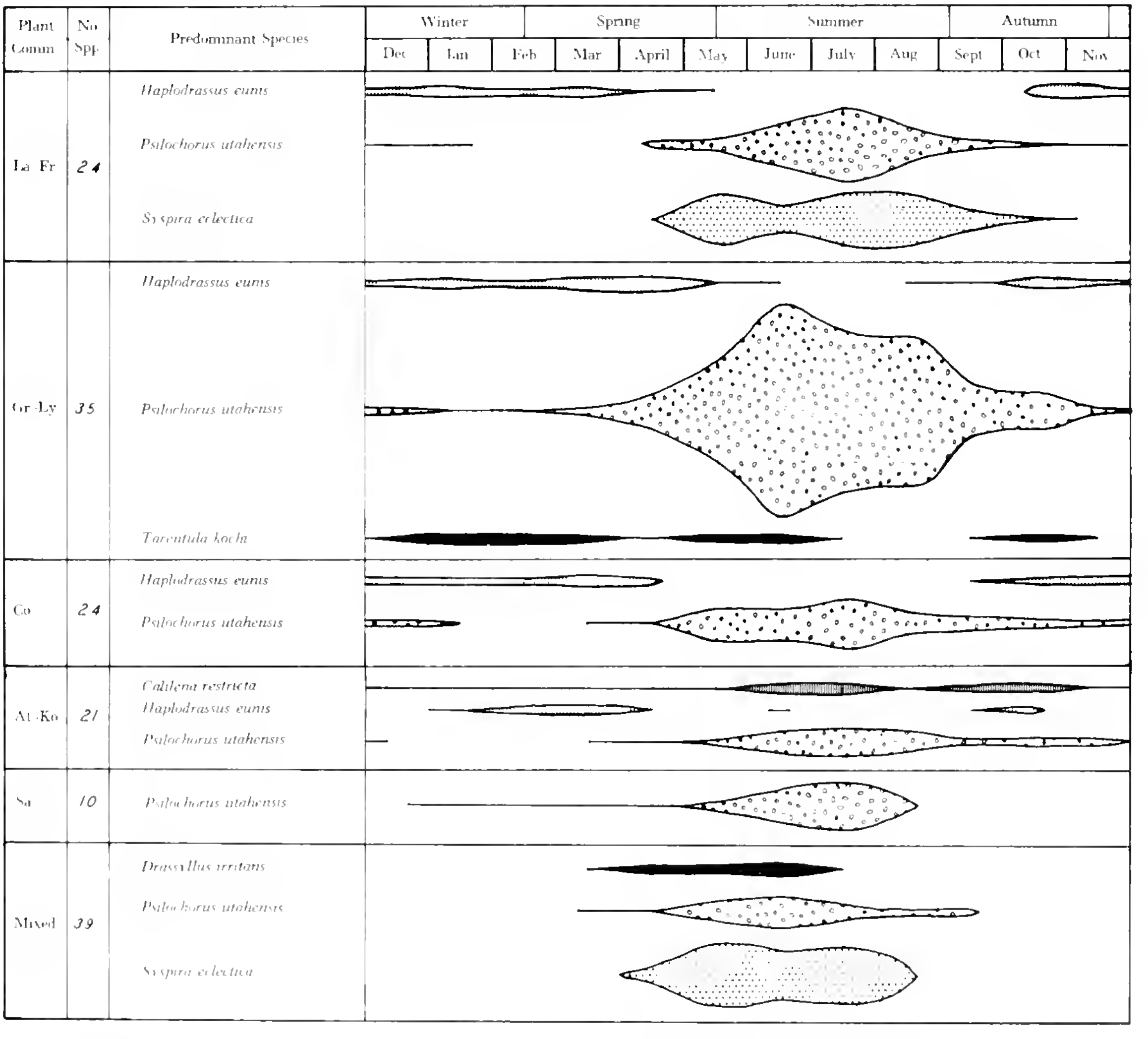


Fig. 24. Seasonal occurrence and relative abundance of predominant species of spiders.

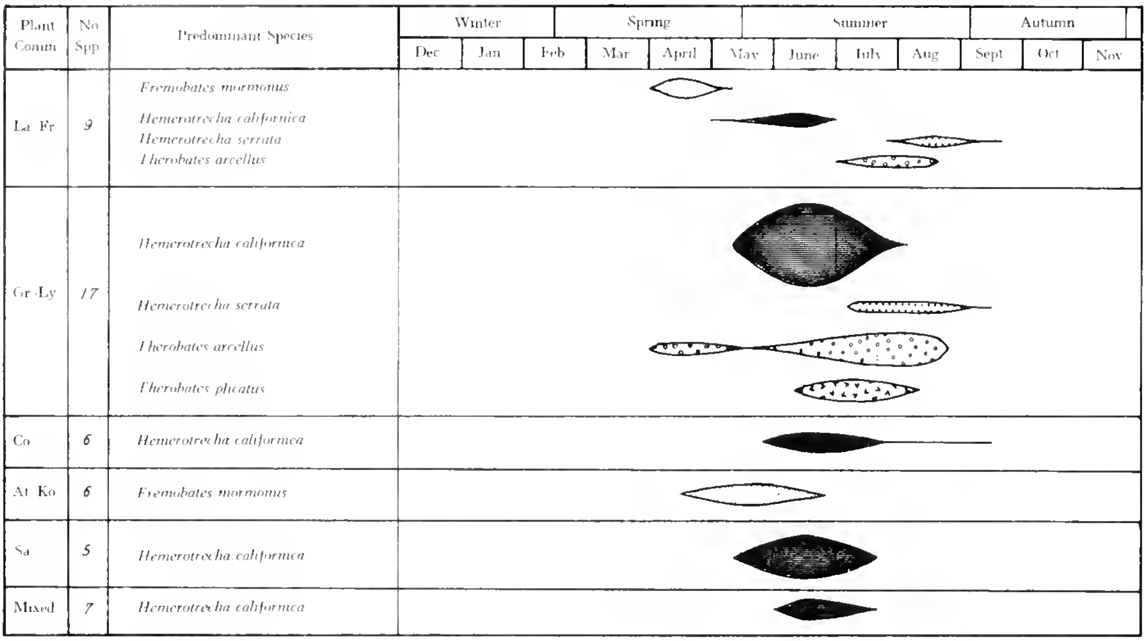


Fig. 25. Seasonal occurrence and relative abundance of predominant species of solpugids.

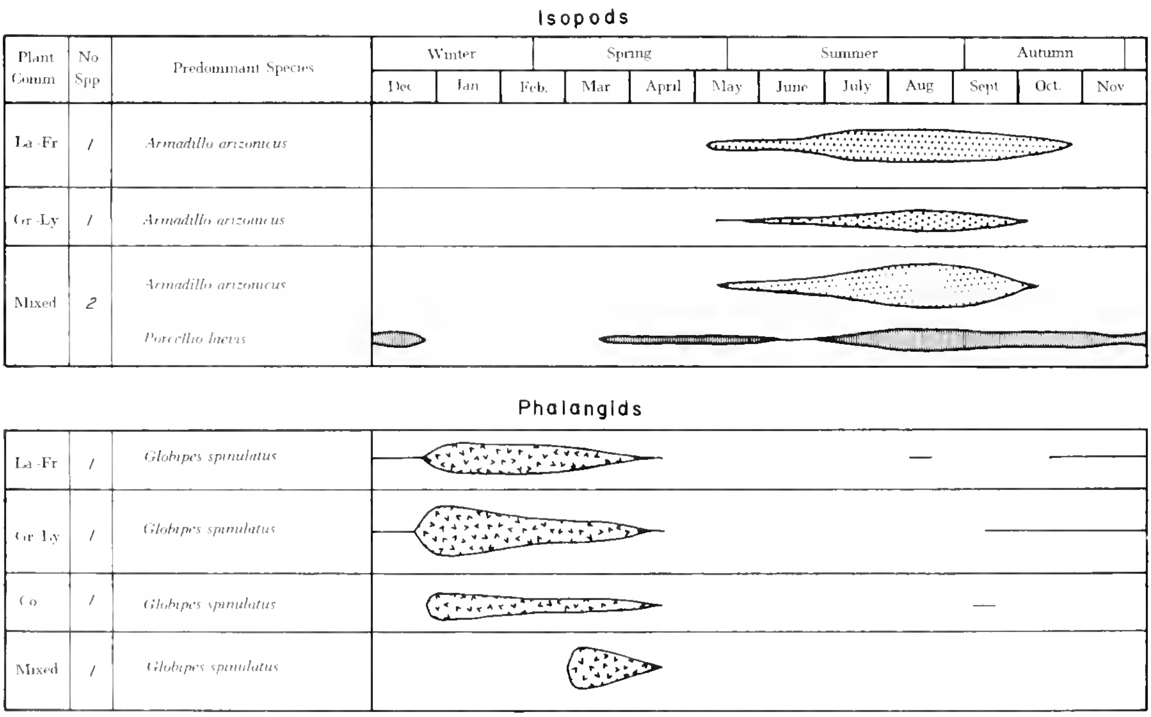


Fig. 26. Seasonal occurrence and relative abundance of predominant species of isopods and phalangids.

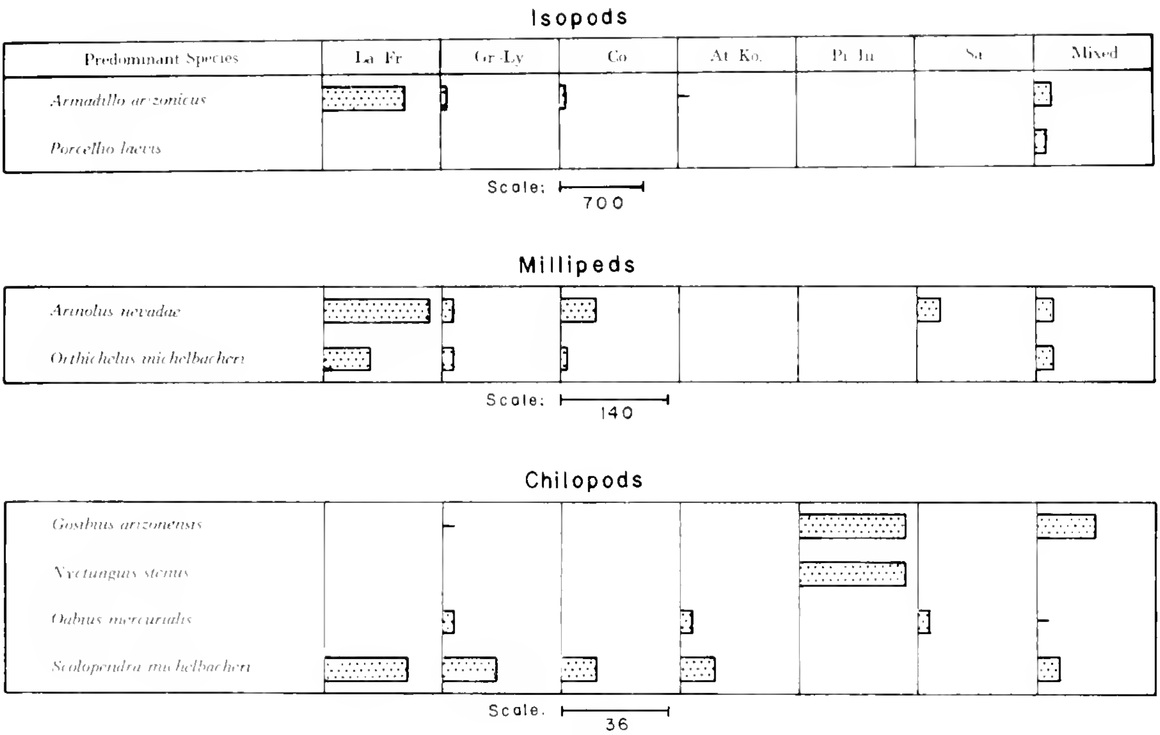


Fig. 27 Distribution by community and relative abundance of predominant species of isopods, millipeds, and chilopods.

GRASSHOPPERS AND CRICKETS

These animals were found in all six communities (Fig. 28). The greatest numbers of indidivuals were found in the Grayia-Lycium, Coleogyne, and Pinyon-Juniper communities, although the greatest number of species was found in the Coleogyne. *Acheta assimilis* and *Trimerotropis pallidipennis* were the most widely distributed of the more than 50 species collected. Seasonally, the occurrence of these animals varied with the species. As a group, grasshoppers and crickets were evident every month of the year. The majority of the species were most obvious during late summer and autumn (Fig. 29).

BEETLES

The darkling beetles (Tenebrionidae) were found in five communities (Fig. 30). They were most abundant in numbers of individuals in the Grayia-Lycium community. The greatest number of species was found in the Larrea-Franseria. Of the approximately 50 species known, *Eleodes obscura* was the most widely distributed. Darkling beetles were evident every

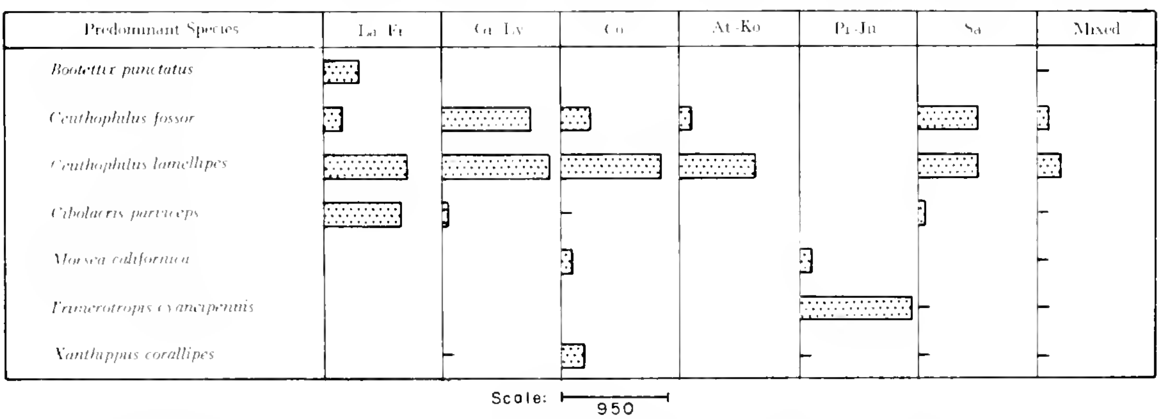


Fig. 28. Distribution by community and relative abundance of predominant species of grasshoppers and crickets.

month of the year, although individual species were restricted seasonally. The period when most species were obvious was late summer through early autumn (Fig. 31).

Ants

Ants were found in all communities, but were most abundant in numbers of individuals in the Grayia-Lycium and Pinyon-Juniper (Fig. 32). The greatest number of species was found in the latter community. Of the 53 species recorded, *Myrmecocystus mexicanus*, *Pogonomyrmex californicus*, and *Pheidole bicarinata* were the most widely distributed. Ants were evident from early spring to middle autumn, although

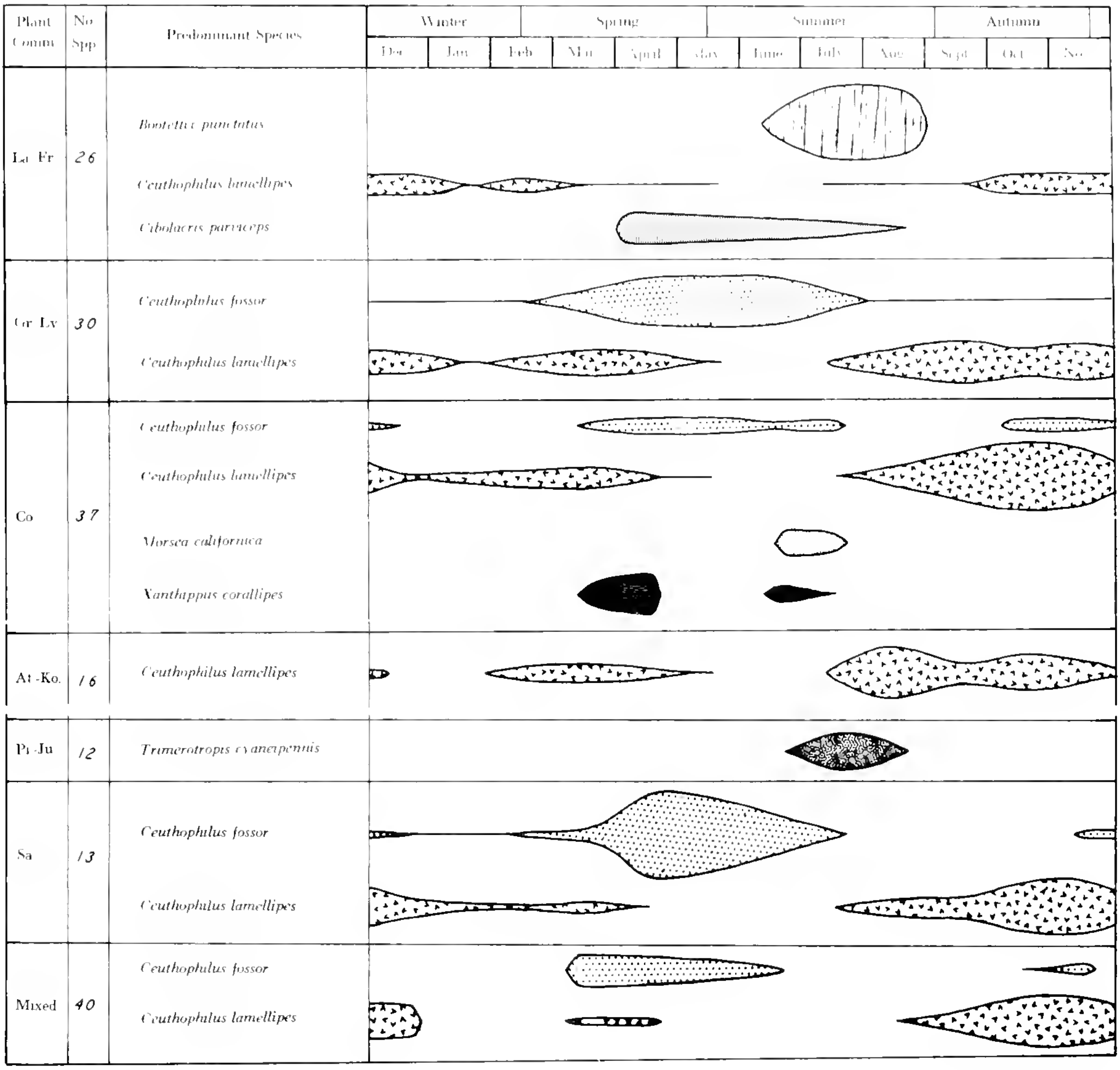


Fig. 29. Seasonal occurrence and relative abundance of predominant species of grasshoppers and crickets.

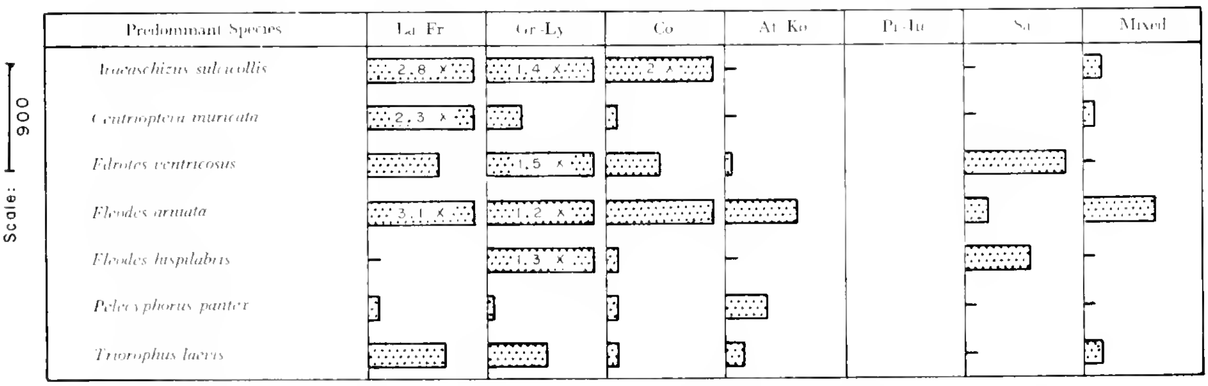


Fig. 30. Distribution by community and relative abundance of predominant species of darkling beetles.

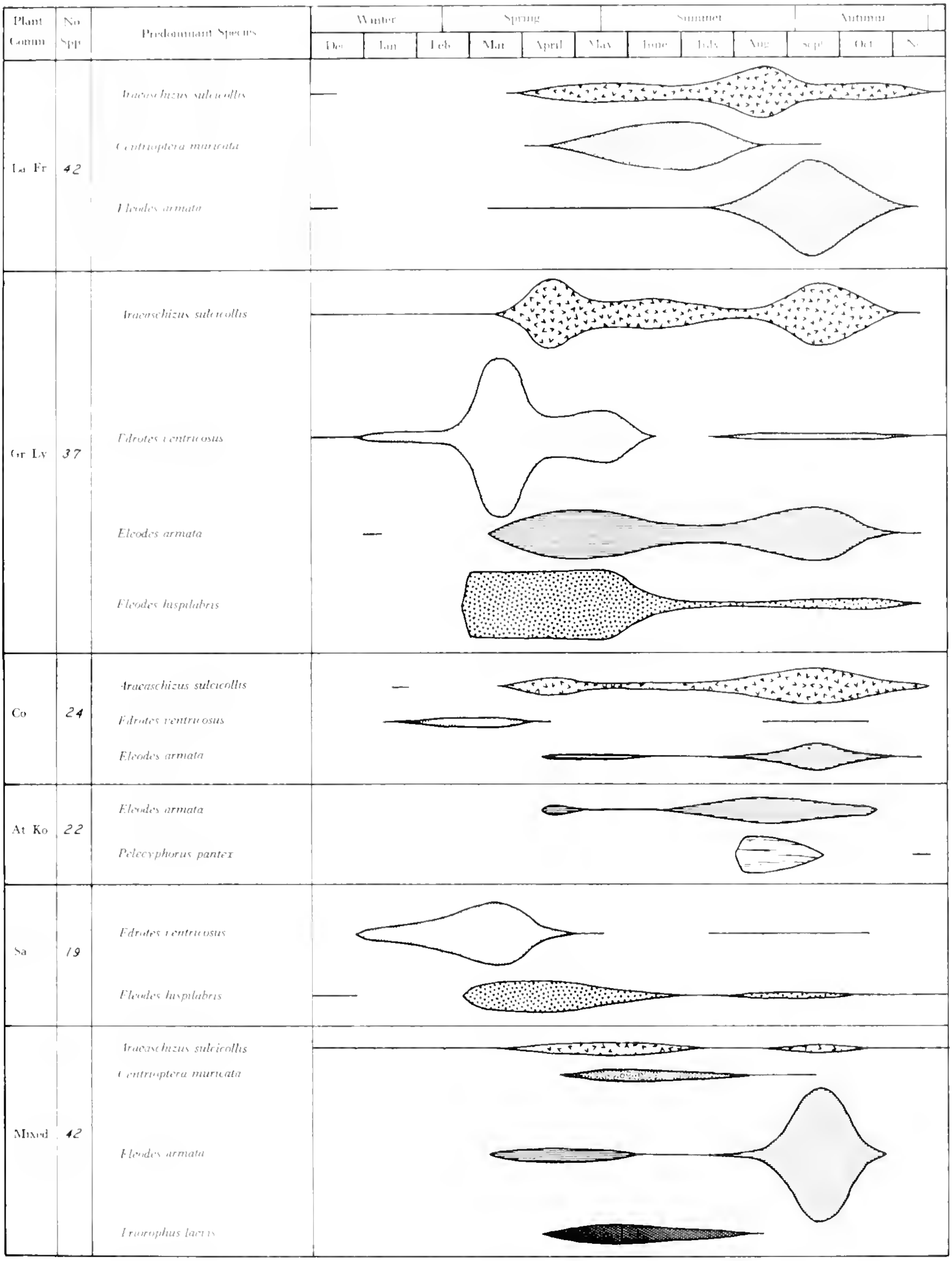


Fig. 31. Seasonal occurrence and relative abundance of predominant species of darkling beetles.

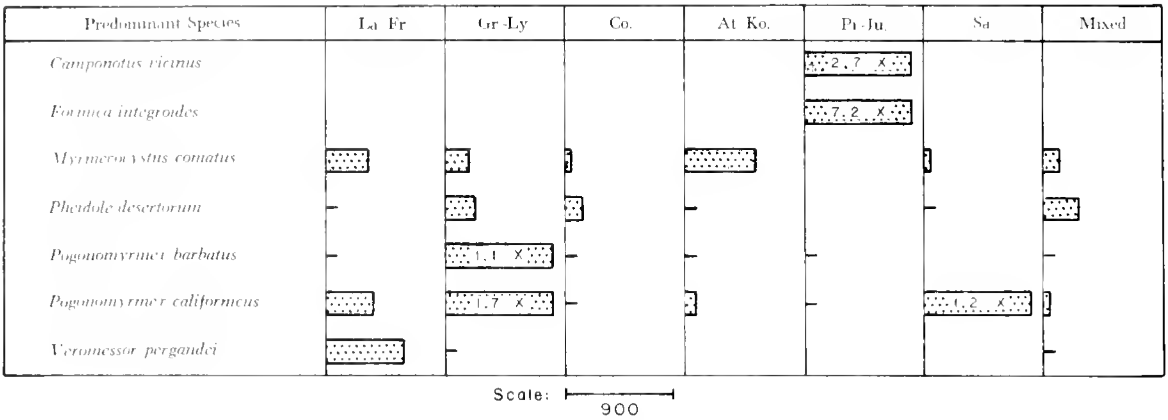


Fig. 32. Distribution by community and relative abundance of predominant species of ants.

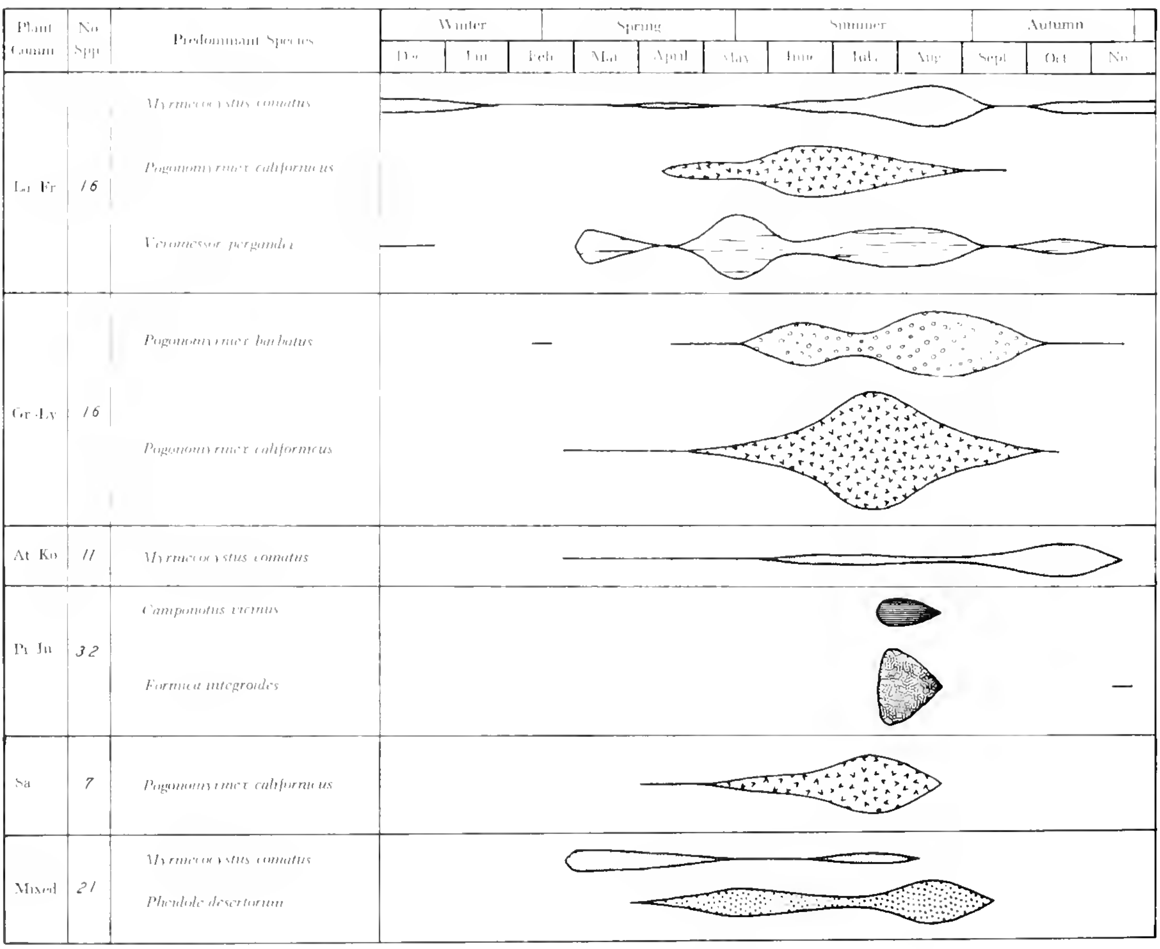


Fig. 33. Seasonal occurrence and relative abundance of predominant species of ants.

most species were more restricted seasonally (Fig. 33). *Myrmecocystus comatus* was obvious every month of the year.

CHILOPODS

The centipedes were found in small numbers in all six communities (Fig. 27). They were most abundant in numbers of individuals in the Pinyon-Juniper community, although the greatest number of species was found in the Grayia-Lycium. The most widely distributed of the five species was *Scolopendra michelbacheri*. Chilopods were obvious principally in the spring and summer (Fig. 34).

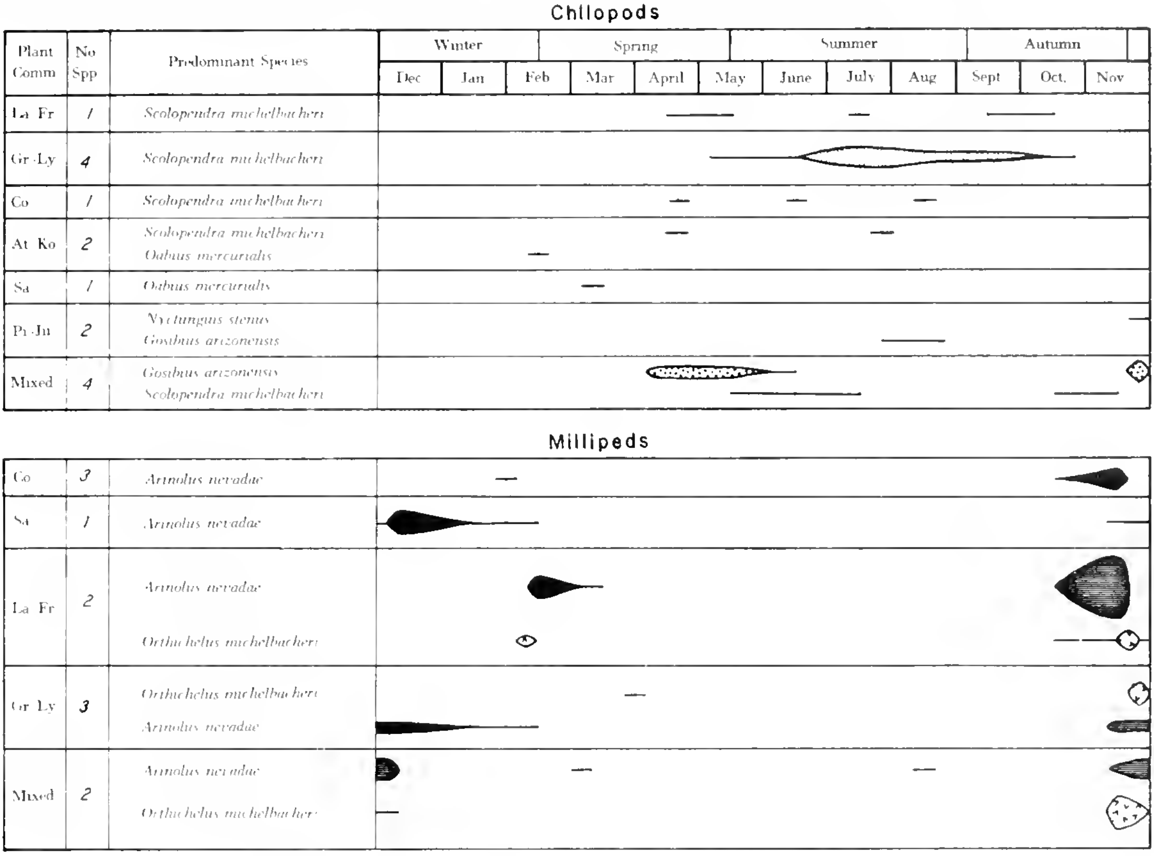


Fig. 34. Seasonal occurrence and relative abundance of predominant species of chilopods and millipeds.

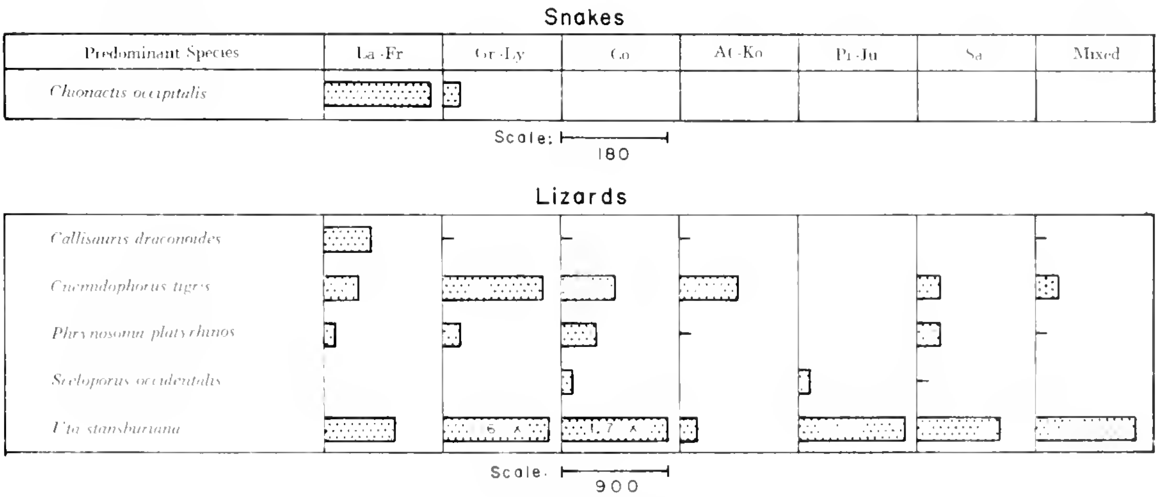


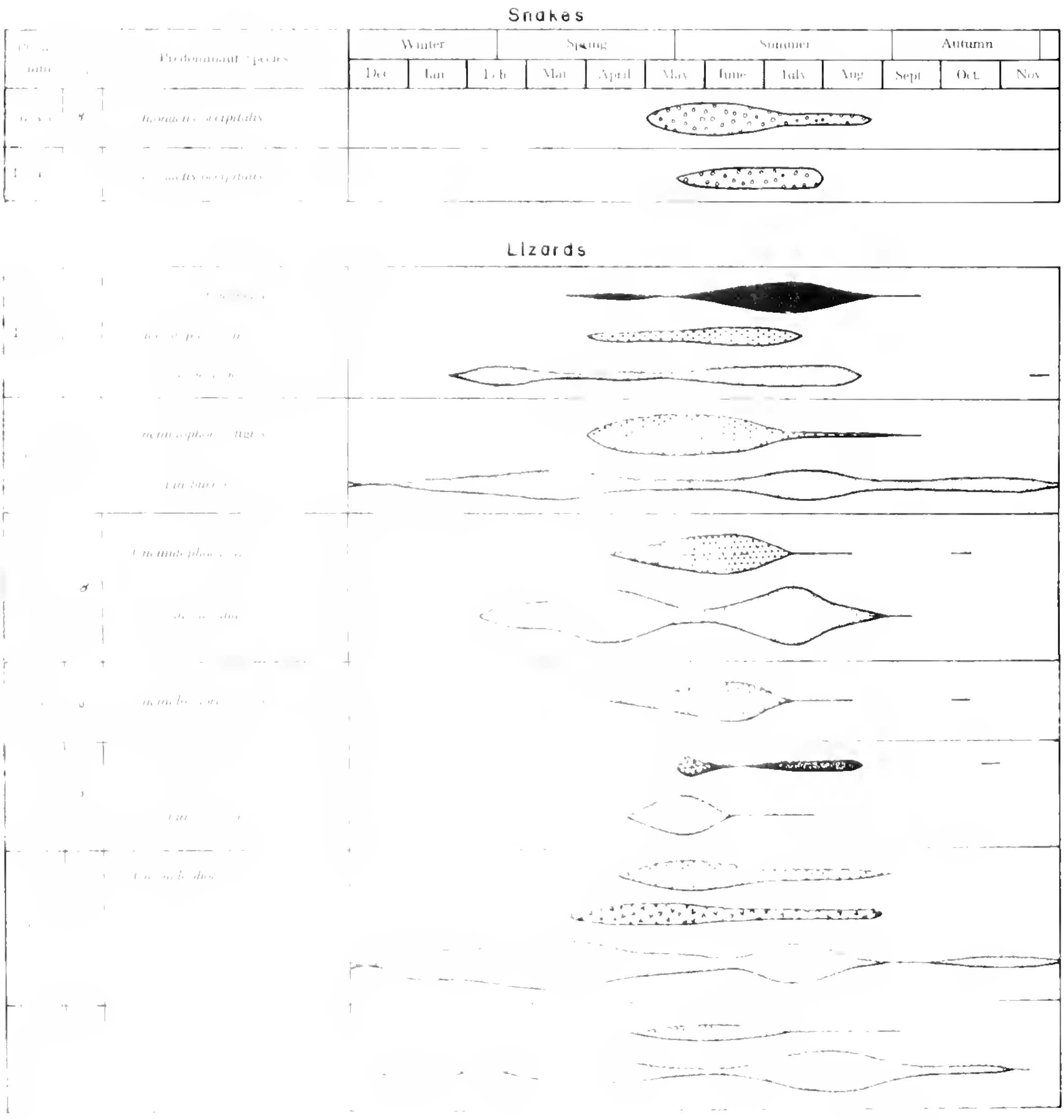
Fig. 35. Distribution by community and relative abundance of predominant species of snakes and lizards.

Millipedes

The [illegible] were not abundant at the [illegible] and were found in only four communities (Fig. 27). The most widely distributed of the four species was [illegible]. This and the other predominant species *Orthichelus* [illegible], were most abundant in the Larrea-Franseria community. The greatest number of species were found in the Grayia [illegible] and the Coleogyne communities. Millipedes were obvious principally during the winter months (Fig. 34).

Lizards

Lizards were found in all communities. No particular community supported greater numbers of individuals of this group as a whole than another, although certain species were more abundant in some communities than in others (Fig. 35). The greatest number of species was found in the Larrea-Franseria. The most widely distributed of the 13 species was the side blotched lizard, *Uta stansburiana*. Lizards as a group were evident principally from early spring to late summer, although *U. stansburiana* was active the year round (Fig. 36).



[illegible] of predominant species of snakes and lizards

SNAKES

They were found in only two communities (Fig. 35). Of the 16 kinds recorded, the greatest number of species was found in the Gravia-Lycium. The single predominant species, the shovel-nosed snake, *Chionactis occipitalis*, was most abundant in the Larrea-Franseria. This species was obvious during late spring and summer (Fig. 36).

BIRDS

Birds were widely distributed at the test site, although certain species were restricted in their distribution (Fig. 37). Nearly 200 species were recorded. They were most abundant in numbers of individuals in the Grayia-Lycium, although the greatest number of species was observed in the Pinyon-Juniper and Larrea-Franseria communities. The most widely distributed species were the black-throated sparrow, *Amphispiza bilineata;* house finch, *Carpodacus mexicanus;* red-tailed hawk, *Buteo jamaicensis;* common raven, *Corvus corax;* loggerhead shrike, *Lanius ludovicianus;* mockingbird, *Mimus polyglottis;* ash-throated flycatcher, *Myiarchus cinerascens*, and mourning dove, *Zenaidura macroura*. Different species of birds were present during different seasons due to their migratory habits (Fig. 38). House finches and horned larks were present all year round.

RABBITS

Although three species were collected, the black-tailed jack rabbit, *Lepus californicus*, was the only predominant one at the test site. The desert cottontail, *Sylvilagus audubonii*, was widely distributed however, and was found in abundance at Cane Springs and other localized situations. Jack rabbits were observed in all six communities, but were most evident in the Grayia-Lycium (Fig. 39). Seasonally they were most obvious during late winter, early spring, and early summer (Fig. 40).

RODENTS

These were the most abundant mammals at the test site and were common to all communities (Fig. 41). Highest populations of rodents as a group were found in the Larrea-Franseria. No single community supported significantly greater numbers of species than another. The most widely distributed of the 10 species was the white-tailed antelope squirrel, *Ammospermophilus leucurus*. Some species were more restricted to certain plant types and, subsequently, soil types, than to others. In the Larrea-Franseria community, *Dipodomys merriami*, *Peromyscus crinitus*, and *Perognathus formosus* were much more abundant in the more pure stands of these plants than where *Lycium* was abundant. This situation was reversed with reference to *D. microps*. In the Coleogyne community fewer *D. merriami* were found in the more pure stands of *Coleogyne* than where *Larrea* or *Artemisia* were associated with *Coleogyne*. Inversely, *D. microps* was most abundant where *Coleogyne* occurred in more pure stands. Most species were obvious the year round (Fig. 42).

CARNIVORES

Only two of the eight species of carnivores at the test site were considered predominant. The coyote, *Canis latrans*, and kit fox, *Vulpes macrotis* were observed in five of the communities (Fig. 39). The coyote ranged most widely. Both species were more frequently observed in the Larrea-Franseria than in other communities. They were most obvious during the winter and early spring (Fig. 43).

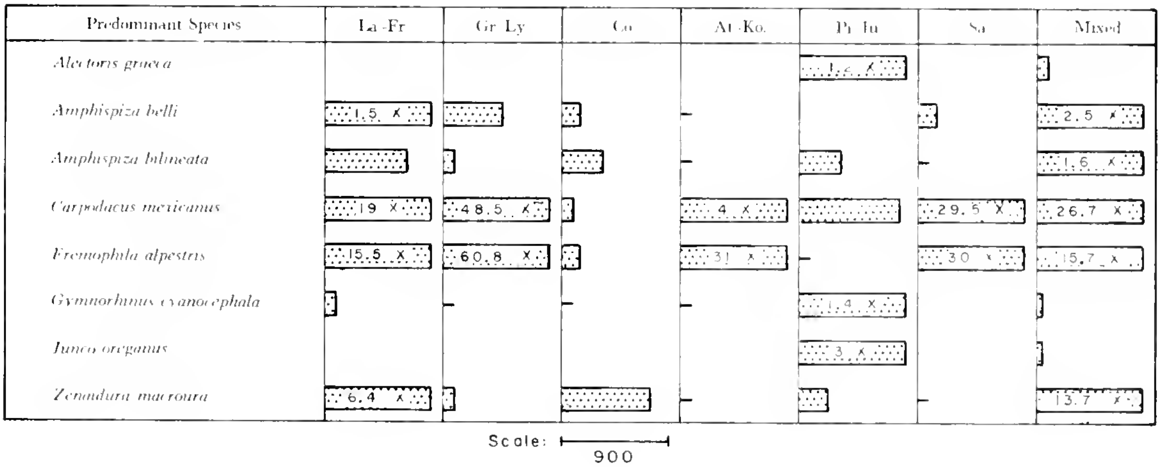


Fig. 37. Distribution by community and relative abundance of predominant species of birds

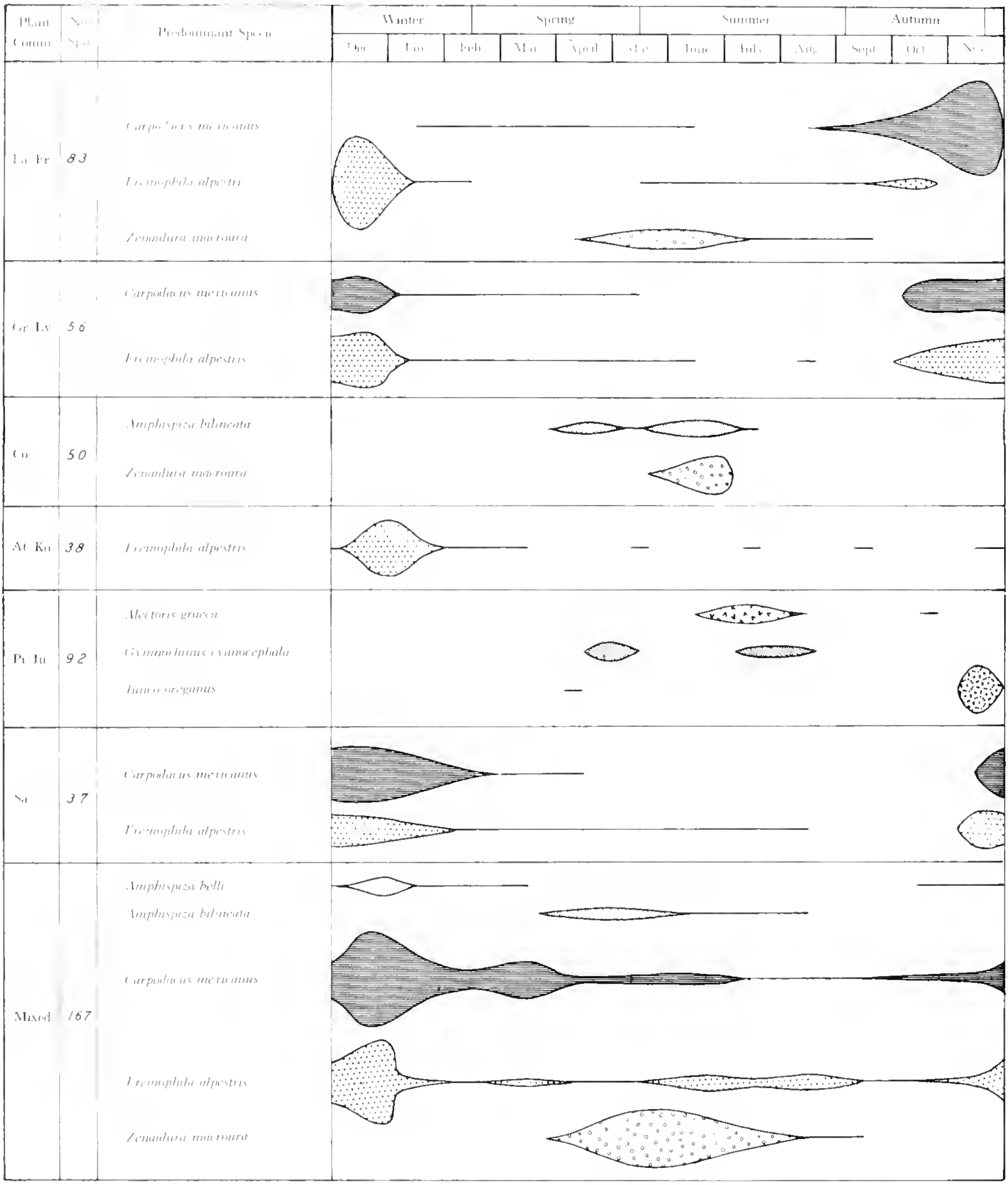


Fig. 38. Seasonal occurrence and relative abundance of predominant species of birds.

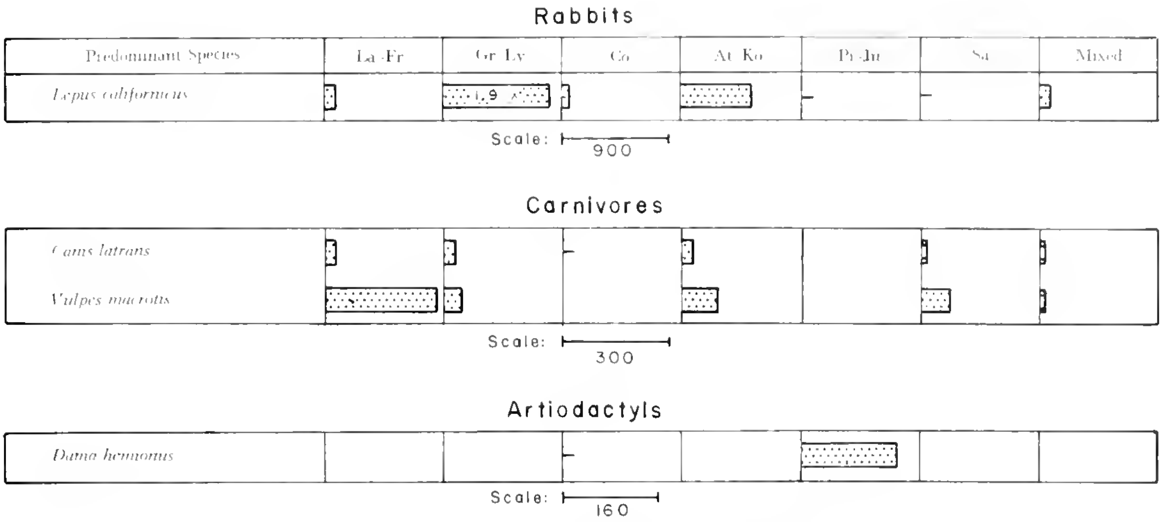


Fig. 39. Distribution by community and relative abundance of predominant species of rabbits, carnivores, and artiodactyls.

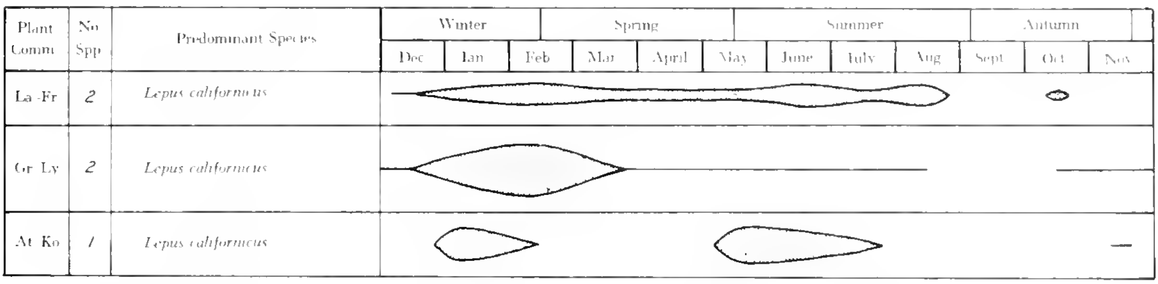


Fig. 40. Seasonal occurrence and relative abundance of predominant species of rabbits.

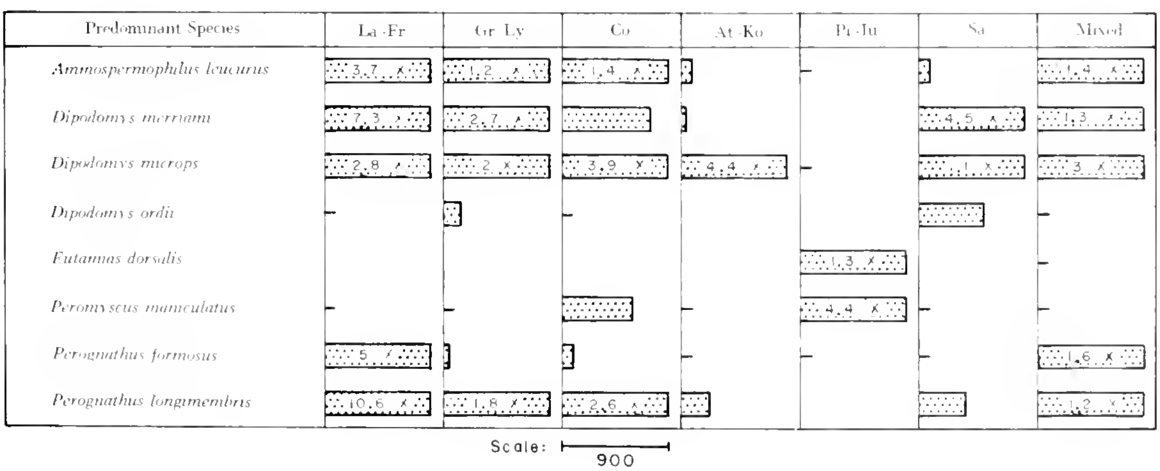


Fig. 41. Distribution by community and relative abundance of predominant species of rodents.

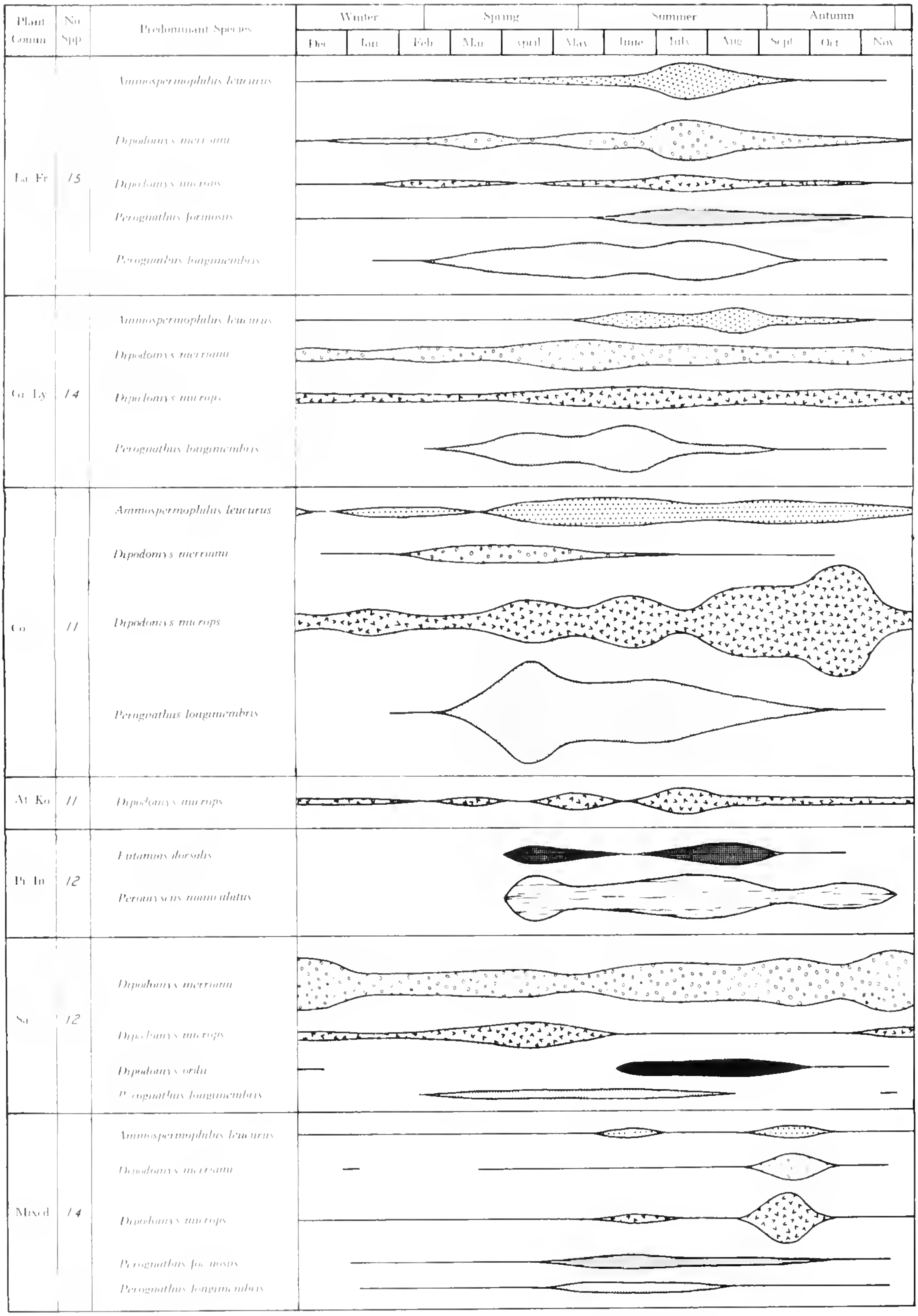


Fig. 12. Seasonal occurrence and relative abundance of predominant species of rodents.

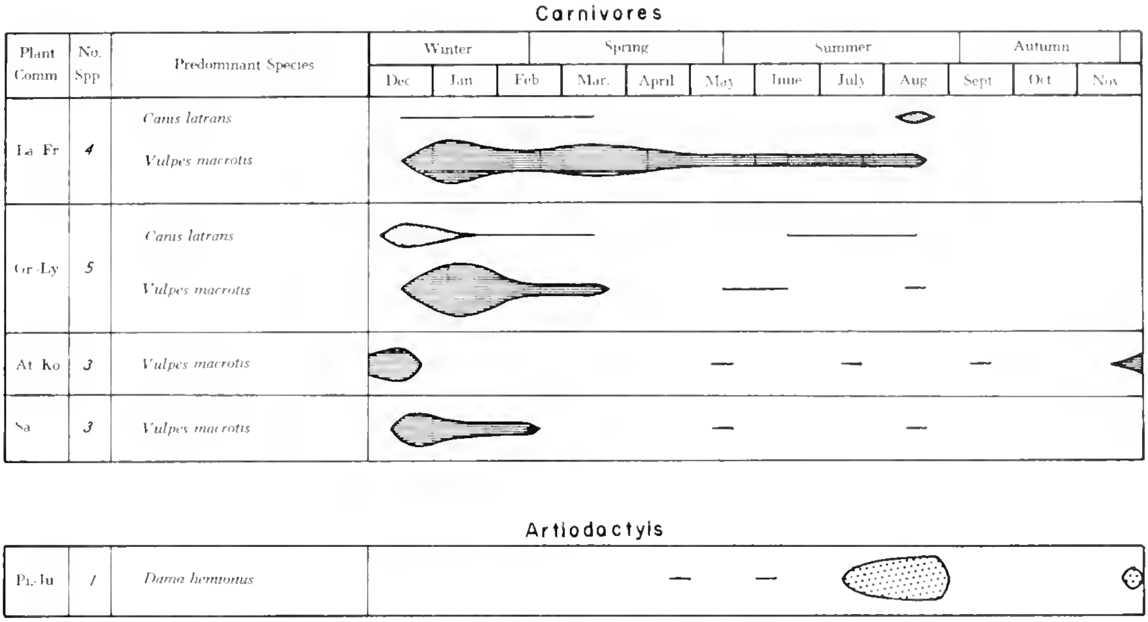


Fig. 43. Seasonal occurrence and relative abundance of predominant species of carnivores and artiodactyls.

ARTIODACTYLS

The mule deer, *Dama hemionus*, was the only member of this group that is abundant at the test site. It was observed principally in the Pinyon-Juniper community during the late summer (Figs. 39 and 43). A skeleton of a mountain sheep, *Ovis canadensis*, was found in the Spotted Mountain Range at the southeastern corner of the test site.

DISCUSSION

Relatively greater numbers of individuals were found in the Larrea-Franseria community than in others, although greater numbers of species of animals were found in the Grayia-Lycium community. Considerable collecting was done in all the communities during the three-year period, but more was done in the Grayia-Lycium community. As would be expected, more species were discovered there. The relative abundance of animals was determined by adjusting the actual numbers collected in each community in proportion to the total number of trap nights or collecting attempts in each community. Consequently, proportionately more individuals were found in the Larrea-Franseria community than in the others.

The number of species of certain groups found by us has been limited by the collecting techniques used in our studies. Our techniques were designed for generalized collection and were undoubtedly better for some animal groups than for others. A variety of specialized techniques would add many species to the list now known from our studies. This has been shown, in part, by the work of specialists in certain taxonomic groups, e.g. Andrew H. Barnum with grasshoppers and crickets, and Arthur C. Cole with ants. Special collecting by them during the relatively short time they spent at the test site added species which were not collected during the previous two-year period. In addition, it must be pointed out that even in our generalized collecting methods there were many animal groups taken that have not been taxonomically studied, for we have been unable to locate specialists to make such determinations. It can be expected that the number of species for the test site will be markedly added upon when the entire set of collections has been identified.

It is not feasible to employ specialists for all the taxonomic groups of animals which occur at the test site. Therefore, we have given emphasis only to those groups which occur abundantly in the desert habitat and for which specialists are available, or which lend themselves to collecting methods that can be utilized as part of our broad ecological investigation. These methods, however, have been adequate over the three-year period to reveal the predominant kinds of animals which occur at the test site, their relative abundance, and ecological and seasonal distribution. With these data as a basis further studies of a more detailed nature may be continued with individual groups of animals at the Nevada Test Site. As the total collections are finally classified, and as specialists use additional specialized techniques of collection, present analyses of data from our studies will need revision.

LITERATURE CITED

Allred, D. M. 1960. Comparative ecological studies of animals at the Nevada Test Site. 1959-1960. Annual progress report of Brigham Young University to U. S. Atomic Energy Commission.

Allred, D. M. 1961. Comparative ecological studies of animals at the Nevada Test Site. 1960-1961. Annual progress report of Brigham Young University to U. S. Atomic Energy Commission.

Allred, D. M. 1962a. Comparative ecological studies of animals at the Nevada Test Site. 1961-1962. Annual progress report of Brigham Young University to U. S. Atomic Energy Commission.

Allred, D. M. 1962b. Mites on squirrels at the Nevada atomic test site. J. Parasitol., (in press).

Allred, D. M. and D E. Beck. 1962. Ecological distribution of mites on lizards at the Nevada atomic test site. Herpetologica, 18(1):47-51.

Allred, D. M. and D E. Beck. 1963a. Comparative ecological studies of animals exposed to radiation at the Nevada Test Site. Proc. First Nat. Symposium on Radioecology, Ft. Collins, Colorado, 1961. Reinhold Publ. Corp., (in press).

Allred, D. M. and D E. Beck. 1963b. Ecological distribution of some rodents at the Nevada atomic test site. Ecology, (in press).

Allred, D. M., D E. Beck, and J. R. Murdock. 1960. Comparative ecological studies of animals exposed to nuclear detonation. (Abstr.). Proc. Utah Acad. Sci., Arts and Letters, 37:152-153.

Anonymous. 1961. Birds of the desert game range. U. S. Fish and Wildlife Service, Dept. of Interior, Publ. RL-132-R-2.

Banta, B. H. 1950. Record of *Xantusia vigilis* Baird from southern Nye Co., Nevada. Herpetologica, 6:34.

Banta, B. H. 1953. Some herpetological notes from southern Nevada. Herpetologica, 9:75-76.

Beatley, J. C. 1962. Vascular plants of the U. S. Atomic Energy Commission's Nevada Test Site, Nye County, Nevada. Univ. of California, Los Angeles, Publ. 508. Biol. and Med., TID-4500-17th Ed.

Bently, G. H. 1919. Reptiles collected in the vicinity of Current, Nye Co., Nevada. Copeia, 1919:87-91.

Burt, W. H. 1934. The mammals of southern Nevada. Trans. San Diego Soc. Nat. Hist., 7(36):375-428.

Chamberlin, R. V. 1962a. New records and species of chilopods from Nevada and Oregon. Entomol. News, 73:134-138.

Chamberlin, R. V. 1962b. Millipeds from the Nevada test area. Proc. Biol. Soc. Washington, 75:53-56.

Clokey, I. W. 1951. Flora of the Charleston mountains, Clark County, Nevada. Univ. of California Press, Berkeley; 274 pp.

Cole, A. C. 1963. A new species of *Veromessor* Forel from the Nevada Test Site and notes on related species. Ann. Entomol. Soc. Am., (in press).

Dice, L. R 1943. The Biotic provinces of North America. Univ. of Michigan Press, Ann Arbor; 78 pp.

Drouet, F. 1959. Algal flora of the Nevada Test Site. (Abstr.). J. Colorado-Wyoming Acad. Sci., 4(11):31.

Durrell, L. W. and L. M. Shields. 1960. Fungi isolated in culture from soils on the Nevada Test Site. Mycologia, 52(4):636-641.

Fautin, R. W. 1946. Biotic communities of the northern desert shrub biome in western Utah. Ecol. Monographs, 16:251-310.

Fisher, A. K. 1893. The Death Valley expedition. A biological survey of parts of California, Nevada, Arizona, and Utah. U.S.D.A. North American Fauna, No. 7. Part II. Report of the ornithology of the Death Valley expedition of 1891, comprising notes on the birds observed in southern California, southern Nevada, and parts of Arizona and Utah; pp. 7-158.

Fremont, J. C. 1845. Report of the exploring expeditions to the Rocky Mountains in the year 1842, and to Oregon and north California in the years 1843-1844. Washington, D. C.; 693 pp.

Goates, M. A. 1963. Parasitic mites of kangaroo rats of the Nevada atomic test site. Master's Thesis, Brigham Young University.

Gullion, G. W., W. M. Pulich and F. G. Evenden. 1959. Notes on the occurrence of birds in southern Nevada. Condor, 61(4): 278-297.

Hall, E. R. 1946. Mammals of Nevada. Univ. of California Press, Berkeley; 710 pp.

Hardy, R. 1945. The influence of types of soils upon local distribution of some mammals in southwestern Utah. Ecol. Monographs, 15:71-108.

Harrington, M. R. 1930. Archaeological explorations in southern Nevada. Southwest Museum Papers, No. 4; pp. 1-25.

Hayward, C. L., D E. Beck and W. W. Tanner. 1958. Zoology of the upper Colorado River basin. I The biotic communities. Brigham Young Univ. Sci. Bul., 1(3):1-74.

Henshaw, H. W. 1875. Report upon the ornithological collections made in portions of Nevada, Utah, California, Colorado, New Mexico, and Arizona, during the years 1871, 1872, 1873, and 1874. U. S. Geog. Surv. West of 100th Mer.; Chap. III; pp. 131-509

Henshaw, H. W. 1877. Report on the ornithology of portions of Nevada and California Ann. Rep. Geog. Surv. West 100th Mer., by George Wheeler for 1877; pp. 1303-1322.

Henshaw, H. W. 1880. Ornithological report from observations and collections made in portions of California, Nevada, and Oregon. Ann. Rep. Geog. Surv. West 100th Mer., by George Wheeler for 1879; pp. 282-335.

Hoffman, W. J. 1881. Annotated list of the birds of Nevada Bull. U. S. Geol. and Geog. Surv. Terr., 6(2):203-256.

Jaeger, E. C. 1927. Birds of the Charleston mountains of Nevada. Occas. Papers Riverside J. Coll., 2:1-8.

Jaeger, E. C. 1957. The North American deserts. Stanford Univ. Press. Stanford; 308 pp.

Johnson, M. S. and D. E. Hibbard. 1957. Geology of the Atomic Energy Commission Nevada proving grounds area. Nevada. U. S. Geo. Surv. Bull. 1021-K; pp. 333-384.

Jorgensen, C. D. 1962a. Disturbance of mammal traps by jack rabbits. Great Basin Naturalist, 22:83-86.

Jorgensen, C. D. 1962b. Spacial and time distribution of *Dipodomys microps occidentalis* Hall & Dale within distinct plant communities. Ecology, (in press).

Jorgensen, C. D. and A. M. Orton. 1962. Note of lizards feeding on oatmeal bait. Herpetologica. 17(4):278

Killpack, M. L. and M. A. Goates. 1963. Bat captured in snap trap. J. Mammal., (in press).

LaRivers, I. 1938. An annotated list of the Libelluloidea (Odonata) of southern Nevada. Pomona College J. Entomol. and Zool., 30(4):73-85.

LaRivers, I. 1942. Some new amphibian and reptile records for Nevada. Pomona College J. Entomol. and Zool., 34(3):53-68.

LaRivers, I. 1943. A list of the *Eleodes* of Nevada, with the description of a new subspecies (Coleoptera: Tenebrionidae). Pomona College J Entomol and Zool., 35 (4):53-61

LaRivers, I. 1948. A synopsis of Nevada Orthoptera. Am. Midland Naturalist, 39(3): 652-720.

Linsdale, J. M. 1936. The birds of Nevada. Pac. Coast Avifauna, Vol. 23; 145 pp.

Linsdale, J. M. 1940. Amphibians and reptiles in Nevada Proc. Am Acad. of Arts and Sci., 73(8):197-257.

Linsdale, J. M. 1951. A list of the birds of Nevada. Condor, 53(4):228-249.

Merriam, C. H. 1892. The geographic distribution of life in North America with special reference to the Mammalia. Proc. Biol. Soc. Wash., 7:1-64.

Merriam, C. H. 1893. The Death Valley expedition, a biological survey of parts of California, Nevada, Arizona, and Utah. U.S.D.A. North American Fauna, No. 7. Part II. Notes on the distribution of trees and shrubs in the deserts and desert ranges of southern California, southern Nevada, northwestern Arizona, and southwestern Utah; pp. 285-343.

Merriam, C. H. 1898. Life zones and crop zones of the United States. U.S.D.A. Div. Biol. Survey, Bull. 10; pp. 1-79.

Munz, P. A. and D. D. Keck. 1959. The California Flora. Univ. of California Press, Berkeley; 1681 pp.

Murbarger, N. 1956. Ghosts of the glory trail. Desert Magazine Press, Palm Desert, California; 291 pp.

Nelson, E. W. 1875. Notes on birds observed in portions of Utah, Nevada and California. Proc. Boston Soc. Nat. Hist., 17:338-365.

Packham, W. A. 1963. A systematic and ecological study of the darkling beetles of the Nevada Test Site. Masters Thesis, Brigham Young University.

Palmer, T. S. 1893. The Death Valley expedition. A biological survey of parts of California, Nevada, Arizona, and Utah. U.S.D.A. North American Fauna, No. 7. Part II. List of localities visited by the Death Valley expedition; pp. 361-384.

Rehn, J. A. G. 1924. The land of sagebrush and juniper; an account of part of the work of the Nevada-Arizona expedition of 1924 Yearbook (1924). Acad. Nat. Sci. Phila.; pp. 56-67.

Richards, G. 1962. Wintering habits of some birds at the Nevada atomic test site. Great Basin Naturalist, 22:30-31.

Rickard, W. H. 1959. Gross vegetation patterns within the Nevada test site. (Abstr.) J. Colorado-Wyoming Acad. Sci., 4(11):32.

Rickard, W. H. 1961. Notes on bird nests found in a desert shrub community following nuclear detonations. Condor, 63:265-266.

Rickard, W. H. 1963. Vegetational analysis in a creosote bush community and their radiologic implications. Proc. First Nat. Symposium on Radioecology, Ft. Collins, Colorado, 1961. Reinhold Publ. Corp., (in press).

Rickard, W. H. and J. R. Murdock. 1963. Soil temperature and moisture and the distribution of desert communities in southern Nevada. Ecology (submitted for review).

Ridgway, R. 1877. United States geological exploration of the fortieth parallel, by Clarence King. Part III. Ornithology: pp. 303-669.

Shelford, V. E. 1945. The relative merits of the life zone and biome concepts. Wilson Bull., 57:248-252.

Shields, L. M. 1958. A botanical study of nuclear effects at the Nevada Test Site, 1957. Annual report of New Mexico Highlands University to U. S. Atomic Energy Commission.

Shields, L. M. 1959a. An appraisal of radiation effects on vegetation within the Nevada test site. (Abstr.). Proc. 9th Internat. Bot. Cong., 2(A):33.

Shields, L. M. 1959b. Recovery of vegetation in the vicinity of ground zero sites. (Abstr.) J. Colorado-Wyoming Acad. Sci., 4(11):30-31.

Shields, L. M., and W. H. Rickard. 1960. A botanical study of nuclear effects at the Nevada Test Site, 1959. Annual report of New Mexico Highlands University to U. S. Atomic Energy Commission.

Shields, L. M. and P. V. Wells. 1962. Effects of nuclear testing on desert vegetation. Science, 135(3497):38-40.

Shields, L. M. and P. V. Wells. 1963. Recovery of vegetation in the vicinity of atomic target areas at the Nevada test site. Proc. First Nat. Symposium on Radioecology, Ft. Collins, Colorado, 1961. Reinhold Publ. Corp., (in press).

Shields, L. M., W. H. Rickard, and F. Drouet. 1959. A botanical study of nuclear effects at the Nevada Test Site, 1958. Annual report of New Mexico Highlands University to U. S. Atomic Energy Commission.

Shields, L. M., L. W. Durrell, and A. H. Sparrow. 1961. Preliminary observations of radiosensitivity of algae and fungi from soils of the Nevada test site. Ecology, 42 (2):440-441.

Shreve, F. 1951. Vegetation of the sonoran desert, Vol. 1. Carnegie Inst. Wash., Publ. 591; 192 pp.

Stejneger, L. 1893. The Death Valley expedition, a biological survey of parts of California, Nevada, Arizona, and Utah. U.S.D.A. North American Fauna, No. 7. Part II. Annotated list of the reptiles and batrachians collected by the Death Valley expedition in 1891, with descriptions of new species; pp. 159-228.

Tanner, V. M. 1940. A chapter in the natural history of the Great Basin, 1800 to 1855. Great Basin Naturalist, 1(2):33-61.

Tidestrom, I. 1925. Flora of Utah and Nevada. Contr. U. S. Nat. Herb., Vol. 25.

Van Denburgh, J. and J. R. Slevin. 1921. A list of the amphibians and reptiles of Nevada, with notes on the species in the collection of the academy. Proc. Calif. Acad. Sci., Ser. 4, 11(2):27-38.

Van Rossem, A. J. 1936. Birds of the Charleston mountains, Nevada. Pac. Coast Avifauna, Vol. 24; 65 pp.

Weedfall, R. O. 1962. Forecasting thunderstorms in southern Nevada. Report of the U. S. Weath. Bur. Res. Sta., Las Vegas, Nevada, to U. S. Atomic Energy Commission.

White, L. D. and D. M. Allred. 1961. Range of kangaroo rats in areas affected by atomic detonations. Proc. Utah Acad. Sci., Arts and Letters, 38:101-110.

White, L. D. 1962. Concrete molds of rodent burrows. J. Mammal., 43:265.

Yarrow, H. C. 1875. Report upon the collections of batrachians and reptiles made in portions of Nevada, Utah, California, Colorado, New Mexico, and Arizona, during the years 1871, 1872, 1873, and 1874. U. S. Geog. Surv. West of 100th Mer., Chap IV; pp. 509-633.

Yarrow, H. C. and H. W. Henshaw. 1878. Report upon the reptiles and batrachians collected during the years of 1875, 1876, and 1877, in California, Arizona, and Nevada. Ann. Rept. Geog. Surv. West 100th Mer. for 1878; pp. 206-226.

APPENDIX I

SOME COMMON PLANTS OF THE MAJOR COMMUNITIES AND OTHER HABITATS
(Species names follow Munz and Keck, and Beatley)
(La-Fr = Larrea-Franseria, Gr-Ly = Grayia-Lycium, Co = Coleogyne, At-Ko = Atriplex-Kochia, Sa = Salsola, Pi-Ju = Pinyon-Juniper, Mt = Mountains, Spr = Springs)

Species	La-Fr	Gr-Ly	Co	At-Ko	Sa	Pi-Ju	Mt	Spr
Acamptopappus schockleyi		X	X					
Agave utahensis							X	
Agrostis semiverticillata								X
Amaranthus albus								X
Amelanchier utahensis						X		
Amsinckia tessellata	X	X	X		X			
Artemisia spinescens	X	X	X	X				
Artemisia tridentata		X	X			X	X	
Atriplex canescens	X	X		X				X
Atriplex confertifolia	X	X	X	X			X	
Berula erecta								X
Bromus rubens	X	X	X		X		X	X
Carex sp.								X
Cercocarpus intricatus							X	X
Cercocarpus ledifolius						X		
Chaenactis stevioides		X	X		X			
Chara sp.								X
Chrysothamnus nauseosus							X	
Chrysothamnus spp.								X
Chrysothamnus viscidiflorus	X	X	X			X	X	X
Cleome lutea								X
Coleogyne ramosissima	X	X	X			X	X	
Cowania mexicana							X	X
Cowania stansburiana						X		
Cryptantha circumscissa	X				X			
Cryptantha pterocarya					X			
Dalea fremontii	X						X	
Dalea polyadenia	X							
Echinocactus polycephalus							X	
Elymus sp.								X
Ephedra funerea	X							
Ephedra nevadensis	X	X	X				X	
Ephedra torreyana	X						X	
Ephedra viridis						X	X	
Eriogonum spp.	X	X	X		X	X	X	
Eurotia lanata	X	X	X	X				
Fallugia paradoxa							X	
Franseria dumosa	X							
Franseria eriocentra	X							
Grayia spinosa	X	X	X					
Haplopappus cooperi	X	X	X					
Heleocharis parishii								X
Hordeum stebbinsii								X
Hymenoclea salsola	X	X	X				X	
Juncus balticus								X
Juniperus osteosperma			X			X		
Kochia americana		X		X				
Krameria parvifolia	X	X						

Species	La-Fr	Gr-Ly	Co	At-Ko	Sa	Pi-Ju	Mt	Spr
Larrea divaricata	X	X	X				X	
Lepidium fremontii	X							
Lycium andersonii	X	X	X				X	
Lycium pallidum	X							
Lycium richardii	X							
Menodora spinescens	X	X	X					
Mentzelia albicaulis	X				X			
Mimulus guttatus								X
Mirabilis bigelovii							X	
Mirabilis pudica	X				X			
Nicotiana spp.							X	
Oenothera megalantha								X
Opuntia basilaris	X						X	
Opuntia echinocarpa	X							
Opuntia erinacea	X						X	
Oryzopsis hymenoides	X	X	X		X			
Petalonyx nitidus							X	
Pinus monophylla						X		
Polypogon interruptus								X
Polypogon monspeliensis								X
Prunus fasciculata						X	X	X
Purshia glandulosa							X	X
Purshia tridentata						X	X	X
Quercus gambelii						X	X	X
Rumex crispus								X
Rumex salicifolius								X
Salazaria mexicana	X		X					
Salix gooddingii								X
Salsola kali					X			
Salvia dorii	X					X	X	
Sitanion hansenii		X	X					
Stanleya pinnata	X							
Stipa comata						X		
Stipa speciosa		X	X			X		
Suaeda torreyana								X
Symphoricarpos longiflorus						X	X	X
Tamarix pentandra								X
Tetradymia glabrata		X	X					
Tetradymia axillaris	X	X	X					
Thamnosma montana							X	
Typha domingensis								X
Verbena bracteata								X
Veronica anagallis-aquatica								X
Yucca brevifolia	X	X	X					
Yucca schidigera	X						X	

APPENDIX II

Check List of Animals at the Nevada Test Site, Showing Their Known Distribution by Community and Other Areas

Species and family names which follow have been recommended by each specialist dealing with a taxonomic group. Subspecific names are omitted here, but will be included, where appropriate, in subsequent monographic papers dealing with each of the groups.

Code letters for the plant communities and areas are: La-Fr = Larrea-Franseria, Gr-Ly = Gravia-Lycium, Co = Coleogyne, At-Ko = Atriplex-Kochia, Sa = Salsola, Pi-Ju = Pinyon-Juniper, CS = Cane Springs; Other = other miscellaneous areas not classified to community.

Species	Plant Community or Locality							
	La-Fr	Gr-Ly	Co	At-Ko	Sa	Pi-Ju	CS	Other
SCORPIONS								
Vejovidae								
Anuroctonus phaeodactylus		X	X	X				X
Hadrurus hirsutus	X	X	X		X			X
Vejovis boreus	X	X	X			X		
Vejovis confusus	X	X	X	X	X	X		X
Vejovis hirsuticauda	X							X
Vejovis wupatkiensis	X	X			X			X
Vejovis n. sp.	X	X	X	X	X			X
Chactidae								
Superstitionia donensis		X						X
SPIDERS								
Ctenizidae								
Aptostichus n. sp.								X
Theraphosidae								
Aphonopelma n. sp.								X
Filistatidae								
Filistata utahana		X		X				X
Filistata n. sp.								X
Uloboridae								
Uloborus diversus			X					
Dictynidae								
Dictyna calcarata								X
Dictyna reticulata								X
Mallos mians								X
Caponiidae								
Orthonops gertschi	X	X	X					X
Tarsonops sp.								X
Diguetidae								
Diguetia canities			X					
Diguetia signata	X							
Loxoscelidae								
Loxosceles unicolor			X					X
Plectreuridae								
Kibramoa paiuta								X
Plectreurys tristis	X		X					X
Heteropodidae								
Olios fasciculatus				X				
Thomisidae								
Ebo mexicanus		X						

Species	Plant Community or Locality							
	La-Fr	Gr-Ly	Co	At-Ko	Sa	Pi-Ju	CS	Other
Ebo n. sp.								X
Ebo sp. A								X
Ebo sp. B								X
Ebo sp. C								X
Misumenops n. sp.	X							X
Thanatus texanus	X	X						X
Xysticus californicus		X						
Xysticus lassanus	X	X	X					X
Xysticus n. sp.								X
CLUBIONIDAE								
Anyphaena sp.								X
Castianeira descripta		X						
Corinna bicalcarata	X	X						
Micaria gosiuta		X		X				
Micaria n. sp. 1								X
Micaria n. sp. 2								X
Micaria n. sp. 3								X
Micaria n. sp. 4								X
Neoanagraphis chamberlini	X	X	X	X	X			X
Syspira eclectica	X	X	X	X		X		X
GNAPHOSIDAE								
Cesonia classica	X	X	X					X
Drassodes celes				X				
Drassyllus fractus								X
Drassyllus irritans	X	X		X		X		X
Drassyllus moronius		X			X			X
Gnaphosa californica			X	X				X
Gnaphosa hirsutipes	X	X	X	X	X	X		X
Haplodrassus eunis	X	X	X	X	X			X
Herpyllus hesperolus	X	X	X	X	X			X
Megamyrmecion naturalisticum	X		X					X
Nodocion utus		X		X				
Zelotes monachus		X	X					X
Zelotes mannodes				X				
Zelotes puritanus				X				
HOMALONYCHIDAE								
Homalonychus theologus								X
PHOLCIDAE								
Physocyclus tanneri								X
Psilochorus utahensis	X	X	X	X	X	X		X
THERIDIIDAE								
Enoplognatha joshua	X	X	X	X	X			X
Euryopis spinigerus	X							
Latrodectus mactans	X	X		X	X			X
Steatoda fulva		X			X			
Steatoda pulchra		X						
Steatoda washona			X					
MIMETIDAE								
Mimetus eutypus								X
ARGIOPIDAE								
Metepeira gosoga	X	X	X					X
LINYPHIIDAE								
Ceraticelus sp. (nr. *nesiotes*)								X
Cochlembolus sanctus			X					
Erigone dentosa								X
Meioneta formica	X							
Meioneta sp. (nr. *fratrella*)								X
Spirembolus sp.								X

	Plant Community or Locality							
	La-Fr	Gr-Ly	Co	At-Ko	Sa	Pi-Ju	CS	Other
AGELENIDAE								
Agelenopsis aperta		X						X
Calilena restricta		X		X				X
Cicurina utahana						X		
OXYOPIDAE								
Oxyopes n. sp.								X
LYCOSIDAE								
Alopecosa kochi	X	X	X	X		X		X
Geolycosa rafaelana	X	X						
Pardosa ramulosa								X
Schizocosa sp.								X
Tarentula kochi	X	X	X	X		X		X
SALTICIDAE								
Metacyrba arizonensis	X	X	X	X	X			X
Metacyrba taeniola		X						
Metaphidippus n. sp. 1								X
Metaphidippus n. sp. 2								X
Pelenes hirsutus			X					
Pellenes n. sp. 1								X
Pellenes n. sp. 2								X
Pellenes n. sp. 3								X
Phidippus apacheanus		X						
Phidippus formosus		X	X					X
Phidippus opifex				X				
SOLPUGIDS								
EREMOBATIDAE								
Chanbria sp.								X
Eremobates ctenidiellus		X						
Eremobates mormonus	X			X				
Eremobates scopulatus	X	X	X			X		X
Eremobates similis		X						
Eremobates zinni		X		X		X		X
Eremobates n. sp.								X
Eremorhax titania	X	X						
Eremorhax n. sp.		X						
Hemerotrecha bidepressa		X						
Hemerotrecha branchi		X						
Hemerotrecha californica	X	X	X	X				X
Hemerotrecha denticulata		X				X		
Hemerotrecha fruitana		X						
Hemerotrecha serrata	X	X	X	X		X		X
Hemerotrecha n. sp. 1								X
Hemerotrecha n. sp. 2								X
Horribates sp.								X
Therobates arcellus	X	X	X	X		X		X
Therobates arcus								X
Therobates branchi		X						
Therobates cameronensis	X	X	X	X				
Therobates plicatus	X	X						
Therobates n. sp. 1								X
Therobates n. sp. 2								X
Therobates n. sp. 3								X
Therobates n. sp. 4								X
AMMOTRECHIDAE								
Ammotrechula pilosa		X						X
Ammotrechula n. sp. 1								X
Ammotrechula n. sp. 2								X
Branchia potens	X	X	X					X

Species	La-Fr	Gr-Ly	Plant Community or Locality Co	At-Ko	Sa	Pi-Ju	CS	Other
PHALANGIDS								
PHALANGIIDAE								
Globipes spinulatus	X	X	X	X	X			X
MITES								
IXODORHYNCHIDAE								
Ixodorhynchus sp.		X						
HAEMOGAMASIDAE								
Ischyropoda armatus		X	X					X
DERMANYSSIDAE								
Hirstionyssus triacanthus		X						
Ornithonyssus n. sp.	X	X	X					X
AMEROSEIIDAE								
Kleemania sp.		X	X					X
LAELAPTIDAE								
Haemolaelaps glasgowi	X	X	X					X
Haemolaelaps n. sp.		X						X
Hypoaspis leviculus		X	X		X			X
PTERYGOSOMIDAE								
Geckobiella texana		X	X			X		X
TROMBICULIDAE								
Euschöngastia decipiens		X	X		X			X
Euschöngastia radfordi			X	X	X			
Euschöngastia n. sp.		X	X					X
Odontacarus arizonensis	X	X	X					X
Odontacarus linsdalei	X	X	X		X			X
Odontacarus micheneri						X		
Trombicula arenicola	X	X	X	X				X
Trombicula belkini		X	X	X				
Trombicula jessimae	X							
New genus, n. sp.	X	X	X					X
LISTROPHORIDAE								
Listrophorus dipodomys	X	X	X		X	X		
ISOPODS								
PORCELLIONIDAE								
Porcellio laevis								X
ARMADILLIDAE								
Armadillo arizonicus	X	X	X	X				X
MAYFLIES								
BAETIDAE								
Callibaetis sp.								X
CADDICE FLIES								
LIMNEPHILIDAE								
Limnephilus sp.								X
GRASSHOPPERS, CRICKETS, AND RELATIVES								
EUMASTACIDAE								
Morsea californica			X			X		X
TANAOCERIDAE								
Tanaocerus koebelei	X		X			X	X	X
ACRIDIDAE								
Aeoloplides minor	X	X	X	X			X	X
Aeoloplides tenuipennis	X	X		X	X		X	X
Ageneotettix deorum			X					X
Amphitornus coloradus			X				X	X

Species	Plant Community or Locality La-Fr	Gr-Ly	Co	At-Ko	Sa	Pi-Ju	CS	Other
Anconia integra	X	X		X				
Arphia conspersa								X
Bootettix punctatus	X							X
Cibolacris parviceps	X	X	X		X			X
Cordillacris occipitalis		X	X		X	X		X
Derotmema delicatulum	X	X		X				X
Dracotettix plutonius			X					
Eremiacris pallida	X	X	X				X	X
Hesperotettix viridis		X	X					X
Leprus glaucipennis			X					X
Ligurotettix coquilletti	X	X	X					X
Melanoplus aridus	X		X					X
Melanoplus complanatipes			X				X	X
Mestobregma impexum								X
Poecilotettix sanguineus		X					X	X
Psoloessa delicatula		X	X	X		X		X
Trimerotropis albescens		X	X		X			X
Trimerotropis bilobata				X				
Trimerotropis cyaneipennis					X	X		X
Trimerotropis fontana			X					
Trimerotropis inconspicua	X	X	X				X	X
Trimerotropis pallidipennis	X	X	X	X	X		X	X
Trimerotropis sparsa				X				
Trimerotropis strenua	X	X	X		X			X
Tytthotyle maculata	X		X					X
Xanthippus corallipes		X	X		X	X		X
Tettigoniidae								
Anoplodusa arizonensis	X	X	X			X		
Arethaea brevicauda								X
Atelopus lutens	X	X	X	X				X
Capnobotes fuliginosus	X	X	X				X	X
Capnobotes occidentalis						X		X
Insara covilleae	X		X					X
Insara elegans			X					
Gryllacrididae								
Ceuthophilus fossor	X	X	X	X	X			X
Ceuthophilus hebardi						X		
Ceuthophilus lamellipes	X	X	X	X	X			X
Ceuthophilus n. sp. 1		X	X	X	X			X
Ceuthophilus n. sp. 2						X		X
Pristoceuthophilus pacificus						X		X
Stenopelmatus fuscus		X	X		X	X		X
Gryllidae								
Acheta assimilis	X	X	X	X	X		X	X
Cycloptilum comprehendens								X
Myrmecophila manni		X				X		
Oecanthus californicus							X	X
Oecanthus nigricornis							X	
Phasmatidae								
Parabacillus hesperus			X					
Pseudosermyle straminea		X	X				X	
Mantidae								
Litaneutria minor	X	X	X	X	X		X	X
Stagmomantis californicus	X		X				X	X
Polyphagidae								
Arenivaga apacha	X	X	X	X				X
Arenivaga erratica	X	X	X	X	X			X
Eremoblatta subdiaphana	X	X	X	X				X

Species	Plant Community or Locality La-Fr	Gr-Ly	Co	At-Ko	Sa	Pi-Ju	CS	Other
BEETLES								
MELOIDAE								
Cystcodemus armatus	X							
TENEBRIONIDAE								
Alaephus sp.								X
Anemia californica	X							
Anepsius sp. (nr. *brunneus*)		X						
Araeoschizus sulcicollis	X	X	X	X	X			X
Auchmobius sp.								X
Blapstinus n. sp. 1								X
Blapstinus n. sp. 2								X
Centrioptera muricata	X	X	X	X	X			X
Chilometopon abnorme	X	X	X		X			X
Coelocnemis sp.								X
Conibiosoma elongatum	X	X	X	X	X			X
Coniontellus argutus								X
Coniontis sp.								X
Cryptoglossa verrucosa	X		X	X				X
Discodemus sp. (nr. *knausi*)								X
Edrotes ventricosus	X	X	X	X	X			X
Eleodes armata	X	X	X	X	X			X
Eleodes brunnipes						X		
Eleodes concinna						X		
Eleodes dissimilis	X	X				X		
Eleodes grandicollis	X	X	X	X	X			X
Eleodes hispilabris	X	X	X	X	X			X
Eleodes longicollis		X	X		X			X
Eleodes longipilosa	X	X			X			
Eleodes nigrina						X		
Eleodes obscura	X	X	X	X	X	X		X
Eleodes omissa	X	X	X		X	X		X
Eleodes striatipennis								X
Eleodes tenebrosa						X		
Eleodes sp. (nr. *californica*)								X
Embaphion elongatum						X		
Eschatomoxys wagneri								X
Eupsophulus castaneus	X	X						X
Eusattus dubius	X	X						X
Euschides luctatus	X	X	X	X				X
Helops attenuatus	X	X	X	X	X			X
Hylocrinus n. sp.								X
Lobometopon sp.								X
Metopoloba bifossiceps		X	X					X
Metoponium abnorme	X							
Metoponium sp. (nr. *convexicollis*)								X
Notibius substriatus	X	X		X	X			X
Pelecyphorus actuosus	X			X				
Pelecyphorus pantex	X	X	X	X	X			X
Pelecyphorus semilaevis	X	X	X	X				X
Sphaeriotis muricata		X						
Trichiasida acerba	X	X			X			X
Triorophus laevis	X	X	X	X	X			X
Trogloderus costatus	X	X	X		X			X
SCARABAEIDAE								
Aphodius fucosus		X						X
Aphodius militaris	X	X						
Aphodius nevadensis		X	X					
Aphodius sp. (nr. *talpoides*)								X
Cyclocephala longula	X	X						X

Species	Plant Community or Locality La-Fr	Gr-Ly	Co	At-Ko	Sa	Pi-Ju	CS	Other
Diplotaxis deserta	X							
Diplotaxis incuria	X							
Diplotaxis insignis						X		
Diplotaxis moerens	X			X				X
Diplotaxis pacata	X							
Diplotaxis subangulata	X	X						X
Ochodaeus sparsus		X						
Paracotalpa granicollis	X	X	X	X	X		X	X
Phyllophaga sp.								X
Serica sp.								X
CURCULIONIDAE								
Anthonomus peninsularis								X
Anthonomus tenuis				X				
Aragnomus sp.								X
Auletes sp.								X
Cimbocera buchanani								X
Cryptolepidus nevadicus	X	X		X				X
Dinocleus denticollis	X	X	X	X	X			X
Eucyllus echinus		X	X					X
Eucyllus unicolor								X
Eupagoderes geminatus	X							
Eupagoderes varius	X	X	X	X				X
Lepidophorus sp.								X
Mimetes gracilior	X							X
Otidocephalus vittatus								X
Paracimbocera artemisiae	X		X					X
Paracimbocera atra						X		
Smicronyx n. sp.								X
Tychius prolixus		X				X		
Yuccaborus frontalis								X
SCOLYTIDAE								
Ips confusus						X		
ANTS								
FORMICIDAE								
Acanthomyops interjectus								X
Acanthomyops latipes						X		
Aphaenogaster boulderensis								X
Aphaenogaster n. sp.	X	X	X					X
Camponotus maccooki		X				X		
Camponotus ocreatus						X		X
Camponotus vicinus						X		
Crematogaster coarctata	X	X		X				X
Crematogaster depilis	X	X						X
Dorymyrmex bicolor	X							
Dorymyrmex pyramicus	X							
Epipheidole inquilina						X		
Formica fusca						X		
Formica integroides						X		
Formica lasioides						X		
Formica limata						X		
Formica moki						X		
Formica neogagates						X		
Formica neorufibarbis						X		
Formica obscuripes						X		
Formica obtusopilosa			X			X		X
Formica subpolita						X		
Iridomyrmex pruinosum	X	X	X	X	X			X
Lasius crypticus						X		

Species	Plant Community or Locality La-Fr	Gr-Ly	Co	At-Ko	Sa	Pi-Ju	CS	Other
Lasius sitiens			X			X		
Leptothorax andrei						X		
Leptothorax nevadensis						X		
Leptothorax tricarinatus			X					X
Liometopum occidentale						X		
Monomorium minimum						X		
Myrmecocystus comatus	X	X	X	X	X			X
Myrmecocystus lugubris	X			X				
Myrmecocystus mexicanus	X	X	X	X	X	X		X
Myrmecocystus mimicus	X	X		X	X	X		X
Myrmecocystus mojave						X		
Myrmica emeryana						X		
Neivamyrmex minor						X	X	
Pheidole bicarinata	X	X	X	X	X	X		X
Pheidole desertorum	X	X	X	X	X			X
Pheidole pilifera						X		
Pogonomyrmex barbatus	X	X	X	X		X		X
Pogonomyrmex californicus	X	X	X	X	X	X		X
Pogonmyrmex imberbiculus		X	X					
Pogonomyrmex occidentalis			X	X		X		
Pogonomyrmex salinus			X			X		X
Solenopsis aurea		X						
Solenopsis molesta						X		X
Solenopsis salina						X		
Solenopsis xyloni								X
Veromessor lariversi	X	X	X					X
Veromessor lobognathus						X		
Veromessor pergandei	X	X						X
Veromessor n. sp.	X	X	X					X
CHILOPODS								
SCOLOPENDRIDAE								
Scolopendra michelbacheri	X	X	X	X				X
SCHENDYLIDAE								
Nyctunguis stenus						X		
TAMPIYIDAE								
New genus, n. sp.		X						X
GOSIBIIDAE								
Gosibius arizonensis		X				X		X
LITHOBIIDAE								
Oabius mercurialis		X		X	X			X
MILLIPEDS								
ATOPETHOLIDAE								
Arinolus nevadae	X	X	X		X			X
Arinolus sequens			X					
Orthichelus michelbacheri	X	X	X					X
LEIODERIDAE								
Titsona tida		X						
TORTOISES								
TESTUDINIDAE								
Gopherus agassizi	X							X
LIZARDS								
GECKONIDAE								
Coleonyx variegatus	X							X
IGUANIDAE								
Callisaurus draconoides	X	X	X	X			X	X

Species	Plant Community or Locality							
	La-Fr	Gr-Ly	Co	At-Ko	Sa	Pi-Ju	CS	Other
Crotaphytus collaris	X			X				X
Crotaphytus wislizeni	X	X	X	X	X			X
Dipsosaurus dorsalis	X							
Phrynosoma platyrhinos	X	X	X	X	X		X	X
Sauromalus obesus	X	X	X					X
Sceloporus magister	X	X	X		X		X	X
Sceloporus occidentalis			X		X	X		
Uta stansburiana	X	X	X	X	X	X	X	X
Xantusidae								
Xantusia vigilis	X							X
Teidae								
Cnemidophorus tigris	X	X	X	X	X		X	X
Scincidae								
Eumeces skiltonianus						X		
SNAKES								
Colubridae								
Arizona elegans		X			X			
Chionactis occipitalis	X	X						
Hypsiglena torquata								X
Lampropeltis getulus		X						X
Masticophis flagellum	X	X	X		X	X		X
Masticophis taeniatus	X					X		X
Phyllorhynchus decurtatus								X
Pituophis catenifer	X	X			X			X
Rhinocheilus lecontei		X						X
Salvadora hexalepis	X	X						X
Sonora semiannulata	X	X						
Tantilla utahensis		X						
Trimorphodon lyrophanes								X
Crotalidae								
Crotalus cerastes	X							X
Crotalus mitchelli	X					X		X
BIRDS								
Podicipedidae								
Aechmophorus occidentalis						X		
Podilymbus podiceps	X		X					X
Podiceps caspicus	X							X
Pelecanidae								
Pelecanus erythrorhynchos								X
Ardeidae								
Ardea herodias	X							X
Butorides virescens						X		
Casmerodius albus							X	X
Ixobrychus exilis								X
Leucophoyx thula	X							X
Nycticorax nycticorax	X							X
Threskiornithidae								
Plegadis chihi								X
Anatidae								
Anas acuta	X							X
Anas carolinensis	X	X					X	X
Anas cyanoptera	X		X					X
Anas discors	X							X
Anas platyrhynchos			X					X
Aythya affinis								X
Aythya americana	X							X

Species	Plant Community or Locality							
	La-Fr	Gr-Ly	Co	At-Ko	Sa	Pi-Ju	CS	Other
Branta canadensis								X
Bucephala albeola	X							X
Bucephala clangula								X
Mareca americana								X
Melanitta perspicillata								X
Mergus serrator								X
Oxyura jamaicensis	X							X
Spatula clypeata								X
CATHARTIDAE								
Cathartes aura	X	X	X	X	X	X		X
ACCIPITRIDAE								
Accipiter cooperii	X	X				X	X	X
Accipiter striatus							X	X
Aquila chrysaetos	X	X	X	X	X	X		X
Buteo jamaicensis	X	X	X	X	X	X	X	X
Buteo lagopus	X	X		X	X			X
Buteo regalis	X	X		X				X
Buteo swainsoni	X	X	X	X	X	X		X
Circus cyaneus	X	X	X	X	X	X		X
PANDIONIDAE								
Pandion haliaetus	X					X		X
FALCONIDAE								
Falco mexicanus	X	X	X	X	X			X
Falco sparverius	X	X	X	X	X	X		X
PHASIANIDAE								
Alectoris graeca						X		X
Lophortyx gambelii	X					X	X	X
RALLIDAE								
Fulica americana	X							X
CHARADRIIDAE								
Charadrius alexandrinus								X
Charadrius semipalmatus								X
Charadrius vociferus	X	X	X					X
Eupoda montana								X
Pluvialis dominica								X
Squatarola squatarola								X
SCOLOPACIDAE								
Actitis macularia	X				X	X		X
Capella gallinago	X						X	X
Catoptrophorus semipalmatus								X
Ereunetes mauri								X
Erolia alpina		X						
Erolia bairdii	X		X					X
Erolia minutilla	X					X		X
Limnodromus scolopaceus								X
Limosa fedoa								X
Micropalama himantopus								X
Numenius americanus	X							
Totanus flavipes	X						X	X
Totanus melanoleucus	X							X
Tringa solitaria								X
RECURVIROSTRIDAE								
Himantopus mexicanus								X
Recurvirostra americana								X
PHALAROPODIDAE								
Lobipes lobatus						X	X	X
Steganopus tricolor			X					X

	Plant Community or Locality							
Species	La-Fr	Gr-Ly	Co	At-Ko	Sa	Pi-Ju	CS	Other
LARIDAE								
Larus californicus								X
Larus delawarensis					X			X
Larus philadelphia								X
COLUMBIDAE								
Zenaidura macroura	X	X	X	X	X	X	X	X
CUCULIDAE								
Geococcyx californianus	X		X	X		X	X	X
STRIGIDAE								
Asio flammeus			X					X
Asio otus			X				X	X
Bubo virginianus								X
Speotyto cunicularia	X	X	X		X			X
CAPRIMULGIDAE								
Chordeiles acutipennis	X	X		X	X			X
Chordeiles minor	X	X	X	X		X		X
Phalaenoptilus nuttallii	X	X						X
APODIDAE								
Aeronautes saxatalis			X			X		X
TROCHILIDAE								
Calypte costae					X		X	X
Selasphorus platycercus							X	
Selasphorus rufus								X
ALCEDINIDAE								
Megaceryle alcyon								X
PICIDAE								
Asyndesmus lewis				X		X	X	X
Colaptes cafer	X		X	X		X	X	X
Dendrocopos scalaris					X			X
Dendrocopos villosus						X		
Sphyrapicus varius							X	X
TYRANNIDAE								
Contopus sordidulus	X	X	X	X		X	X	X
Empidonax oberholseri						X		
Empidonax wrightii						X		X
Myiarchus cinerascens	X	X	X	X	X	X	X	X
Nuttallornis borealis			X			X	X	X
Pyrocephalus rubinus						X		
Sayornis nigricans	X						X	X
Sayornis saya	X	X	X	X	X	X		X
Tyrannus verticalis	X	X	X	X	X	X		X
Tyrannus vociferans						X	X	X
ALAUDIDAE								
Eremophila alpestris	X	X	X	X	X	X		X
HIRUNDINIDAE								
Hirundo rustica	X	X					X	X
Petrochelidon pyrrhonota	X							X
Riparia riparia	X							X
Stelgidopteryx ruficollis	X						X	X
Tachycineta thalassina	X	X				X		X
CORVIDAE								
Aphelocoma coerulescens		X				X		X
Corvus brachyrhynchos	X					X		X
Corvus corax	X	X	X	X	X	X	X	X
Cyanocitta stelleri	X					X		
Gymnorhinus cyanocephala	X	X	X	X		X	X	X
Nucifraga columbiana						X		

	Plant Community or Locality							
Species	La-Fr	Gr-Ly	Co	At-Ko	Sa	Pi-Ju	CS	Other
Pica pica								X
PARIDAE								
Parus gambeli						X		
Parus inornatus						X		
Psaltriparus minimus		X				X		X
SITTIDAE								
Sitta carolinensis						X		
TROGLODYTIDAE								
Campylorhynchus brunneicapellum				X				
Salpinctes obsoletus	X	X		X	X	X	X	X
Telmatodytes palustris						X		X
Thryomanes bewickii						X		X
Troglodytes aedon						X		X
MIMIDAE								
Dumetella carolinensis							X	X
Mimus polyglottos	X	X	X	X	X	X	X	X
Oreoscoptes montanus	X	X	X		X	X		X
Toxostoma lecontei	X	X	X	X	X		X	X
TURDIDAE								
Hylocichla guttata			X			X	X	X
Hylocichla ustulata								X
Myadestes townsendi		X				X		X
Sialia currucoides	X	X	X		X	X		X
Sialia mexicana						X		X
Turdus migratorius						X	X	X
SYLVIIDAE								
Polioptila caerulea		X				X	X	X
Regulus calendula						X	X	X
MOTACILLIDAE								
Anthus spinoletta	X	X		X	X	X	X	X
BOMBYCILLIDAE								
Bombycilla cedrorum						X		X
PTILOGONATIDAE								
Phainopepla nitens							X	
LANIIDAE								
Lanius ludovicianus	X	X	X	X	X	X	X	X
STURNIDAE								
Sturnus vulgaris	X	X		X	X		X	X
VIREONIDAE								
Vireo gilvus						X	X	X
Vireo solitarius						X		X
Vireo vicinior						X		
PARULIDAE								
Dendroica auduboni	X	X	X			X	X	X
Dendroica coronata								X
Dendroica petechia						X	X	X
Dendroica nigrescens		X	X			X	X	X
Dendroica townsendi						X		X
Geothlypis trichas							X	X
Icteria virens								X
Oporornis tolmiei							X	X
Vermivora celata							X	X
Vermivora virginiae						X		X
Vermivora ruficapilla								X
Wilsonia pusilla				X				X
PLOCEIDAE								
Passer domesticus	X							X

Species	La-Fr	Gr-Ly	Co	At-Ko	Sa	Pi-Ju	CS	Other
	Plant Community or Locality							
ICTERIDAE								
Agelaius phoeniceus	X	X	X		X	X	X	X
Euphagus cyanocephalus	X	X	X		X		X	X
Icterus bullockii	X					X	X	X
Icterus parisorum			X	X	X	X	X	X
Molothrus ater	X	X	X		X	X	X	X
Sturnella neglecta	X	X	X	X	X		X	X
Xanthocephalus xanthocephalus	X	X					X	X
THRAUPIDAE								
Piranga ludoviciana				X		X	X	X
FRINGILLIDAE								
Amphispiza belli	X	X	X	X	X		X	X
Amphispiza bilineata	X	X	X	X	X	X	X	X
Calcarius lapponicus						X		
Carpodacus cassinii	X					X		
Carpodacus mexicanus	X	X	X	X	X	X	X	X
Carpodacus purpureus						X		
Chlorura chlorura						X		X
Chondestes grammacus	X			X		X	X	X
Guiraca caerula							X	
Hesperiphona vespertina						X		X
Iridoprocne bicolor	X						X	X
Junco caniceps						X		X
Junco hyemalis						X		
Junco oreganus						X	X	X
Melospiza lincolnii	X					X	X	X
Melospiza melodia							X	X
Passerculus sandwichensis	X		X		X			X
Passerina amoena						X	X	X
Pheucticus melanocephalus	X	X	X			X	X	X
Pipilo erythrophthalmus		X				X	X	X
Pooecetes gramineus		X	X				X	X
Spinus pinus						X	X	X
Spinus psaltria								X
Spinus tristis	X	X		X			X	X
Spizella atrogularis						X		
Spizella breweri	X		X			X		X
Spizella passerina	X	X				X	X	X
Zonotrichia atricapilla								X
Zonotrichia leucophrys	X	X	X			X	X	X
MAMMALS								
VESPERTILIONIDAE								
Antrozous pallidus			X					X
Corynorhinus rafinesquii								X
Corynorhinus townsendii								X
Myotis californicus								X
Pipistrellus hesperus	X						X	X
LEPORIDAE								
Lepus californicus	X	X	X	X	X	X	X	X
Sylvilagus audubonii	X	X	X		X	X	X	X
Sylvilagus nuttallii						X		X
SORICIDAE								
Notiosorex crawfordi								X
Sorex merriami						X		
Sorex tenellus						X		
SCIURIDAE								
Ammospermophilus leucurus	X	X	X	X	X	X	X	X

Species	Plant Community or Locality							
	La-Fr	Gr-Ly	Co	At-Ko	Sa	Pi-Ju	CS	Other
Eutamias dorsalis						X		X
Spermophilus tereticaudus	X							
Spermophilus towsendii	X			X				
Spermophilus variegatus						X		
GEOMYIDAE								
Thomomys umbrinus	X	X		X				X
HETEROMYIDAE								
Dipodomys deserti	X				X			X
Dipodomys merriami	X	X	X	X	X			X
Dipodomys microps	X	X	X	X	X	X		X
Dipodomys ordii	X	X	X		X			X
Perognathus formosus	X	X	X	X	X	X		X
Perognathus longimembris	X	X	X	X	X			X
Peroganthus parvus	X	X	X			X		X
CRICETIDAE								
Lagurus curtatus						X		
Neotoma lepida	X	X	X	X	X	X		X
Onychomys torridus	X	X	X	X	X	X		X
Peromyscus crinitus	X	X	X	X	X	X		X
Peromyscus eremicus							X	X
Peromyscus maniculatus	X	X	X	X	X	X		X
Peromyscus truei		X				X		X
Reithrodontomys megalotis					X			
ERETHIZONTIDAE								
Erethizon dorsatum	X							
CANIDAE								
Canis latrans	X	X	X	X	X			X
Vulpes macrotis	X	X		X	X			X
PROCYONIDAE								
Bassariscus astutus						X		X
MUSTELIDAE								
Mustela frenata		X						
Spilogale gracilis								X
Taxidea taxus	X	X	X	X	X			X
FELIDAE								
Felis concolor								X
Lynx rufus	X	X	X					X
CERVIDAE								
Dama hemionus			X			X		
BOVIDAE								
Ovis canadensis								X

APPENDIX III

Summary of New Species of Animals from the Nevada Test Site

The following resumé is the first periodic listing of new animal species which have been described from collections made at the Nevada Test Site as part of the A.E.C.-B.Y.U. ecological studies.

Phylum: Arthropoda

Class: Diplopoda

Order: Spirobolida

Family: Atopetholidae

Species: **Arinolus sequens**

Publication: Proc. Biol. Soc. Washington, 75:53-54; figs. 4-5; 30 March 1962.

Author: Ralph V. Chamberlin, University of Utah, Salt Lake City.

Type and Locality: Male holotype; Nevada: vicinity of Mercury, November, 1960.

Depository of Type Specimen: Invertebrate Museum, University of Utah, Salt Lake City, Utah.

Comments: The type specimen was taken from a can pit-trap, November 10, 1960, in a *Coleogyne ramosissima* plant community where the soil is compact with numerous rocks up to several inches in diameter. The specific locality at the test site is 36 miles due north of Mercury, Nye County, Nevada, in B.Y.U. study area 10D, transect A, station 1.

Species: **Arinolus nevadae**

Publication: Proc. Biol. Soc. Washington, 75: 54; figs. 1-3; 30 March 1962.

Author: Ralph V. Chamberlin, University of Utah, Salt Lake City.

Types and Locality: Many specimens, taken mostly in October, November, and December, 1960; Nevada: Mercury and adjacent area.

Depository of Type Specimens: Invertebrate Museum, University of Utah, Salt Lake City, Utah.

Comments: Although Chamberlin did not specifically designate types in his description, he included drawings of male structures. Correspondence from him in December, 1962, indicated that the holotype male was collected in October, 1960. This specimen was taken from a can pit-trap in a *Salsola kali* plant community where the soil is loose sand and clay with few rocks. The specific locality at the test site is 27 miles northwest (15 degrees west of north) of Mercury, Nye County, Nevada. This is in B.Y.U. study area 1F, transect L, station 2.

Order: Cambalida

Family: Leioderidae

Species: **Titsonia tida**

Publication: Proc. Biol. Soc. Washington, 75: 54-55; fig. 6; 30 March 1962.

Author: Ralph V. Chamberlin, University of Utah, Salt Lake City.

Types and Locality: Two specimens taken in March, 1960; Nevada: Nevada test area, vicinity of Mercury.

Depository of Type Specimens: Invertebrate Museum, University of Utah, Salt Lake City, Utah.

Comments: Chamberlin did not designate a type or indicate the sex of the two specimens. One of these was taken from a can pit-trap, March 31, 1961, in a *Salsola kali* plant community where the soil is loose clay, sand, and few rocks. The other was taken from a can pit-trap, March 31, 1960, in a *Coleogyne ramosissima* plant community where the soil is compact with many rocks several inches in diameter. The specific locality at the test site is 27 miles northwest (15 degrees west of north) of Mercury, Nye County, Nevada. This is in B.Y.U. study area 1B, transect F, station 4.

Class: Chilopoda

Order: Geophilida

Family: Schendylidae

Species: **Nyctunguis stenus**

Publication: Entomological News 73(5):134-135; May, 1962.

Author: Ralph V. Chamberlin, University of Utah, Salt Lake City.

Types and Locality: Nevada: Clark Co., Mercury, Nevada Test Area.

Depository of Type Specimens: Invertebrate Museum, University of Utah, Salt Lake City, Utah

Comments: Chamberlin did not designate the type, number of specimens, or dates collected. He indicated in personal correspondence that the holotype female was taken in January, 1961, and "other specimens" in November and December, 1960.

The type locality was erroneously designated as Clark County; it should be Nye County. The holotype was collected by hand in a *Pinus monophylla-Juniperus osteosperma* plant community where there were numerous outcroppings of rocks. The specific locality at the test site is on the eastern edge of Rainier Mesa, 38 miles northwest (25 degrees west of north) of Mercury, Nye County, Nevada. This is in B.Y.U. study area 12C, transect A.

Order: Lithobiida

Family: Lithobiidae

Species: **Oabius mercurialis**

Publication: Entomological News, 73(5):137-138; May, 1962.

Author: Ralph V. Chamberlin, University of Utah, Salt Lake City.

Types and Locality: Female type taken 26 January 1961; a second specimen taken 19 December 1960; Nevada: Clark Co., Mercury.

Depository of Type Specimens: Invertebrate Museum, University of Utah, Salt Lake City.

Comments: Chamberlin erroneously designated the type locality as Clark County; it should be Nye County. The holotype was collected by means of a can pit-trap in a *Grayia spinosa-Lycium andersonii* plant community. The specific locality at the test site is 28 miles northwest (15 degrees west of north) of Mercury, Nye County, Nevada. This is in B.Y.U. study area 1B, transect B, station 20.

Class: Arachnida

Order: Solpugida

Family: Eremobatidae

Species: **Therobates plicatus**

Publication: American Museum Novitates, No. 2092, pp. 11-12; figs. 63-67; 13 June 1962.

Author: Martin H. Muma, University of Florida, Lake Alfred.

Types and Locality: Male holotype from Mercury, Nevada, on July 15, 1960. Female allotype from Mercury, Nevada, on July 6, 1960. Male paratypes from the same locality on July 19, 1960, and July 21, 1960. Female paratype from the same locality on July 25, 1960.

Depository of Type Specimens: American Museum of Natural History, New York, New York.

Comments: All the type specimens were taken from can pit-traps in B.Y.U. study area 1B. The holotype, female paratype, and one male paratype were taken on transect F, station 10; the other male paratype at station 15. The allotype was taken on transect D, station 15. All collections were made in a *Salsola kali* community where the soil is loose sand and clay with few rocks. The type locality at the test site is 27 miles northwest (15 degrees west of north) of Mercury, Nye County, Nevada.

Species: **Therobates arcellus**

Publication: American Museum Novitates, No. 2092, pp. 13-14; figs. 68-71; 13 June 1962.

Author: Martin H. Muma, University of Florida, Lake Alfred.

Types and Locality: Male holotype from Mercury, Nevada, April 7, 1960. Female allotype and female paratype from same locality, July 19, 1960. Female paratype, same locality, July 27, 1960.

Depository of Type Specimens. American Museum of Natural History, New York, New York.

Comments: All the type specimens were taken from can pit-traps at the test site in B.Y.U. study area 1B. The holotype was taken on transect H, station 27, in a *Coleogyne ramosissima* plant community where the soil is compact with numerous rocks up to several inches in diameter. The allotype was taken on transect F, station 5, and the paratype on transect B, station 1. These two latter stations are in a *Salsola kali* plant community where the soil is loose sand and clay with few rocks.

Date Due

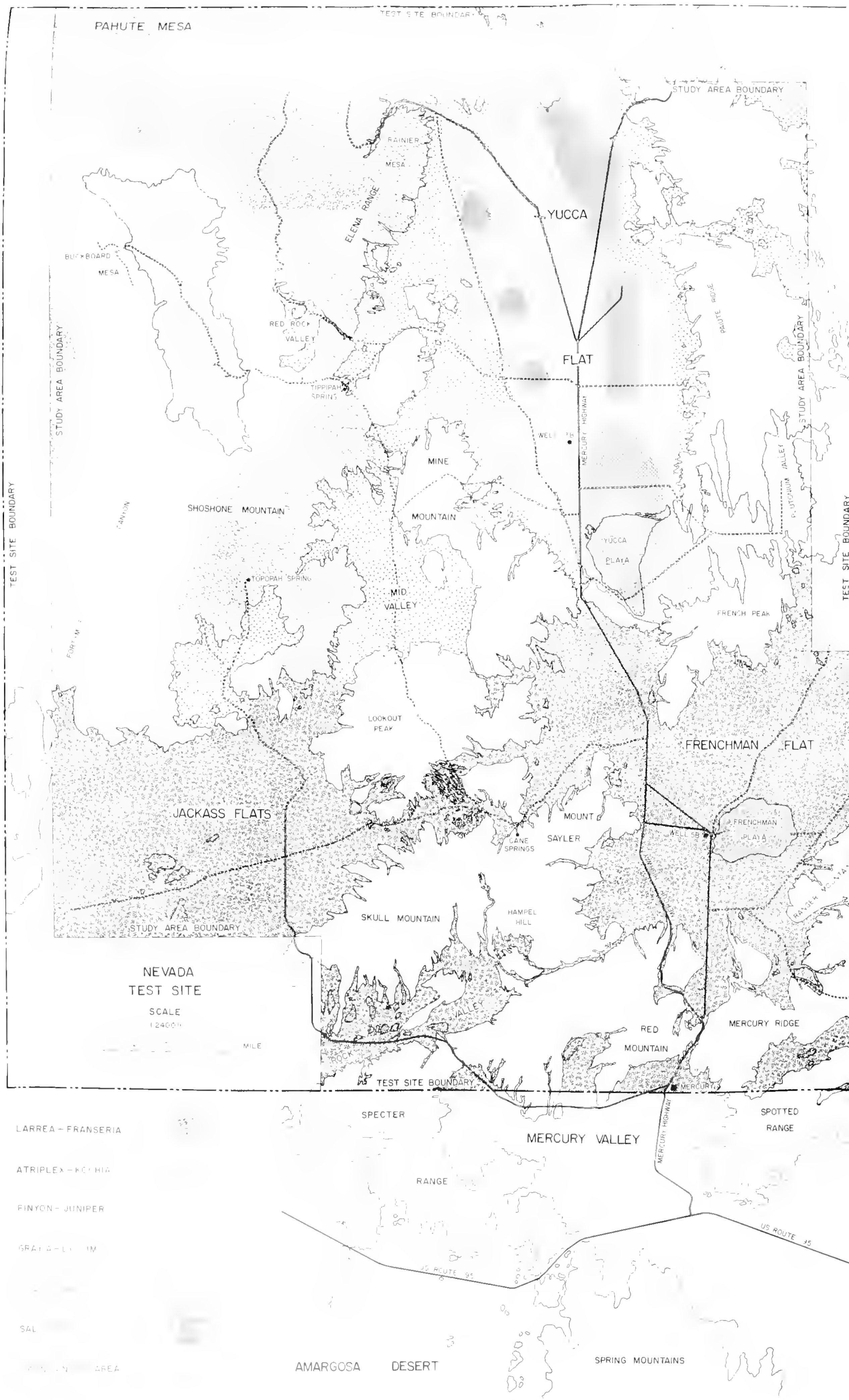


Fig. 11 Extent of the major plant communities at the Nevada Test Site.

FORTYMILE
MID
VALLEY
FRENCH PEAK

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HARD-BODIED TICKS OF THE WESTERN UNITED STATES

Part 1

PICTORIAL KEY FOR THE SEPARATION OF THE GENERA*

by

Elias P. Brinton and D Elden Beck
Department of Zoology and Entomology
Brigham Young University
Provo, Utah

Introduction

This paper is concerned only with the adults of the several genera in the western United States. Subsequent papers are planned to include the nymphal and larval stages. Once keys are available for classifying all stages of development to genus, the several developmental stages will be classified to the species category.

The western United States as defined in these papers will be concerned with the geography west of the Continental Divide, south of the Canadian border and north of the Mexican boundary line. Nevertheless, the keys and other information will naturally be applicable to parts of western Canada and Mexico, and to a limited extent to those states in the United States bordering the Continental Divide.

Methods

Ticks are supported on a mold of typewriter cleaner putty. This putty enables manipulation of the specimen to facilitate observation of all body surfaces. Orientation of the tick is best done by use of fine pointed forceps. A pair of A. O. Spencer Universal Illuminators will suffice for good lighting, which is equally important to a wide range of magnification. Magnification from 10 to 120 diameters is necessary to identify the features noted in this study.

When ticks are under observation for a prolonged period, they should occasionally be moistened with a drop of preservative or placed in the liquid for a short period of time. Seventy percent ethyl alcohol has been the preservative used in these studies. New solutions have always been used when the specimens are returned to bottles for permanent storage.

Acknowledgments

Extensive collections have been made throughout the western United States by various expeditions sent out from the Brigham Young University Department of Zoology and Entomology. These collections have been greatly added to by generous gifts and loans of specimens by several institutions, organizations and individuals. The Rocky Mountain Laboratory at Hamilton, Montana, through the courtesy of Glen M. Kohls and Carlton M. Clifford, has been most cooperative. Dale Parker and Elmer Johnson of the University of Utah Ecology Unit at Dugway, Utah, have supplied collections from several years' study at that location. All of the collections of ticks resulting from the three-year ecology study (1960-61-62) on the A.E.C.-B.Y.U. Ecology Project at the Nevada Test Site, Mercury, Nevada, have been in our possession. Carl O. Mohr, University of California at Berkeley, has placed all of his collections of ticks at our disposal, and we also have some collections provided by the California State Department of Health through the courtesy of Allan M. Barnes.

Charles L. Douglas in his studies at Mesa Verde National Park, Colorado, has collected a long series of ticks which he has loaned us. Marvin Coffey at the Southern Oregon College, Ashland, Oregon, likewise sent a representative collection from that area. T. A. Filipi and William R. Rapp sent the entire *Dermacentor* adult collection from the Nebraska State Department of Health. Rex W. Allen of the University of New Mexico sent us a representative collection of *Dermacentor hunteri* Bishopp he had taken at the Nevada Bighorn Wildlife Reservation near Las Vegas, Nevada. Charles Hansen, biologist at the same station, has been continually supplying us collections obtained from the Bighorn Sheep. Through the help of Carl Musebeck we also received an important shipment of ticks from the U.S. National Museum. Students, colleagues, and interested friends have been attentive to our interests in this project, and ticks are being sent to us regularly from near and far.

*This investigation supported in part by Research Grant E-1273 from the National Institutes of Health, United States Public Health Service.

Explanation of Figures

Almost all the drawings are original and have been made from field-collected specimens. Each illustration was drawn so that parts are in exact measurable proportion to each other. Only those anatomical external features which were pertinent to the present study have been included and labeled. In the pictorial key those anatomical parts are labeled as described in the couplets of the key.

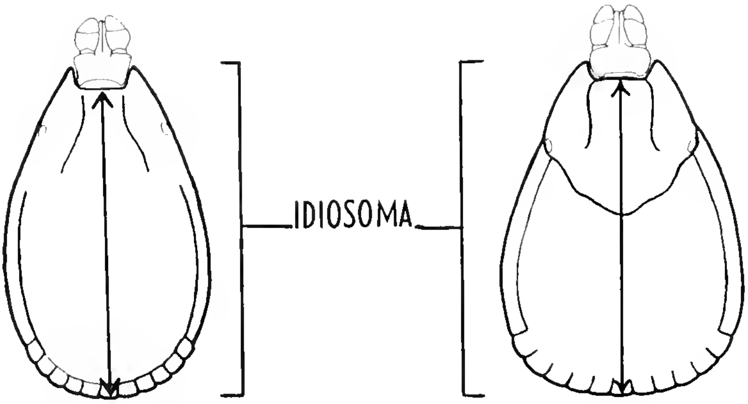
Dorsal and ventral views of both sexes have been illustrated to facilitate further taxonomic and anatomical comparison in this and subsequent studies. Sequence of figures is as follows:

1. Descriptions and illustrations for the separation of the adult, nymphal and larval stages of hard-bodied ticks.
2. Pictorial key for the separation of the genera of hard-bodied ticks in the western United States.
3. Dorsal and ventral views of adult male and female ticks of the several genera in the western United States.

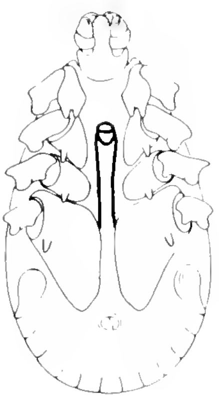
Identification of Developmental Stages of the Hard-Bodied Ticks

The following brief descriptions and illustrations will readily assist the inexperienced worker to distinguish between the larval, nymphal and adult stages.

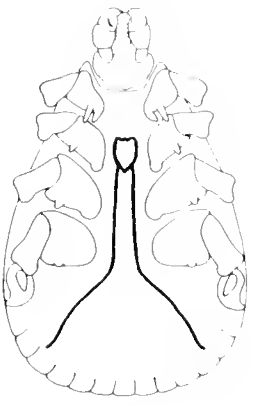
Adult: Four pairs of legs present. Genital aperture or plate located between coxal plates I and II. The female and male can be differentiated by the length and size of the scutal plate. The female scutal plate usually extends posteriorly from $\frac{1}{4}$ to $\frac{1}{2}$ the length of the idiosoma, depending upon the extent of engorgement. The male scutal plate covers the entire idiosoma except at the peripheral margin in some genera.



male female

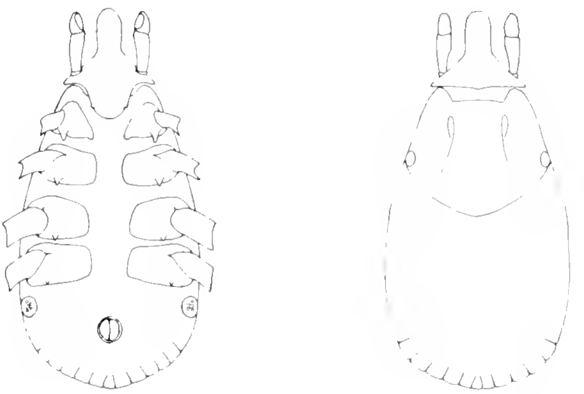


male

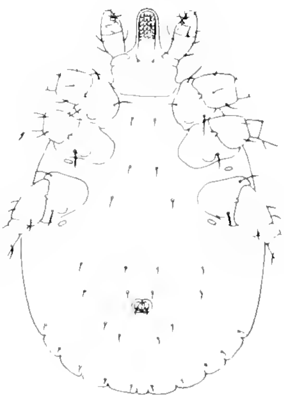


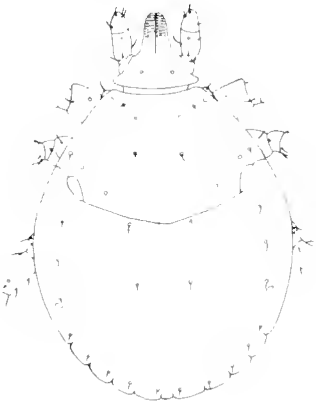
female

Nymph: Four pairs of legs present. Genital opening or plate absent. Care should be taken not to confuse an engorged nymph for a partially engorged female. The scutal plate of the nymph only partially covers the idiosoma as in the female. The unengorged nymph is much smaller than an unengorged adult.



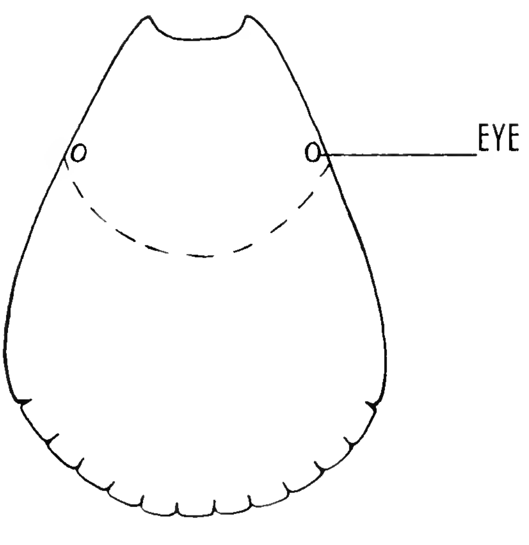
Larva: Three pair of legs present. Larvae in most cases are very small.



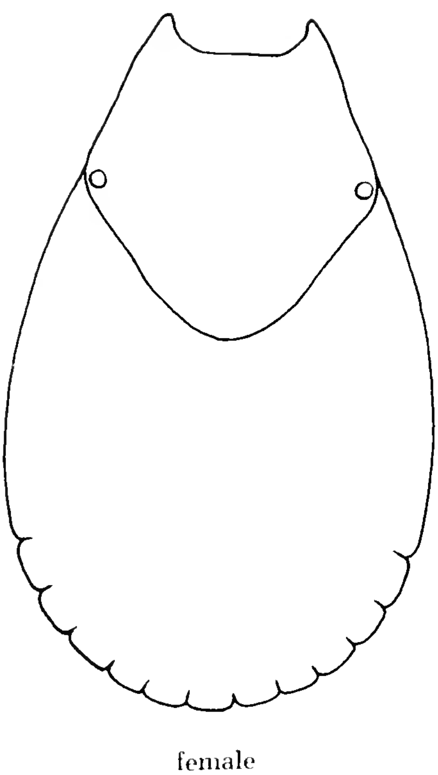


PICTORIAL KEY FOR SEPARATION OF ADULT GENERA

1. Eyes present 2

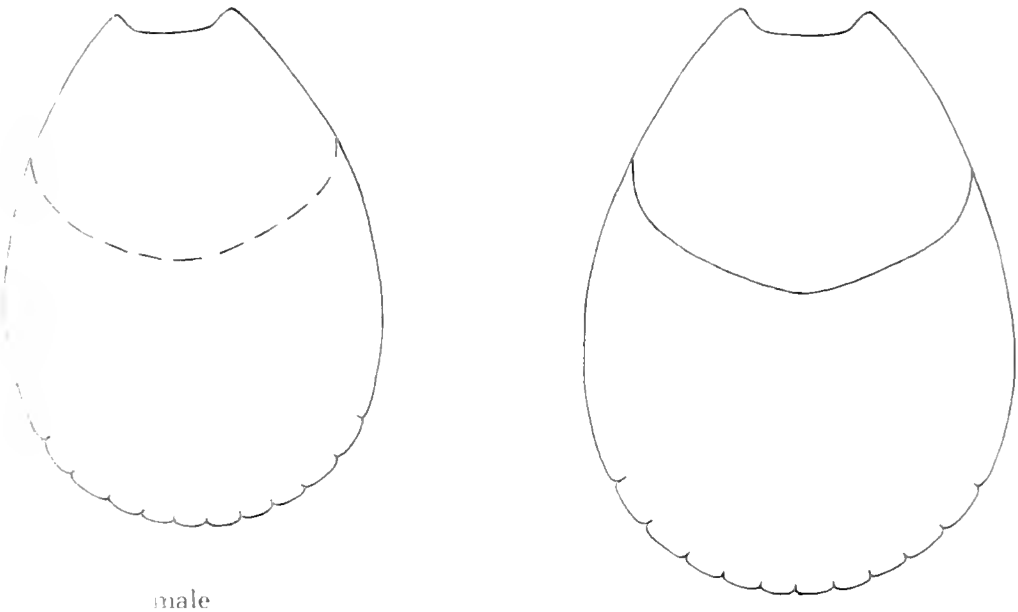


male



female

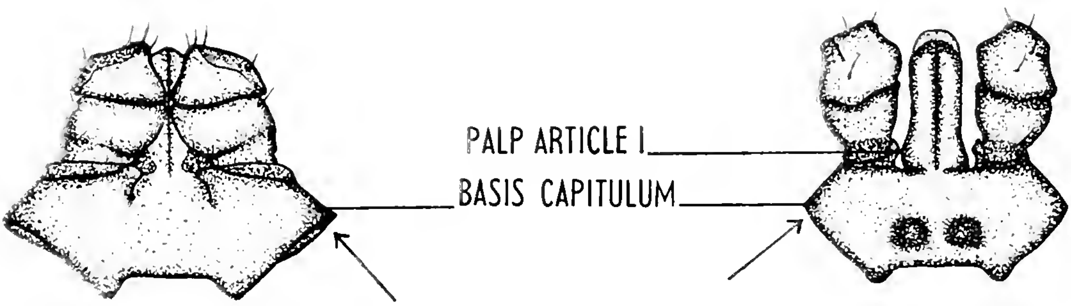
Eyes absent 3



male

female

2. Basis capitulum laterally triangulate .... *Rhipicephalus*
See figures 17, 18, 19, 20 for dorsal and ventral views of male and female specimens.

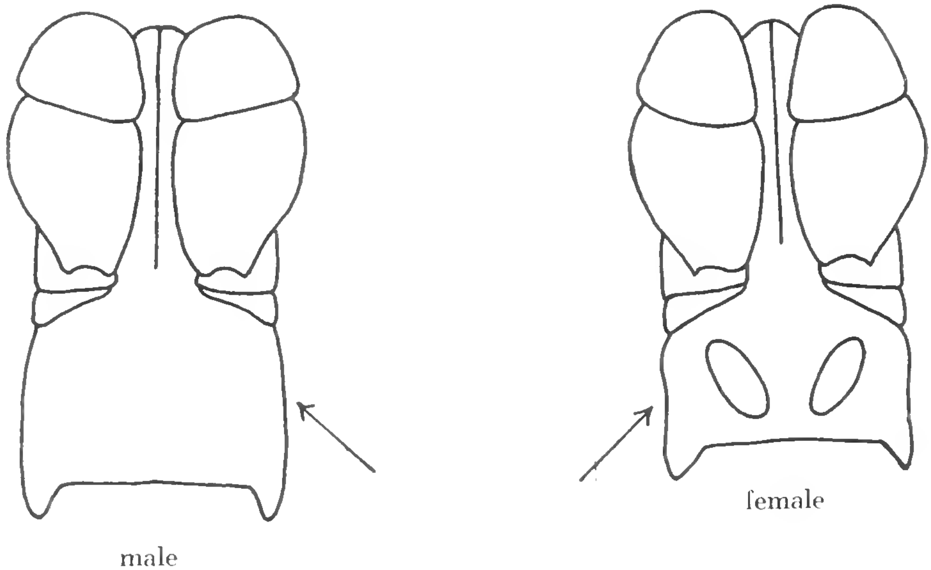


male

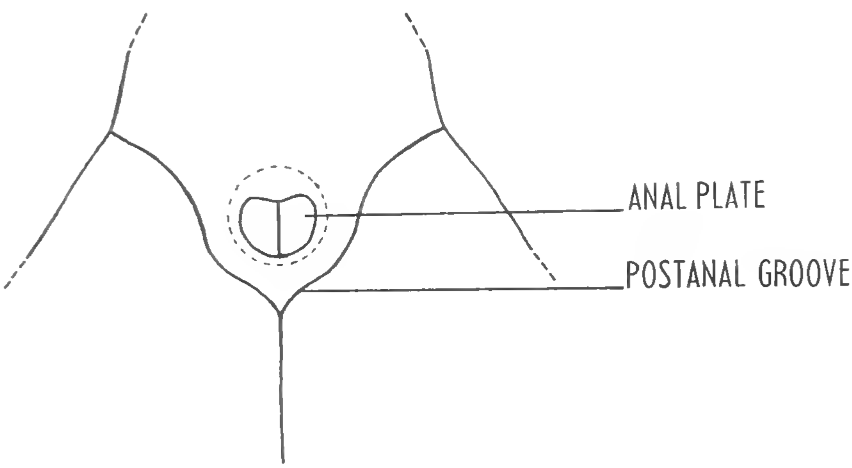
female

*There is one species of *Rhipicephalus* in North America. This key will suffice to identify the adult stage of *Rhipicephalus sanguineus* (Latreille) See figs. 17, 18, 19 and 20.

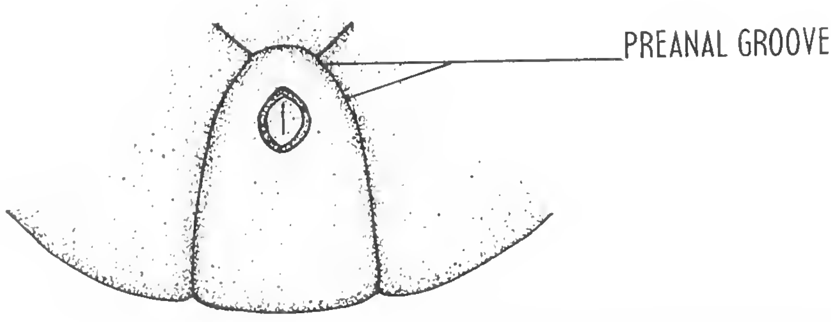
Basis capitulum not laterally triangulate 4



3. Postanal groove present .... *Haemaphysalis
See figures 5, 6, 7, 8 for dorsal and ventral views of male and female specimens.

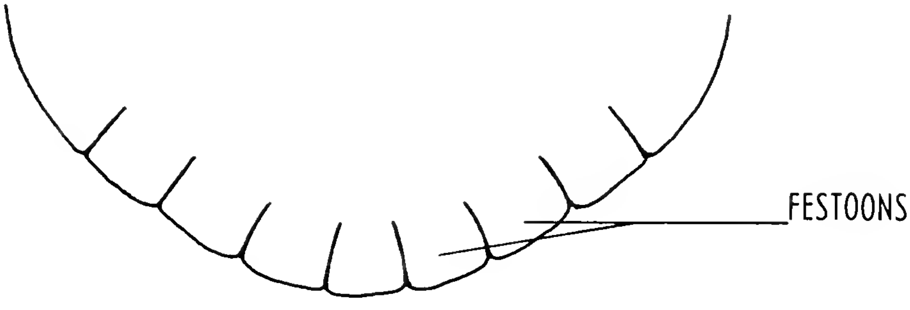


Preanal groove present .... *Ixodes*
See figures 1, 2, 3, 4 for dorsal and ventral views of male and female specimens.

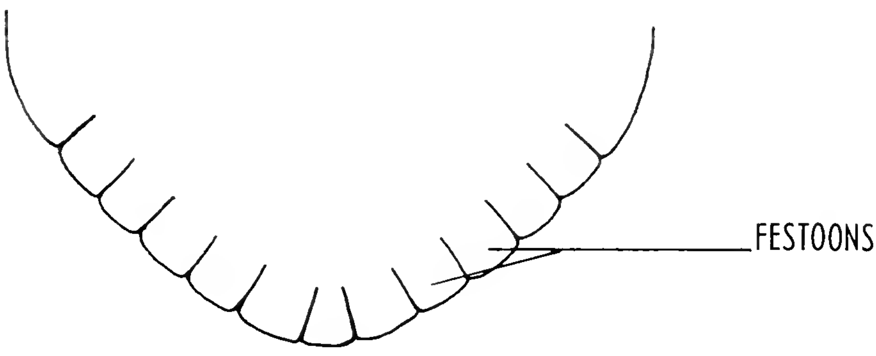


*There are two species of *Haemaphysalis* in North America. This key will suffice to identify *Haemaphysalis leporis-palustris* (Packard) adults.

4. Seven festoons present .... *Anocentor
See figures 13, 14, 15, 16 for dorsal and ventral views of male and female specimens.



Eleven festoons present .... *Dermacentor*
See figures 9, 10, 11, 12 for dorsal and ventral views of male and female specimens.



**Anocentor nitens* (Neumann) although not distributed in the western United States has been included in this study, in that it is a borderline species in its distribution. In addition there is only one species in North America. Its distribution is in southcentral Texas, Mexico, Central America and the Caribbean Islands. See figs. 13, 14, 15 and 16.

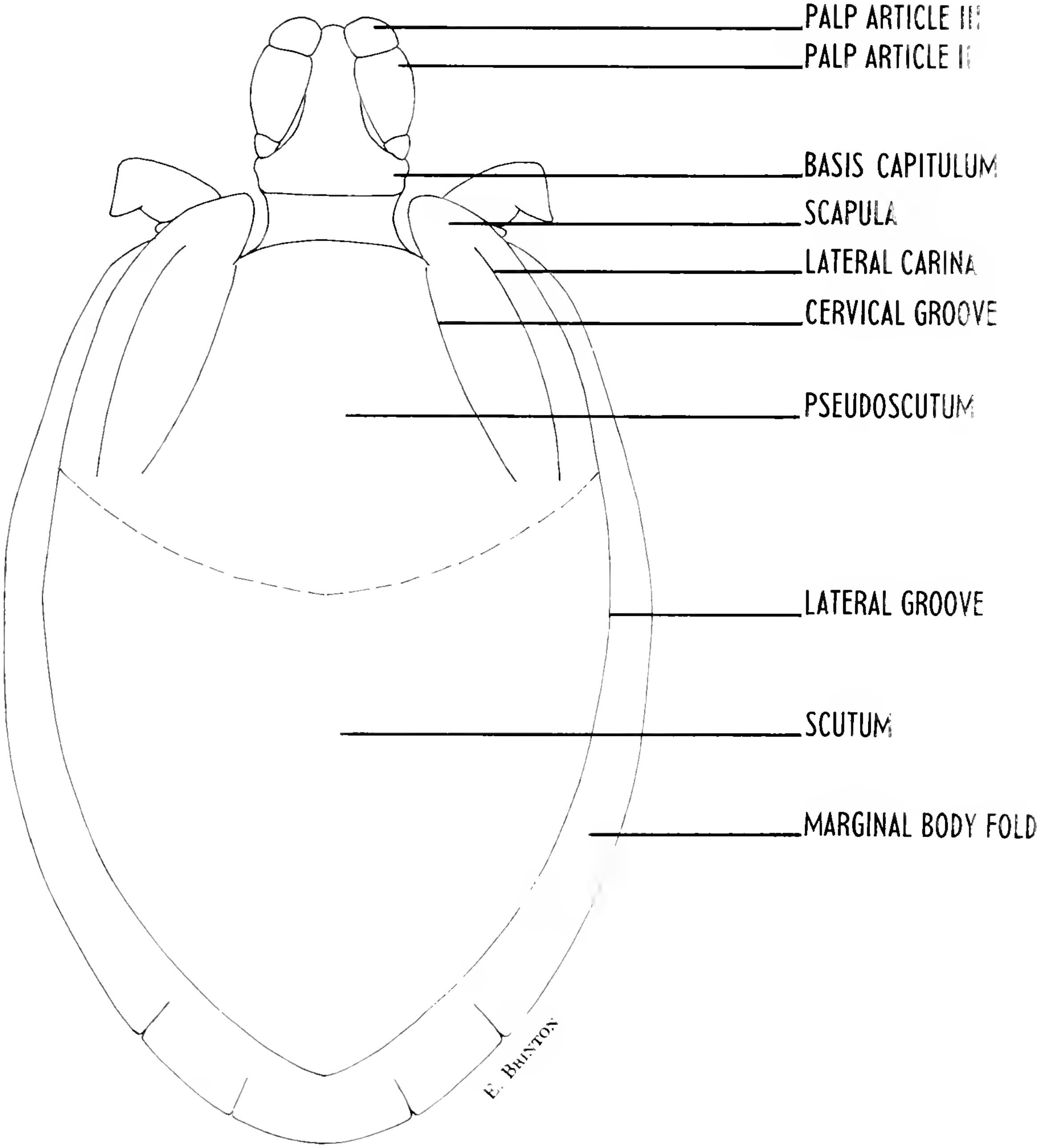


Fig. 1.—Dorsal view, adult male *Ixodes*.
(Modified from Cooley and Kohls, 1945)
Pseudoscutal suture indicated by broken line

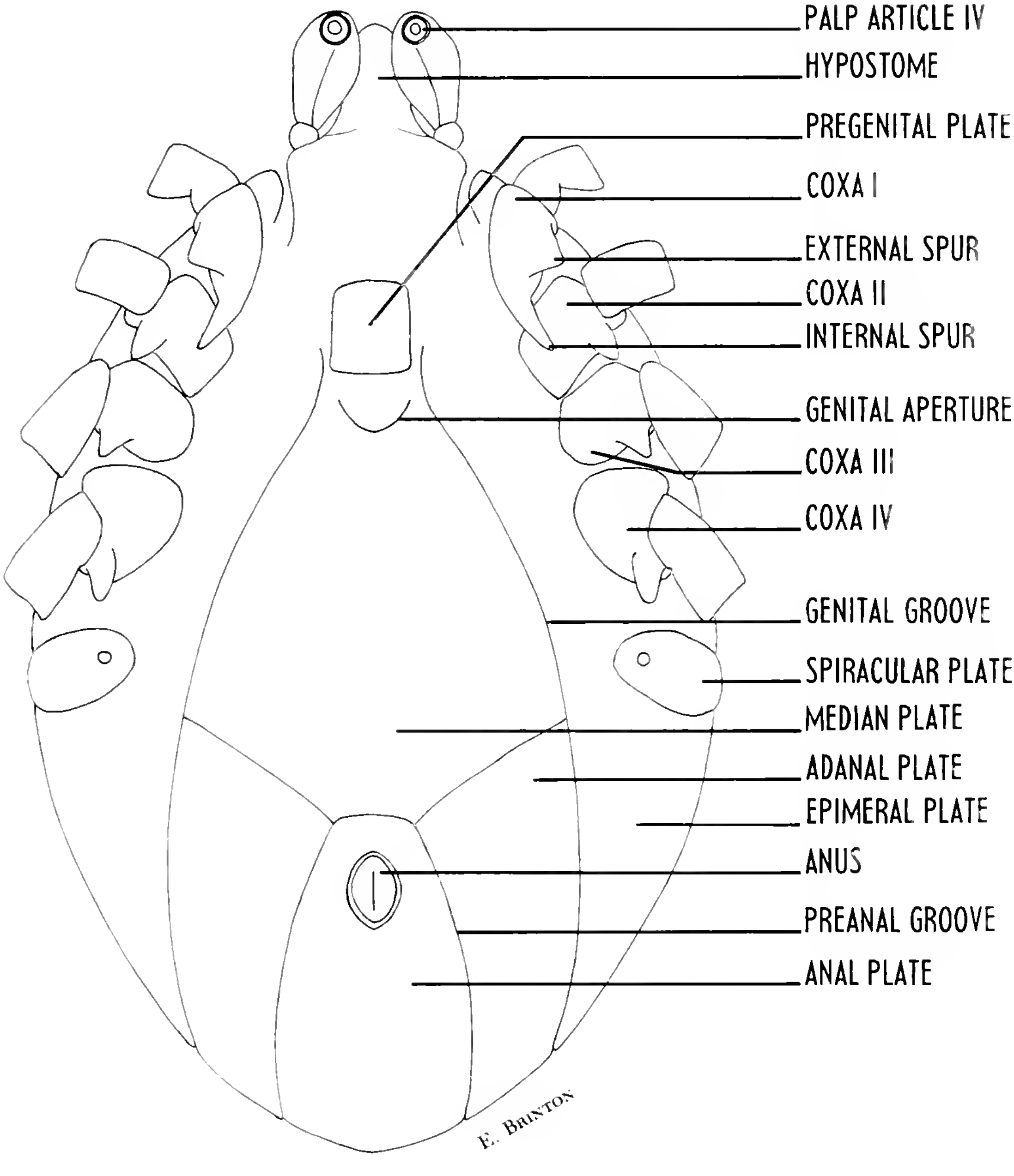


FIG. 2.—Ventral view, adult male *Ixodes*.
(Modified from Cooley and Kohls, 1945)

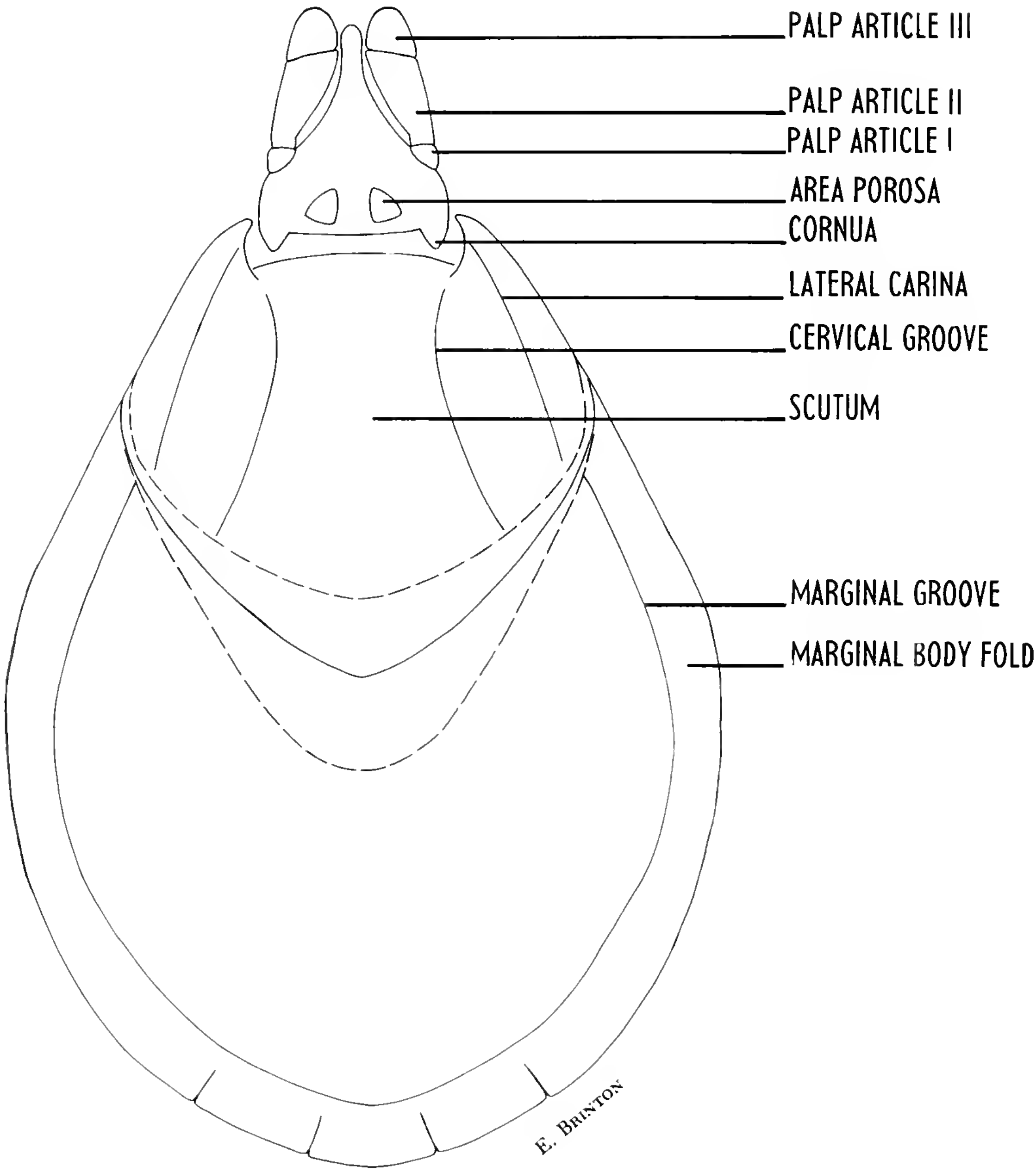


FIG. 3.—Dorsal view, adult female *Ixodes*.
(Modified from Cooley and Kohls, 1945)
The broken lines indicate degree of variation in outline of scutal margin encountered in the several species of the genus.

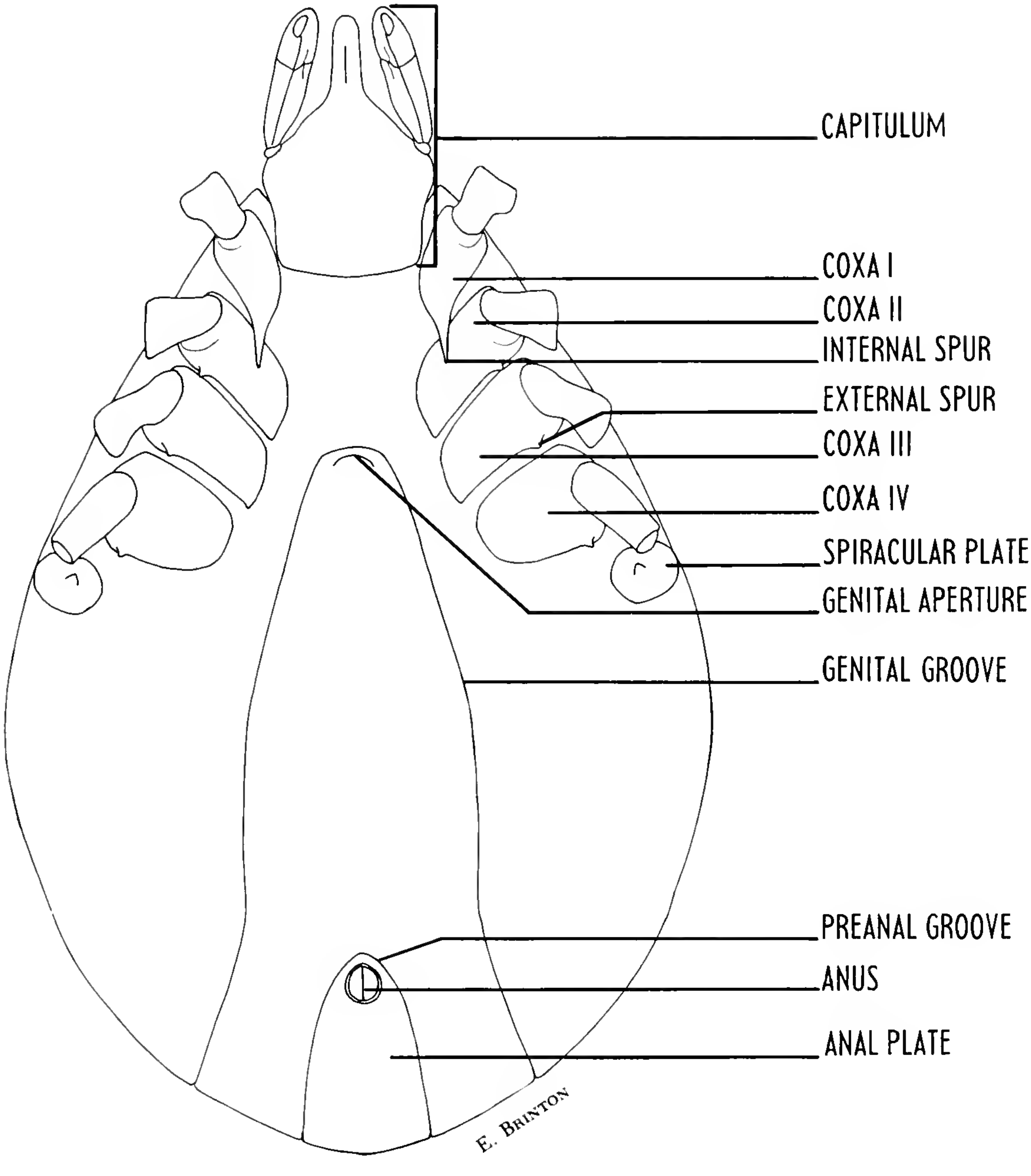


FIG. 4.—Ventral view, adult female *Ixodes*.

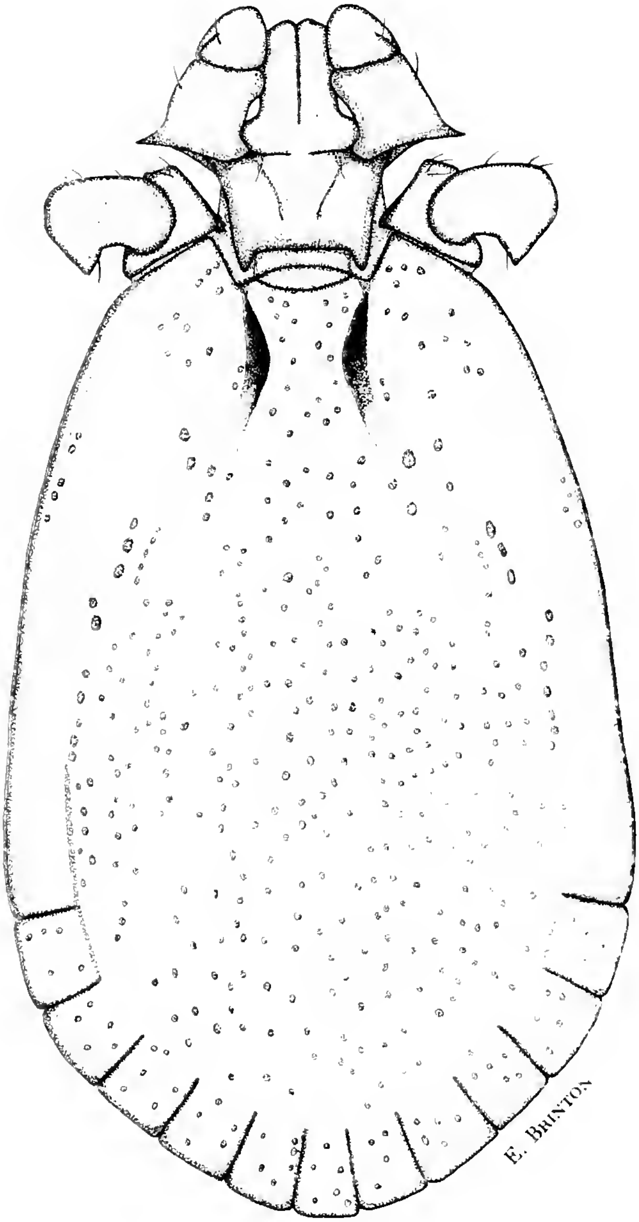


FIG. 5.—Dorsal view, adult male *Haemaphysalis*.

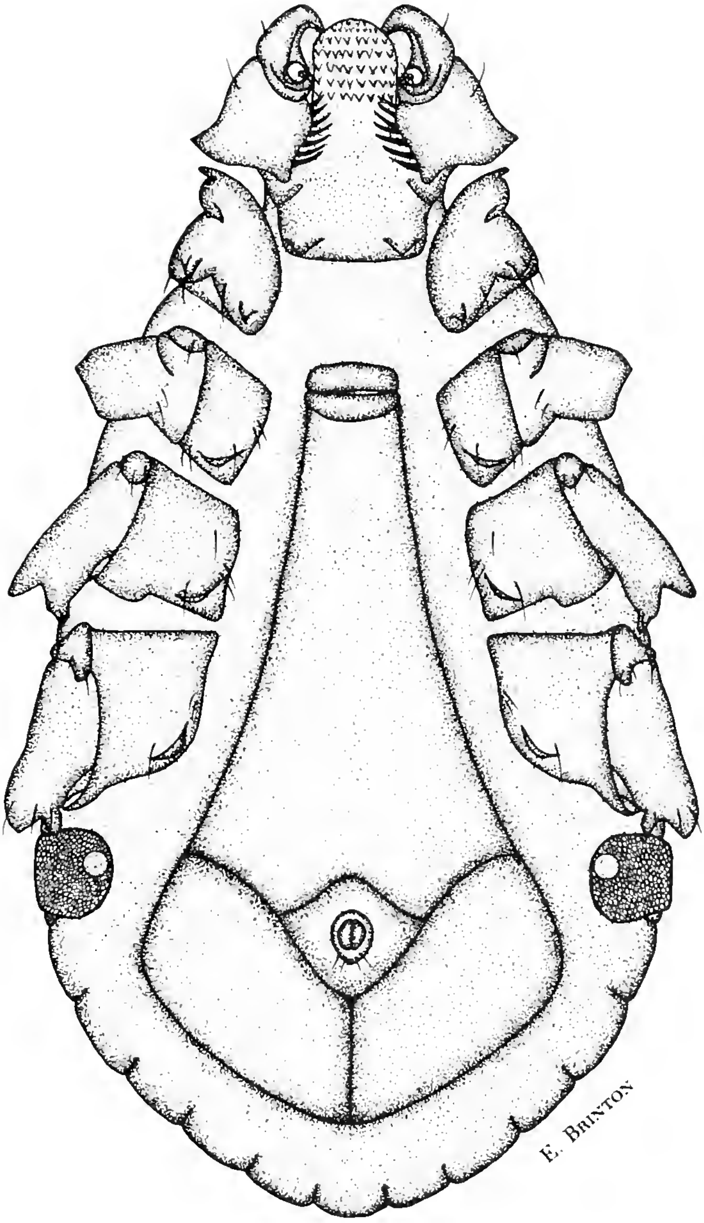


Fig. 6.—Ventral view, adult male *Haemaphysalis*.

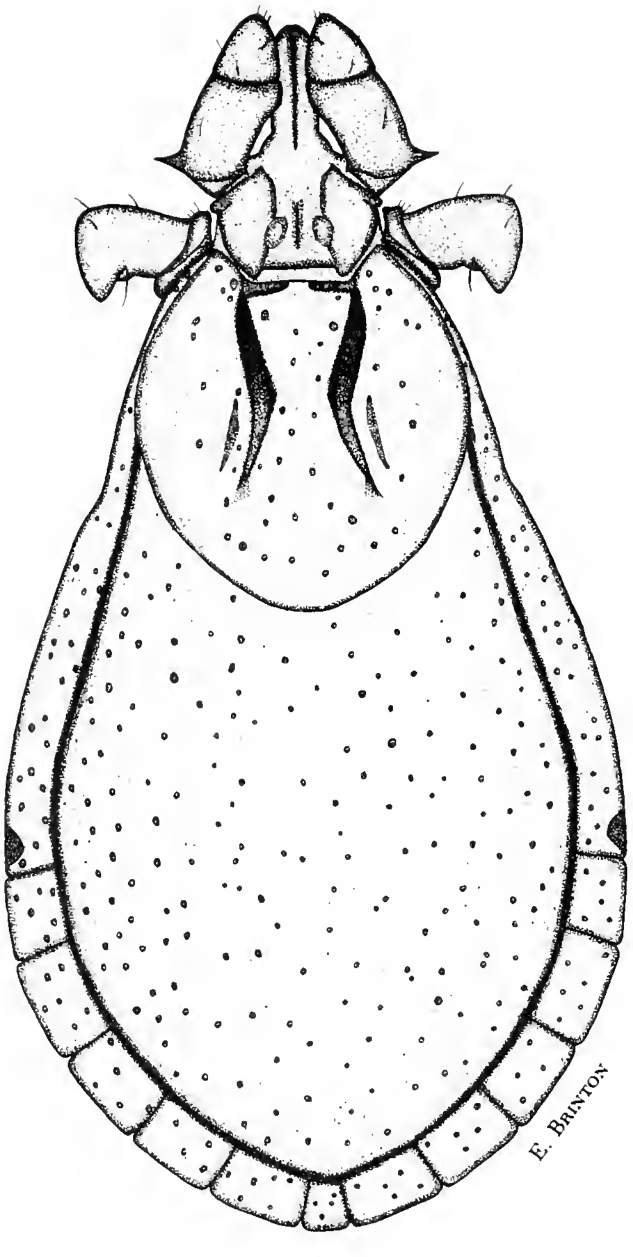


Fig. 7.—Dorsal view, adult female *Haemaphysalis*.

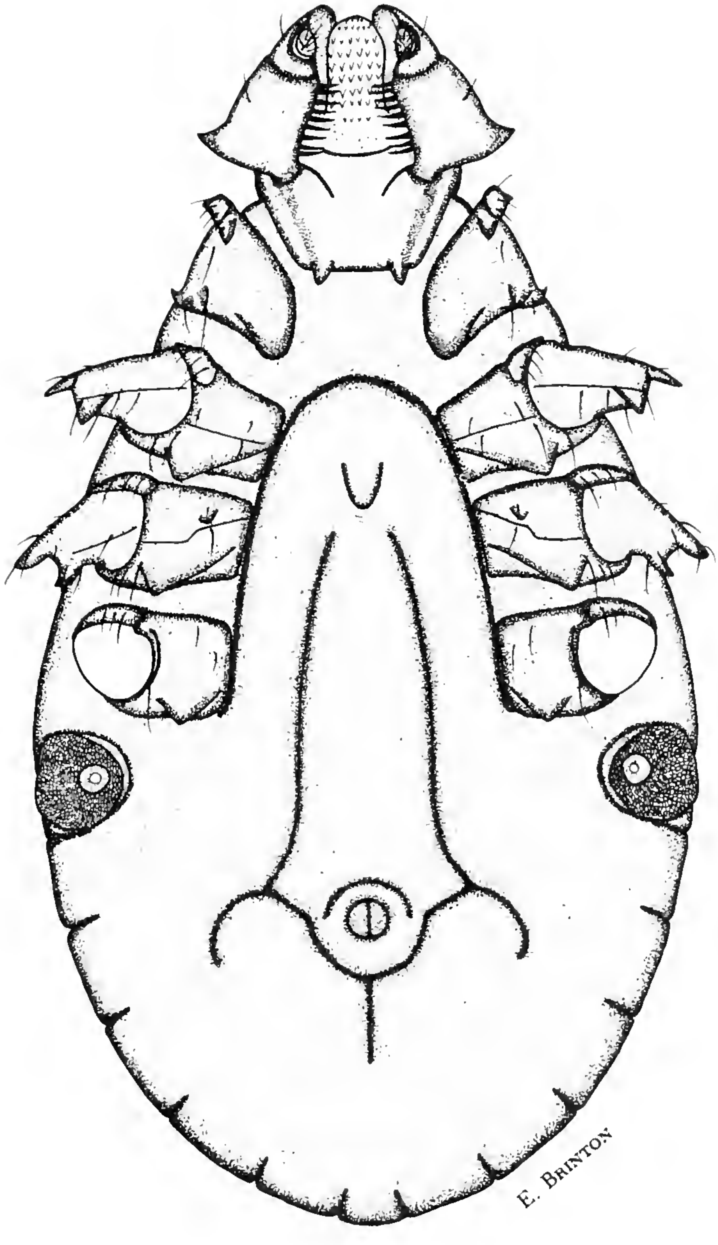


Fig. 8.—Ventral view, adult female *Haemaphysalis*.

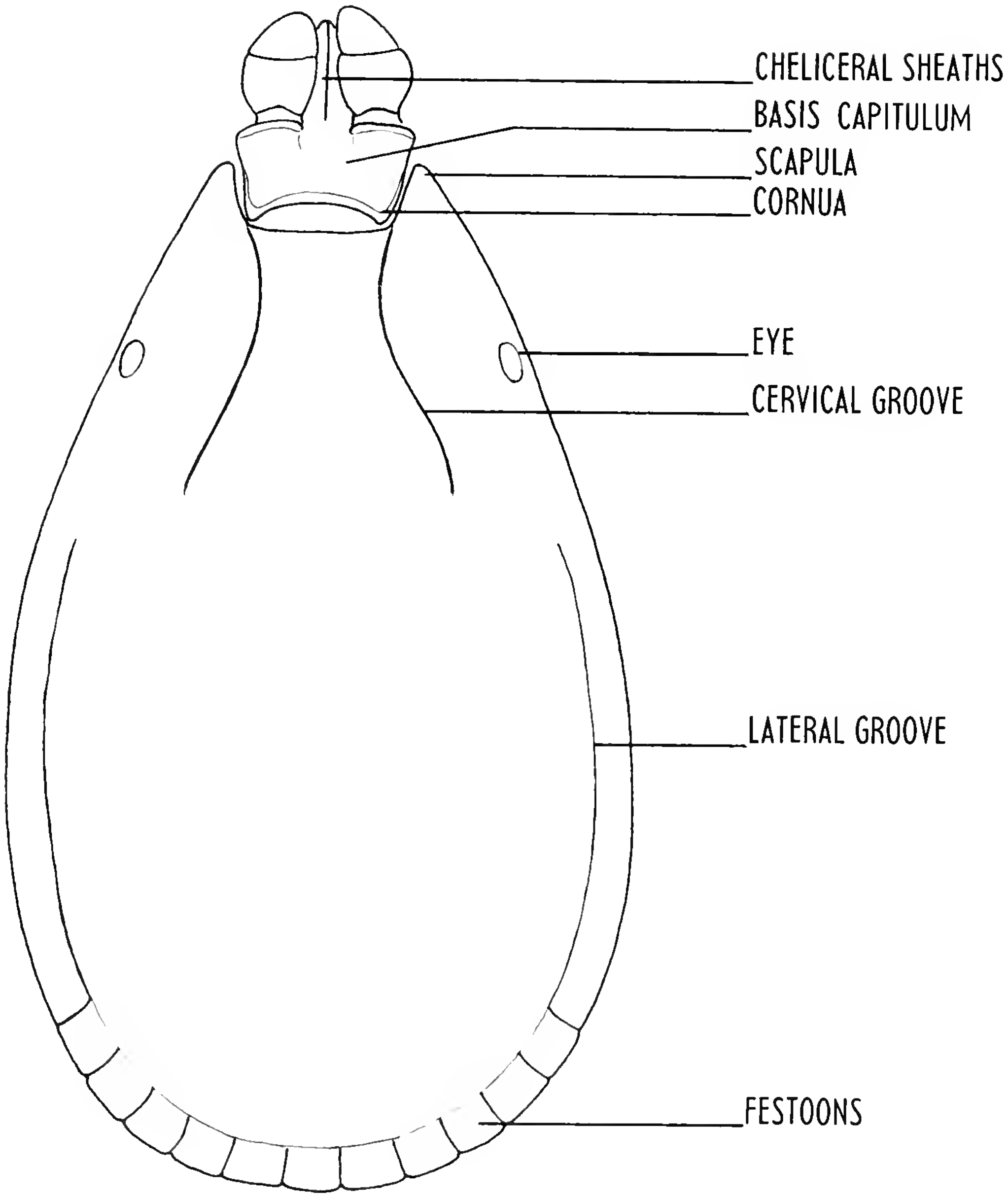


Fig. 9.—Dorsal view, adult male *Dermacentor*.

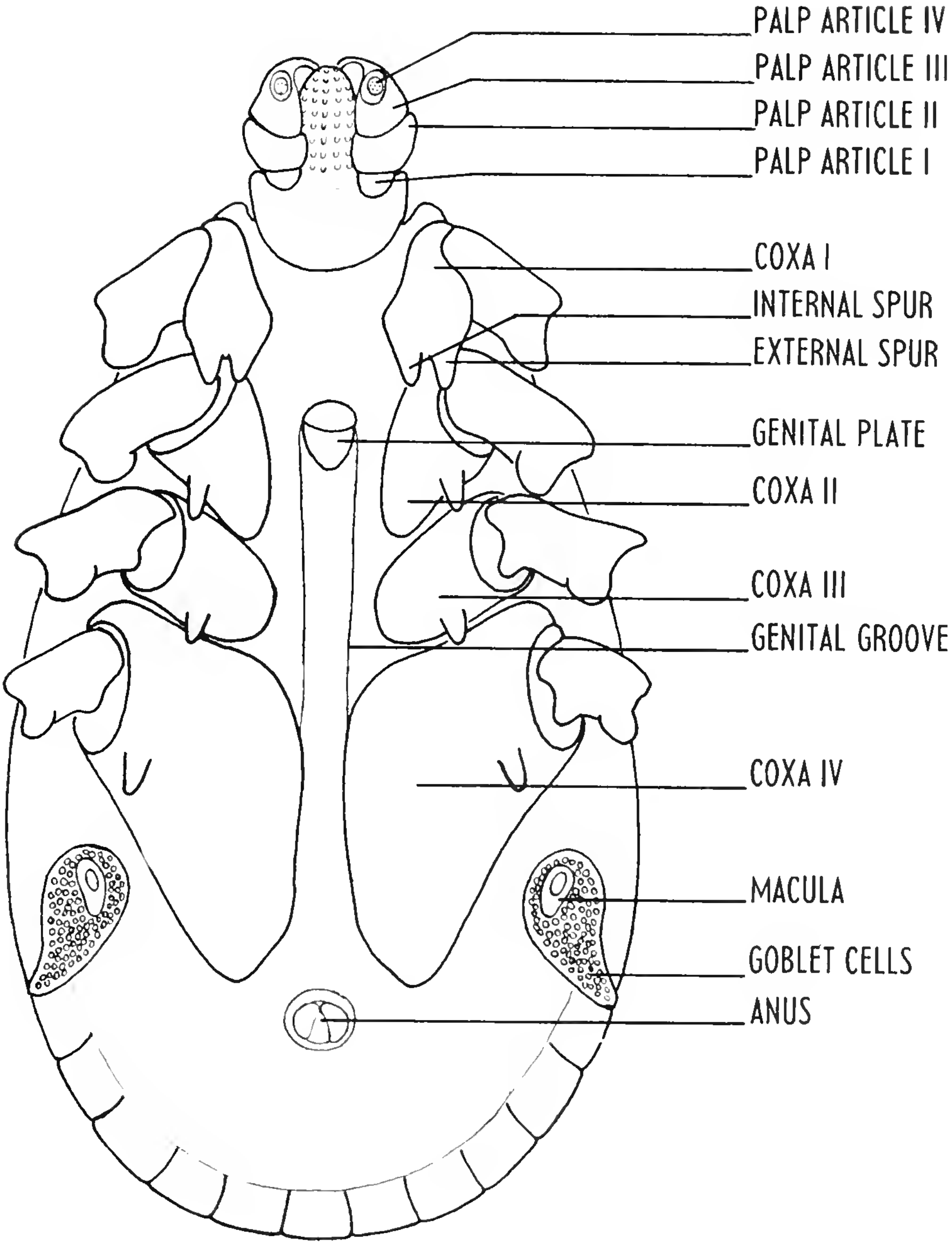


Fig. 10.—Ventral view, adult male *Dermacentor*.

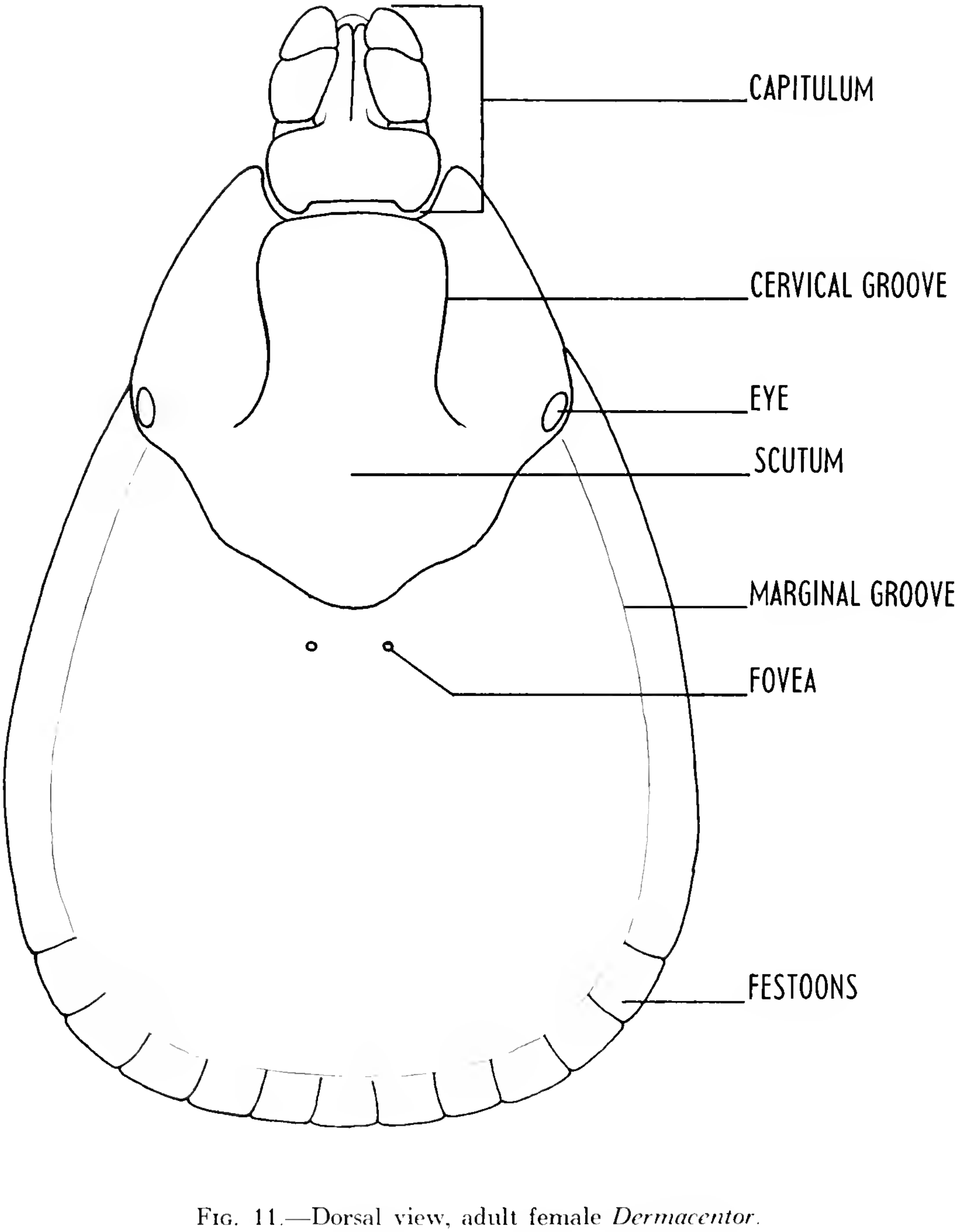


Fig. 11.—Dorsal view, adult female *Dermacentor*.

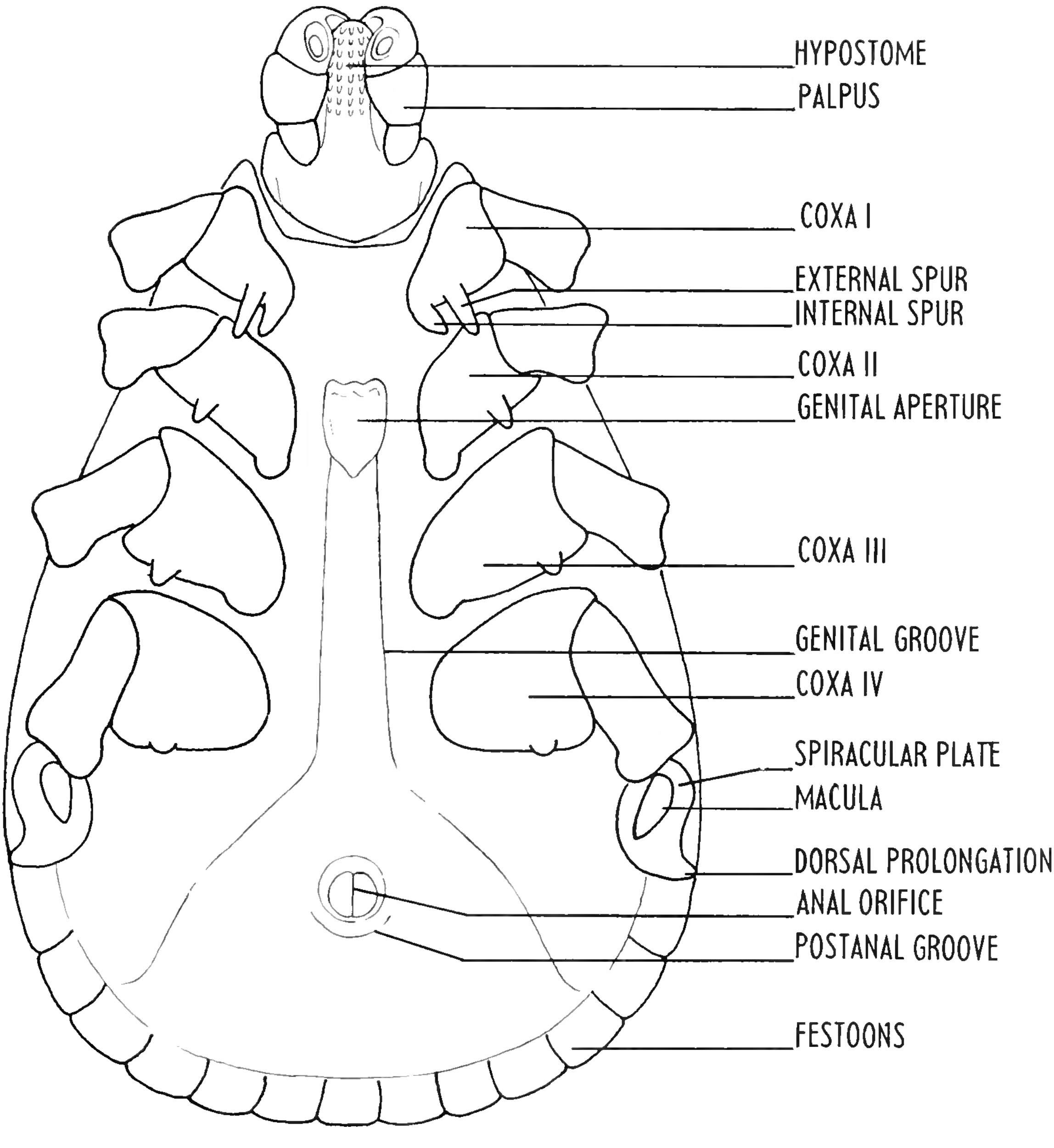


FIG. 12.—Ventral view, adult female *Dermacentor*.

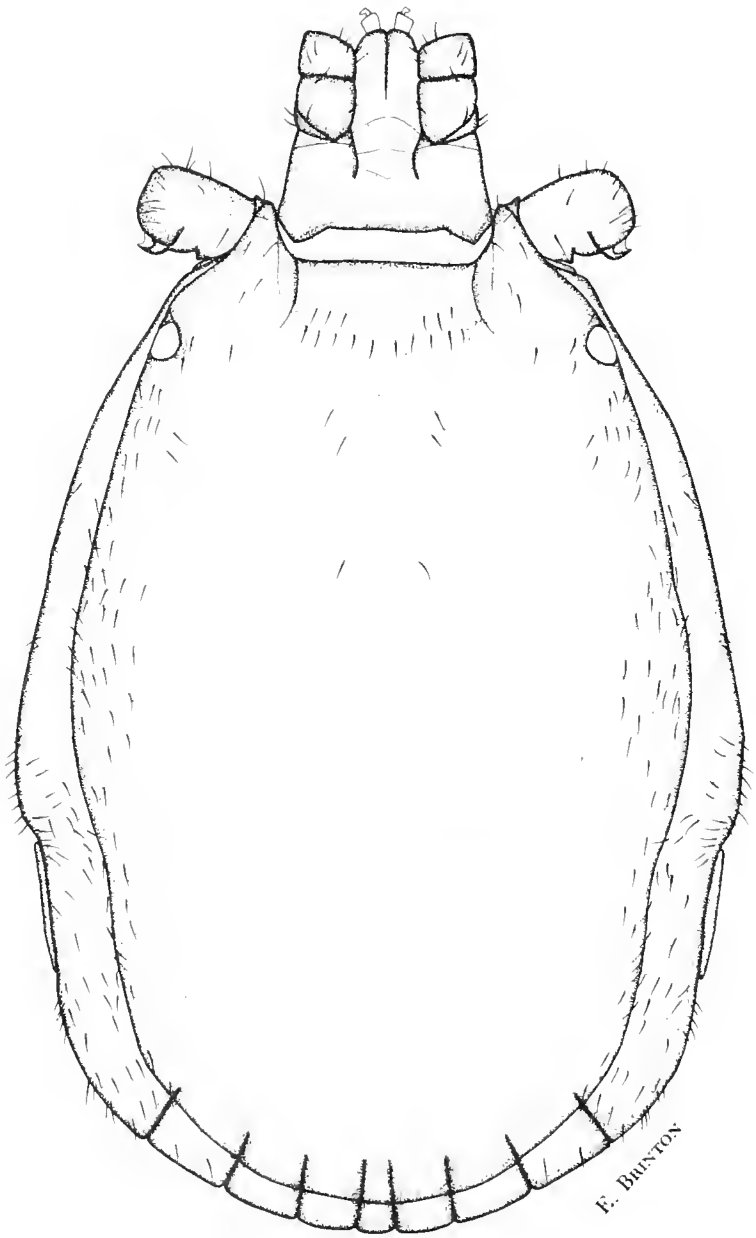


Fig. 13.—Dorsal view, adult male *Anocentor*.

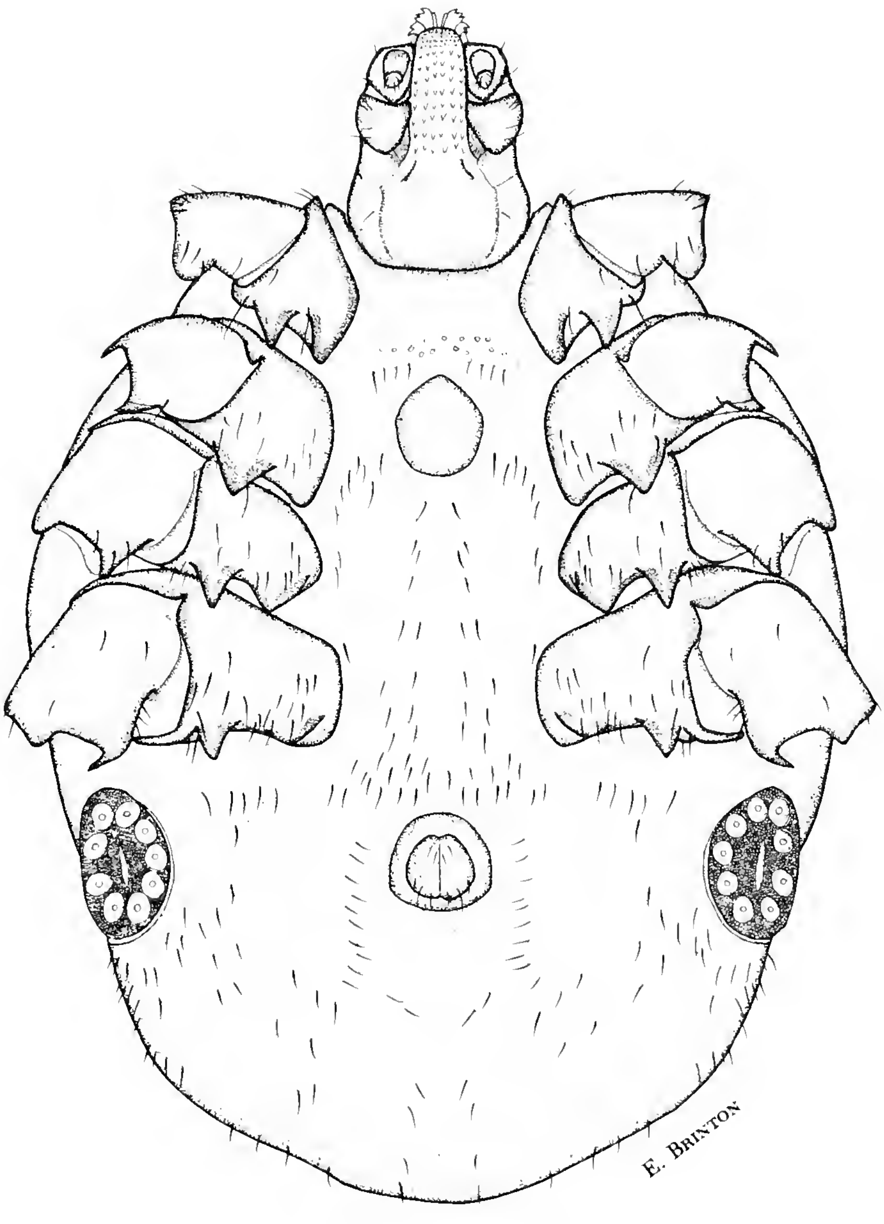


Fig. 14.—Ventral view, adult male *Anocentor*.

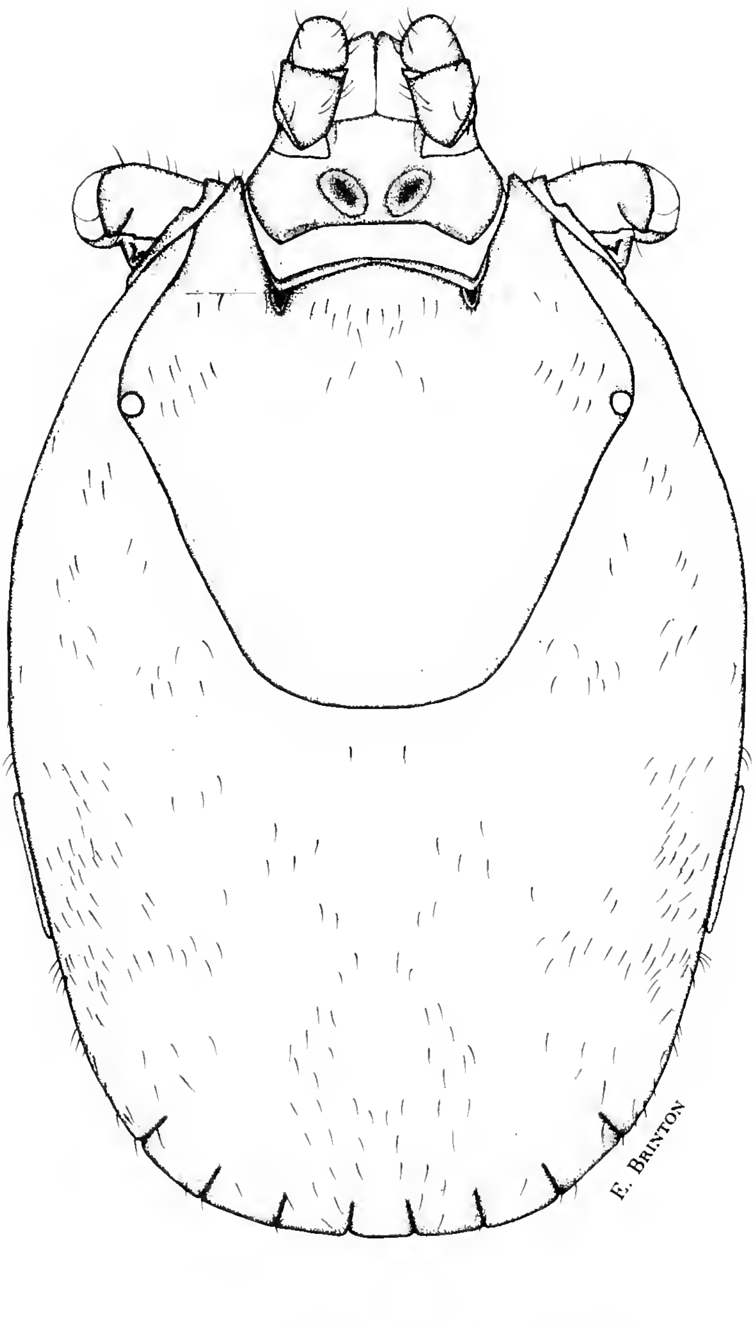


Fig. 15.—Dorsal view, adult female *Anocentor*.

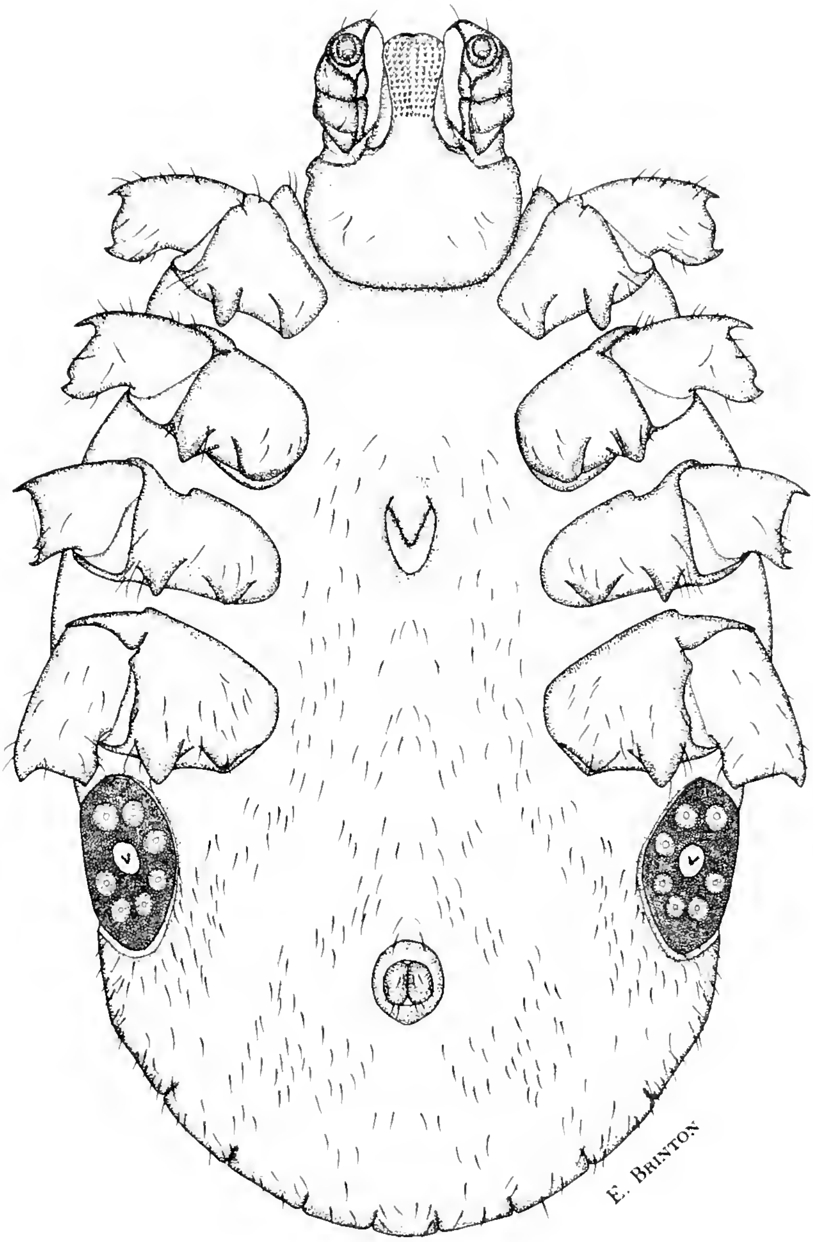


Fig. 16.—Ventral view, adult female *Anocentor*.

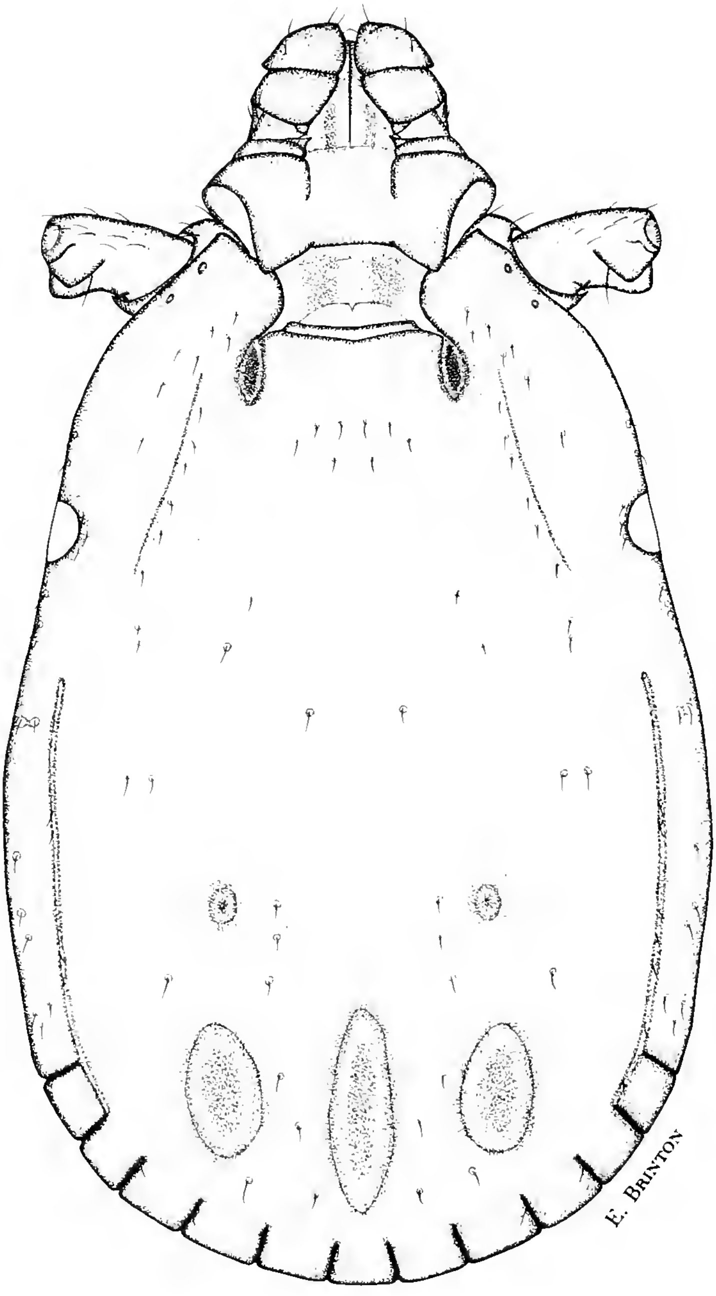


Fig. 17.—Dorsal view, adult male *Rhipicephalus*.

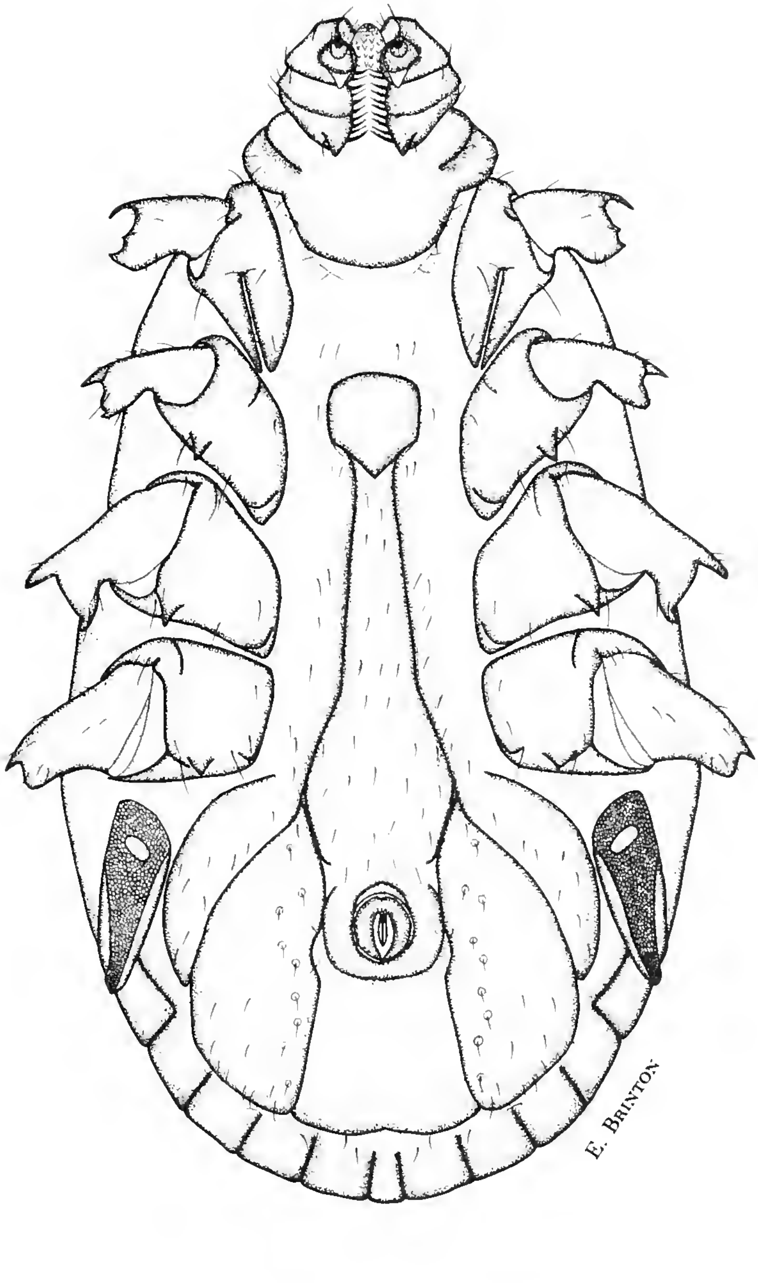


FIG. 18.—Ventral view, adult male *Rhipicephalus*.

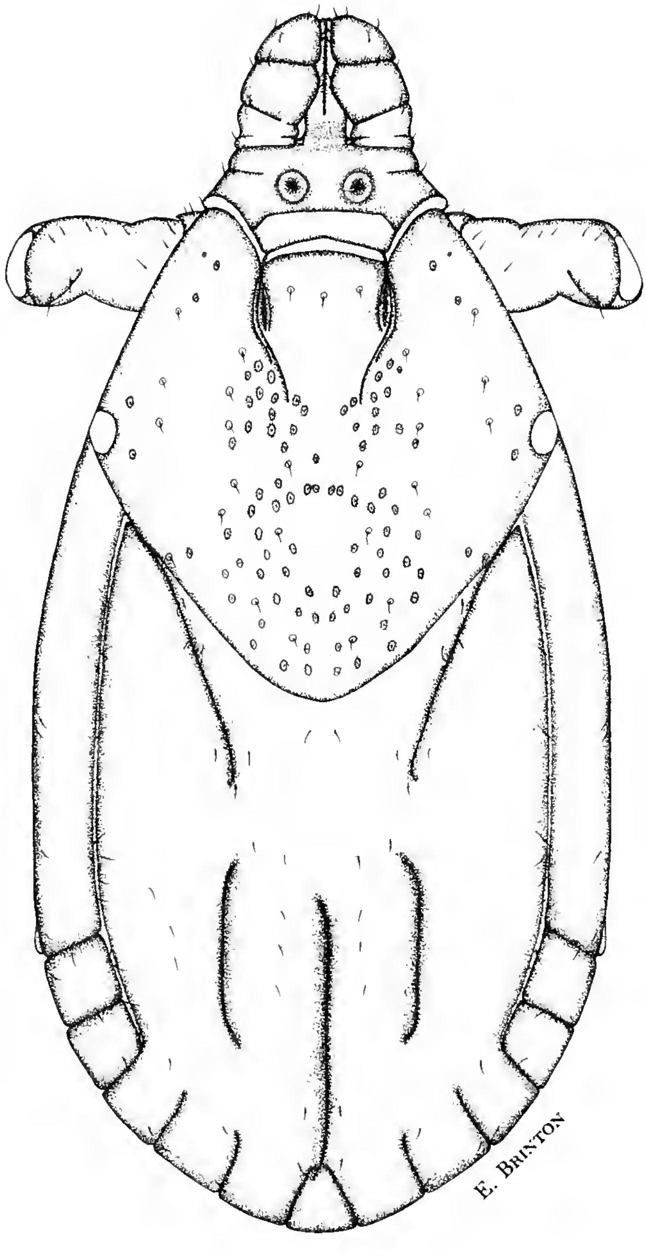


Fig. 19.—Dorsal view, adult female *Rhipicephalus.*

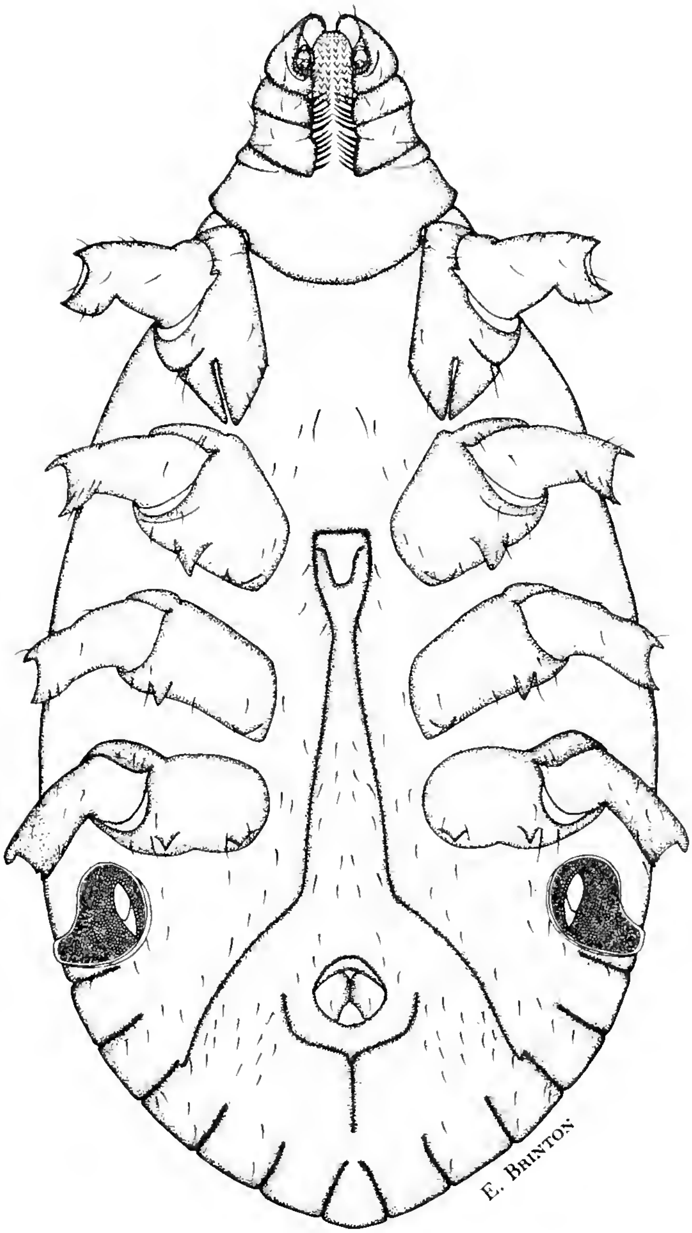


FIG. 20.—Ventral view, auult female *Rhipicephalus*.

References

Cooley, R. A. 1938. The Genera *Dermacentor* and *Otocentor* (Ixodidae) U.S. National Institutes of Health Bulletin 171.

Cooley, R. A. and Kohls, Glen M. 1945. The Genus *Ixodes* in North America. National Institutes of Health Bulletin 184.

Cooley, R. A. 1946. The Genera *Boophilus*, *Rhipicephalus*, and *Haemaphysalis* (Ixodidae) of the New World. National Institutes of Health Bulletin 187.

Gregson, J. D. 1956. The *Ixodoidea* of Canada. Publication 930, Science Service, Entomology Division, Canada Department of Agriculture.

Nuttall, F. H. F. and C. Warburton 1911 Ticks, a monograph of the Ixodoidea, Part II. Cambridge University Press, London.

Serdhukova, G. V. 1955. Zool. Zhurnal. 34(5):1037-1051.

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August, 1963

HARD-BODIED TICKS
OF THE WESTERN UNITED STATES

by

ELIAS P. BRINTON

and

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Brigham Young University

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Biological Series - Volume II, Number 3, Parts II and III

August, 1963

HARD-BODIED TICKS OF THE WESTERN UNITED STATES[1]

Parts II and III

PICTORIAL KEYS FOR THE SEPARATION OF GENERA IN NYMPHAL AND LARVAL STAGES

by

Elias P. Brinton[2]

and

D Elden Beck

INTRODUCTION

Part I, published as a separate study (Brinton & Beck, 1963), was concerned with the identification of adult hard-bodied ticks to the generic level. Parts II and III conclude the pictorial keys composed for the taxonomic seperation of the several ixodid genera found in the Western United States. With keys prepared for the classification of immature ticks and adults of all genera, the next logical step is the application of the same approach to the species of all genera. These additional studies will comprise the publication of subsequent parts of the overall study of the hard-bodied ticks of the Western United States.

We feel that illustrated keys of this type will be a valuable aid to workers concerned with the identification of ticks, especially at the larval and nymphal stages of development.

METHODS

In working up a suitable mounting procedure to prepare the immature ticks for examination, two clearing solutions and three mounting media were tried.

Two clearing solutions used were 85 percent lactic acid, and Nesbitt's solution. We found Nesbitt's solution to be much perferred in that it cleared the specimen faster. When mounted, the legs of the specimen readily extended. Nesbitt's solution is prepared (Evans, *et al.*, 1961, Strandtmann and Wharton, 1958) at room temperature as follows:

Chloral hydrate	40 g.
Water	25 g.
Hydrochloric acid	2.5 ml.

Polyvinyl alcohol (PVA) and two modifications of Berlese's gum chloral media—i.e., Hoyer's and de Faure's—were used as mounting media. For our work, Hoyer's medium was definitely superior. The specimens were much clearer, especially after being allowed to remain in a warming oven for a day or two. The legs remained extended, and the specimens were not distorted. Hoyer's medium is prepared (Evans, *et al.*, 1961, Strandtmann and Wharton, 1958) at room temperature as follows:

Distilled water	50 g.
Chloral hydrate	200 g.
Gum arabic or gum acacia	30 g.
Glycerin	20 g.

In preparing both larvae and nymphs to be observed microscopically, procedures must be used which will result in clear anatomical detail and a minimum of distortion. We found the following clearing and mounting procedure best among several which were tried.

Specimens were removed from the preservative, 70 percent ethyl alcohol, and placed in Nesbitt's solution where they were allowed to remain at room temperature. An hourly check on clearing was advisable. An additional period of not more than three hours was allowed beyond the time when the specimen first appeared to be cleared. Overcleaning is undesirable as this inhibits extension of the legs. It was not always necessary to puncture engorged specimens for some readily cleared without puncturing.

Best results in mounting the specimens on microslides were obtained by taking them directly from Nesbitt's solution and placing them in a drop of Hoyer's medium previously applied to the slide. Before the cover slip was applied, specimens were oriented in the medium to a desired position. This facilitated later observation under high power magnification. The mounted specimen was warmed over an alcohol lamp at brief intervals until the legs had been uniformly extended by the warmed medium. The prepared slide was then placed in a warming oven for 48 hours at a temperature of about 50° C. This caused further clearing and solidification of the mounting medium.

[1]This investigation supported in part by Research Grant AI-01273-07 from the National Institutes of Health, U.S. Public Health Service
[2]Department of Zoology and Entomology, Brigham Young University, Provo, Utah.

If at the end of 12 to 24 hours the legs had contracted from the extended position, rewarming over a flame usually caused them to extend again. Mounted slide specimens were ringed with Zut slide ringing compound.

Live specimens which had been immediately placed in preservative (70 percent ethyl alcohol) cleared much faster than dead specimens which had been removed from the host body. Laboratory-reared specimens should be allowed three to five days after hatching before they are placed in the preservative. This waiting period permits sclerotization of the integument to take place.

Toward the end of our study, we began preserving our ticks in Oudeman's fluid. This preservative has definite advantages over 70 percent ethyl alcohol, in that the specimens die with their legs fully extended. In addition, glycerol which is in the fluid will prevent complete dessication of the specimen should the alcohol evaporate. Our preparation of Oudeman's fluid is as follows:

70% ethyl alcohol	87 parts
Glycerin	5 parts
Glacial acetic acid	8 parts

It is our suggestion that all laboratory specimens be preserved in the above fluid, and the same be applied to field collected specimens when possible.

Drawings of the immature stages were made from slide specimens selected from series of slides examined with the use of a Zeiss phase-contrast microscope. Selected specimens were then placed on a Leitz microslide projector, and the body outline was reproduced on Quadrille paper ruled ten squares to the inch. A penciled general outline of the specimen showing general anatomical arrangement was sketched on the Quadrille paper. Dorsal and ventral aspects were drawn. Details of anatomical and morphological structure were obtained and added to the sketch, by careful examination of each selected specimen with the use of the phase-contrast microscope. Final drawings were accomplished by comparing the semi-completed sketch with unmounted specimens observed with a Leitz stereomicroscope at magnifications of 120-216 diameters. Best illumination for the latter was obtained by use of two A.O. Universal Illuminators located about four inches from the specimens. This final comparative examination is important. In making drawings of the specimen compressed by the cover slip some distortion may be expected.

Workers using our pictorial keys will be dealing with both mounted and unmounted specimens. Initially we used Polyvinyl alcohol (PVA) as a mounting medium. Several disadvantages were found in using it. The following are some examples. When mounted specimens are flamed over the alcohol lamp, they often become distorted due to swelling. This is especially true for the intersegmental membrane between the coxa and trochanter. Specimens which had been mounted for a period of about three to four weeks were found to be distorted due to excessive flattening caused by contraction of the PVA under the cover slip. We are also of the opinion that PVA reduces the clarity as observed by the phase-contrast microscope.

Palp article two in all stages of development in *Haemaphysalis* of the new world species has a distinct lateral angular projection. While this character is common to all known new world species—i.e., *H. leporis-palustris* (Packard), *H. chordeilis* (Packard) and *H. juxtakochi* Cooley (Kohls, 1960)—it is not common to all old world and Asian species. The drawings made for this study were *H. leporis-palustris*.

The posterior scutal margin of the different stages of development for *Dermacentor* in the Western United States are generally constant with only slight variation. The genus *Ixodes* in the Western United States shows a distinct variation of the posterior scutal margin in all stages of development.

Chaetotaxy was not used to characterize the several genera of ixodid ticks studied for the Western U.S. For example, the pattern of arrangement in *Dermacentor*, *Anocentor*, and *Rhipicephalus* was markedly similar. In *Haemaphysalis* and *Ixodes* however there was an obvious difference in the pattern of arrangement.

Sufficient observation of the setal organization was not made with the nymphs of several genera used in this study to allow generalizations to be made about the patterns of arrangement. The same approach was taken with respect to the adults. The reason that setal examination was not thoroughly investigated and used extensively is that other more obvious characteristics were found that could be used for generic separation. Although we have made relatively limited use of setae in this study, we nevertheless use the same terminology established by Glashinskaya-Babenko (1949) as adapted by Clifford and Anastos (1960).

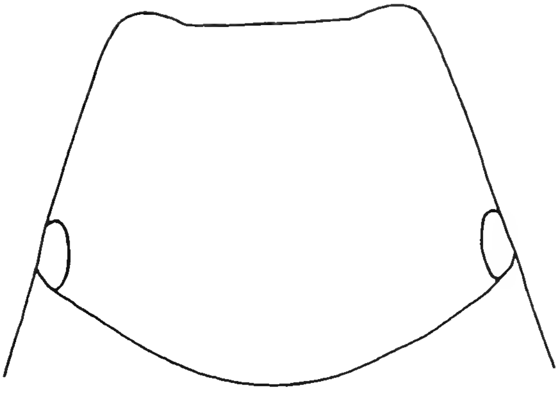
The only integumentary sense organs included in this study were the sensilla sagittiformia located posterior to each coxal plate and a dorso-lateral pair on the opisthosoma in the larvae (Schultz 1942, Dinnik and Zumpt, 1949). See couplet 2 in the key for the identification of the larvae. Also see Figures 33, 35, 37, and 39. The nymphal (and adult) specimens of *A. nitens* were densely hirsute on the idiosoma. Hirsuteness was considered as sparse in the other genera. See Figures 27, 28, and 29, 30.

ACKNOWLEDGMENTS

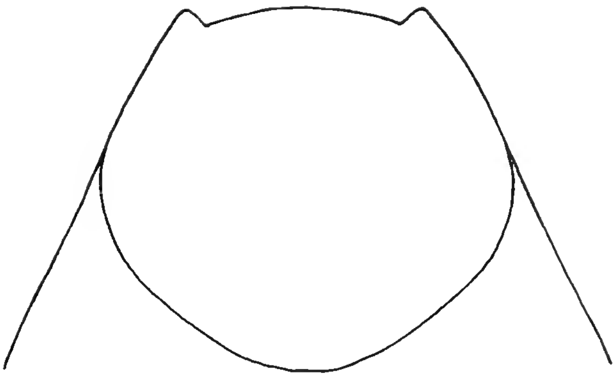
We wish to express our appreciation to the following workers who were not mentioned in Part I: Dr. Betty S. Davis of the University of California's Hastings Natural History Reservation for her co-operation in loaning us a part of their tick collection, Mrs. Eleanor K. Jones of the Rocky Mountain Laboratory for her help and suggestions in aiding us to obtain a reliable mounting procedure, and Mr. Charles L. Douglas of the Wetherill Mesa Archaeological Project, Mesa Verde National Park for the loan of their tick material.

PICTORIAL KEY FOR SEPARATION OF NYMPHS

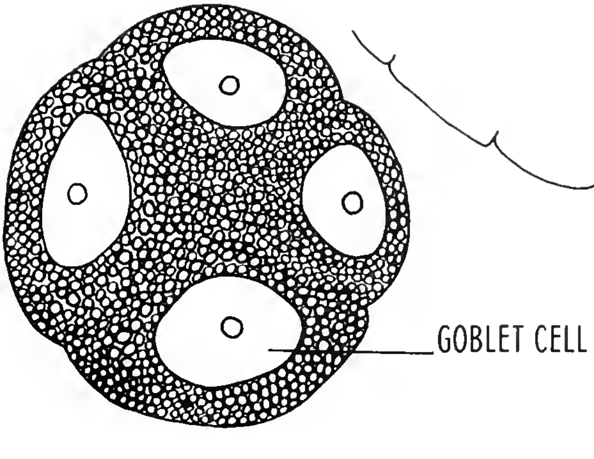
1. Eyes present 2

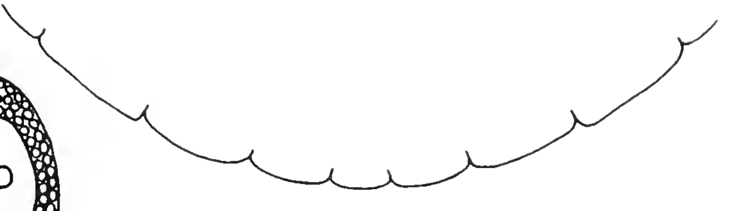


Eyes absent 4

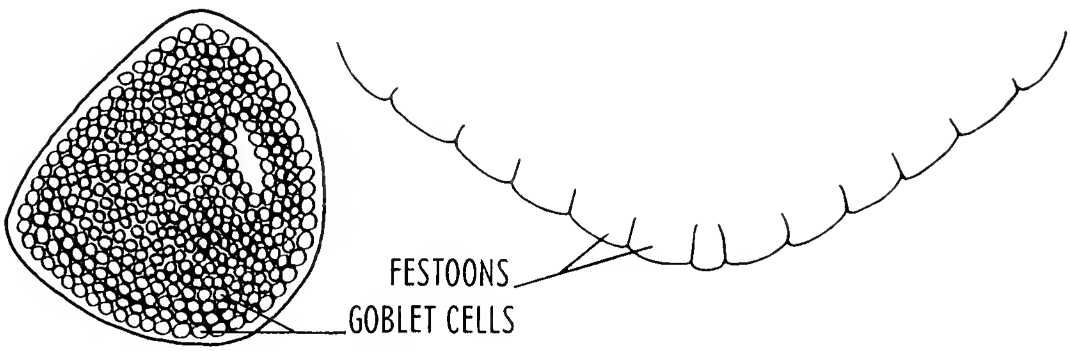


2. Goblet cells very large, usually three to four in number.
Seven festoons present .... *Anocentor*
See Figures 27 and 28 for dorsal and ventral views of nymph.

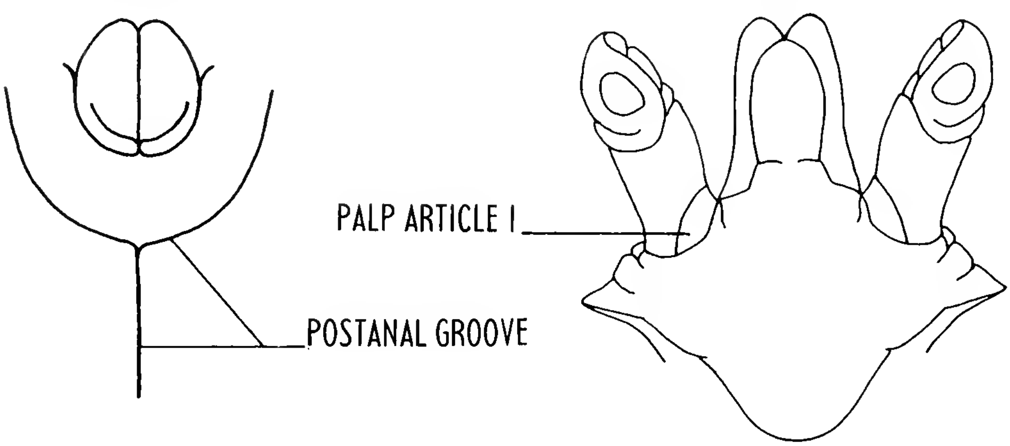




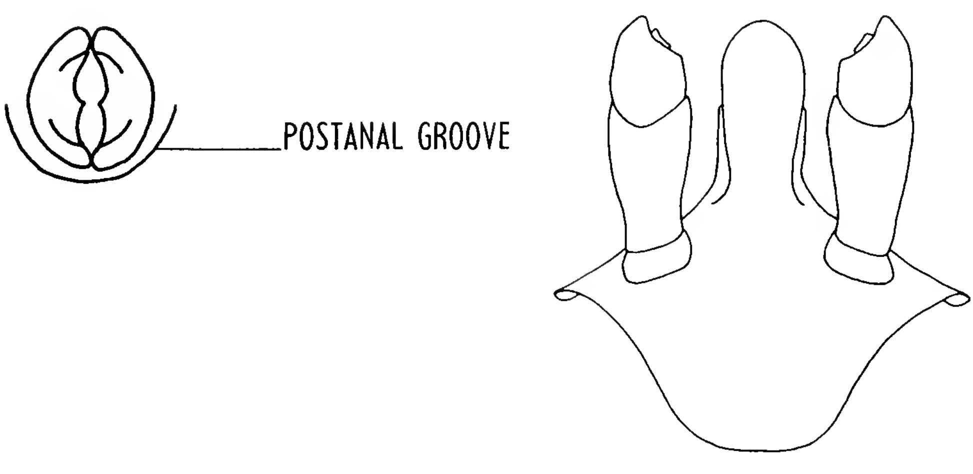
Goblet cells small to moderate, more than four in number. Eleven festoons present 3



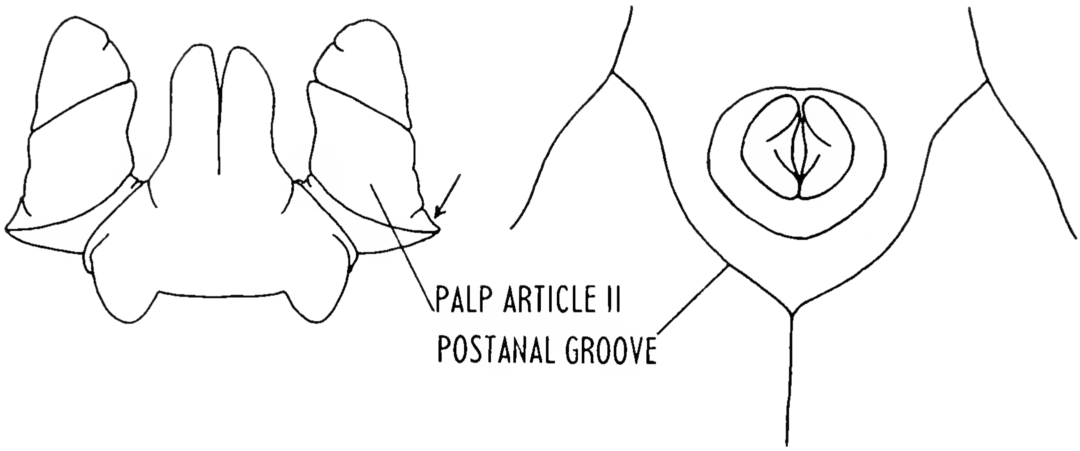
3. Postanal groove distinct. Palp article I not visible dorsally, small and angular ventrally .... *Rhipicephalus*
See Figures 29 and 30 for dorsal and ventral views of nymph.



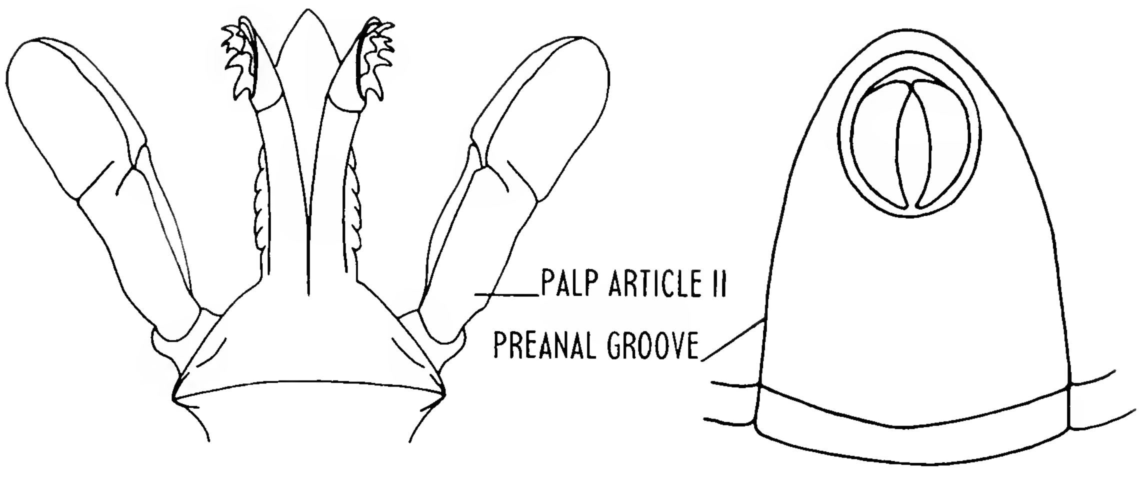
Postanal groove indistinct. Palp article I inconspicious dorsally, not small and angular ventrally .... *Dermacentor*
See Figures 25 and 26 for dorsal and ventral views of nymph.



4. Palp article II laterally triangular. Postanal groove conspicuous and posterior to anus .... *Haemaphysalis*
See Figures 23 and 24 for dorsal and ventral views of nymph.

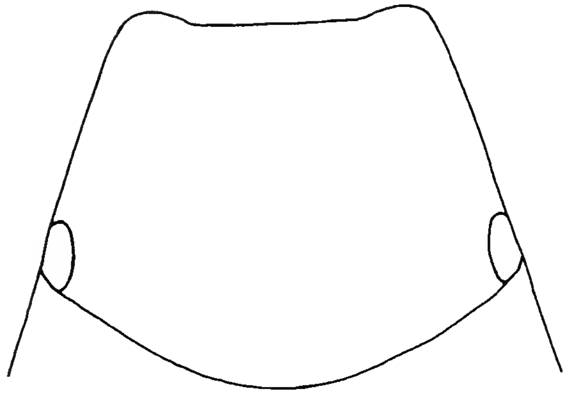


Palp article II not laterally triangular. Preanal groove extending anterior to anus .... *Ixodes*
See Figures 21 and 22 for dorsal and ventral views of nymph.

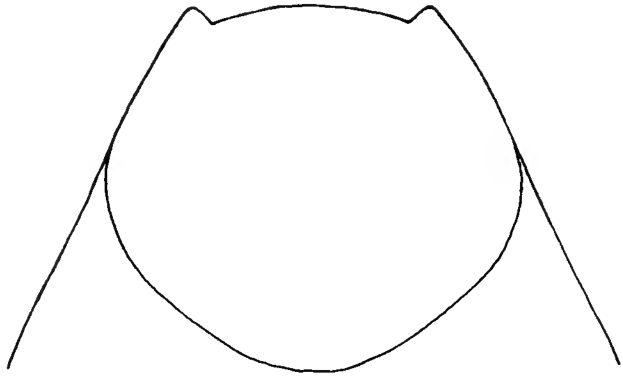


PICTORIAL KEY FOR SEPARATION OF LARVAE

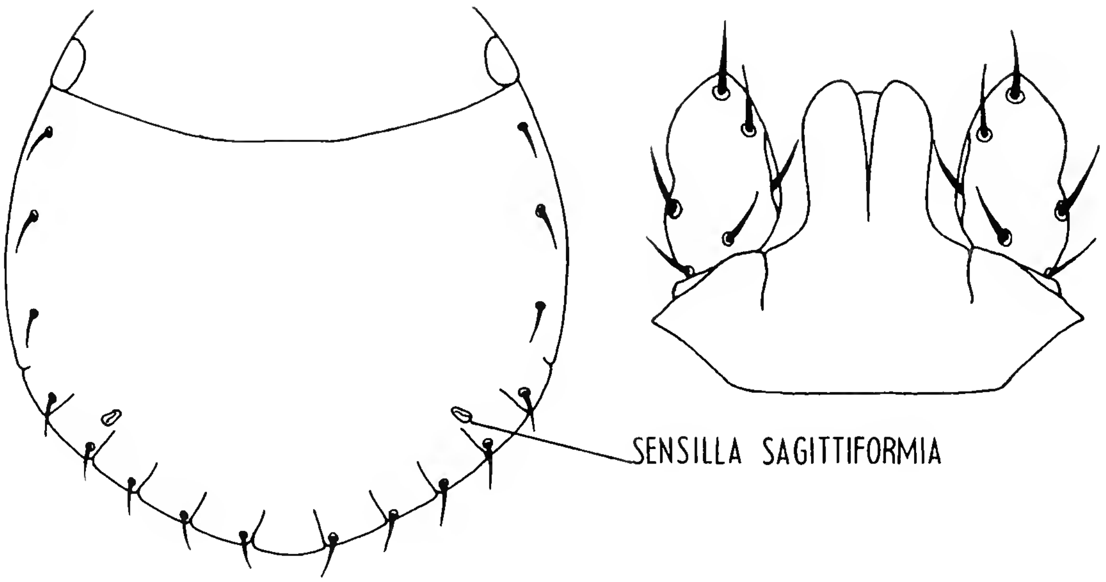
1. Eyes present 2



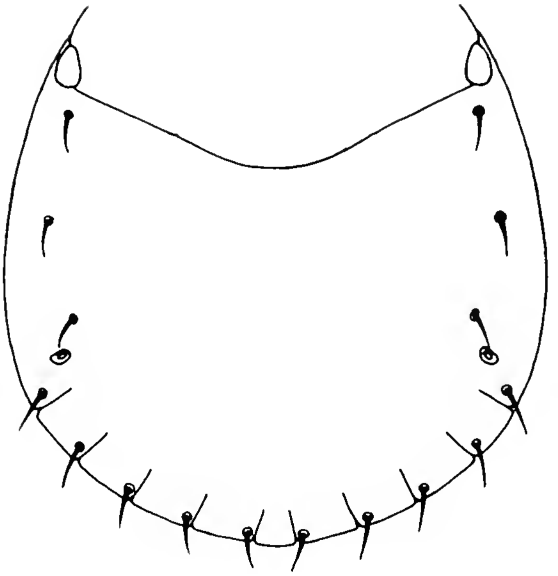
Eyes absent 4

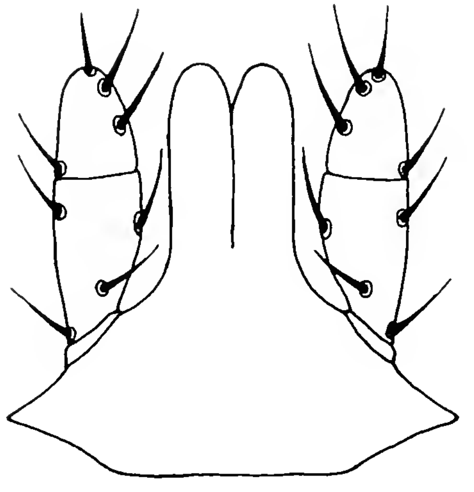


2. Four pairs of marginal dorsal setae anterior to sensilla sagittiformia. Apex of palps narrowly rounded, tending to be somewhat acute .... *Rhipicephalus*
See Figures 39 and 40 for dorsal and ventral views of larva.

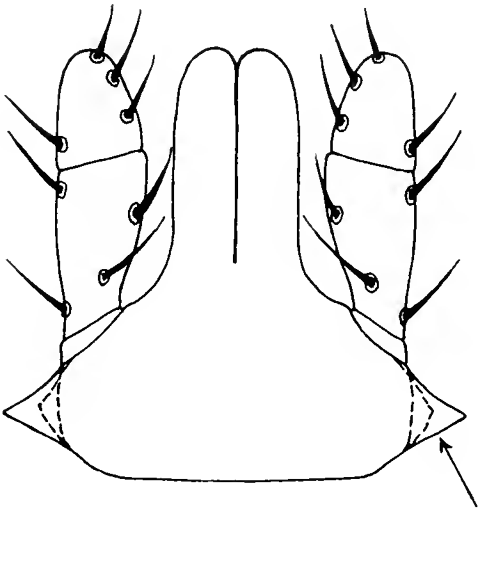


Three pairs of marginal dorsal setae anterior to sensilla sagittiformia. Apex of palps not narrowly rounded, tending to be evenly rounded . . . 3

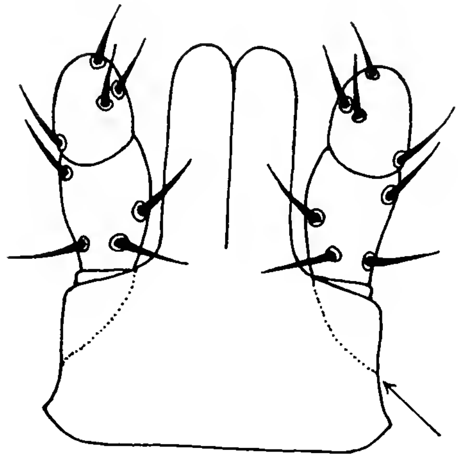




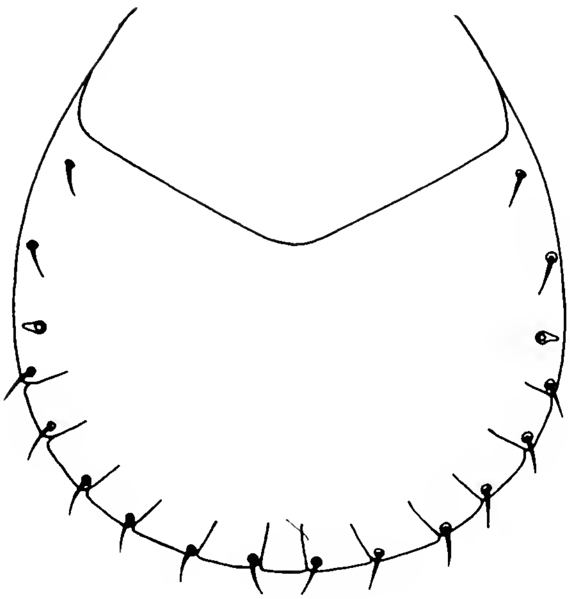
3. Basis capitulum laterally angulate or moderately rounded .... *Dermacentor*
See Figures 35 and 36 for dorsal and ventral views of larva

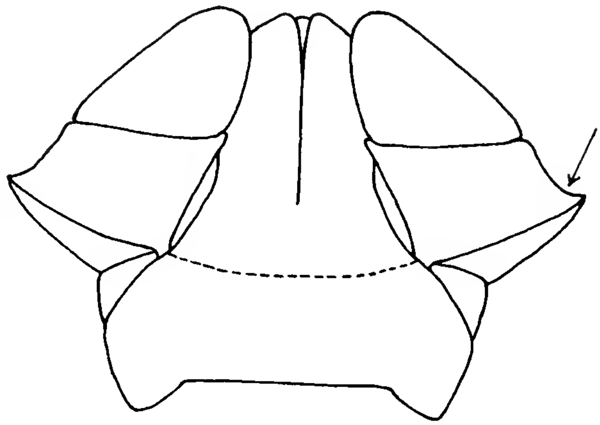


Basis capitulum laterally truncate (square) .... *Anocentor*
See Figures 3 7and 38 for dorsal and ventral views of larva.

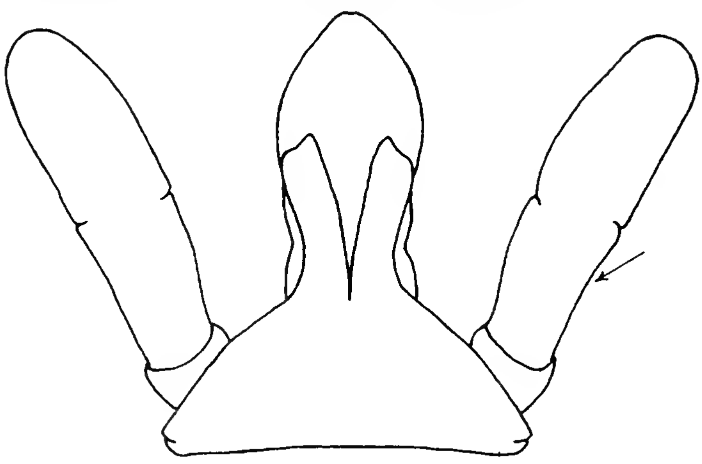


4. Sensilla sagittiformia present. Palp article II laterally triangulate .... *Haemaphysalis*
See Figures 33 and 34 for dorsal and ventral views of larva.





Sensilla sagittiformia absent. Palp article II not laterally triangulate *Ixodes*
See Figures 31 and 32 for dorsal and ventral views of larva.



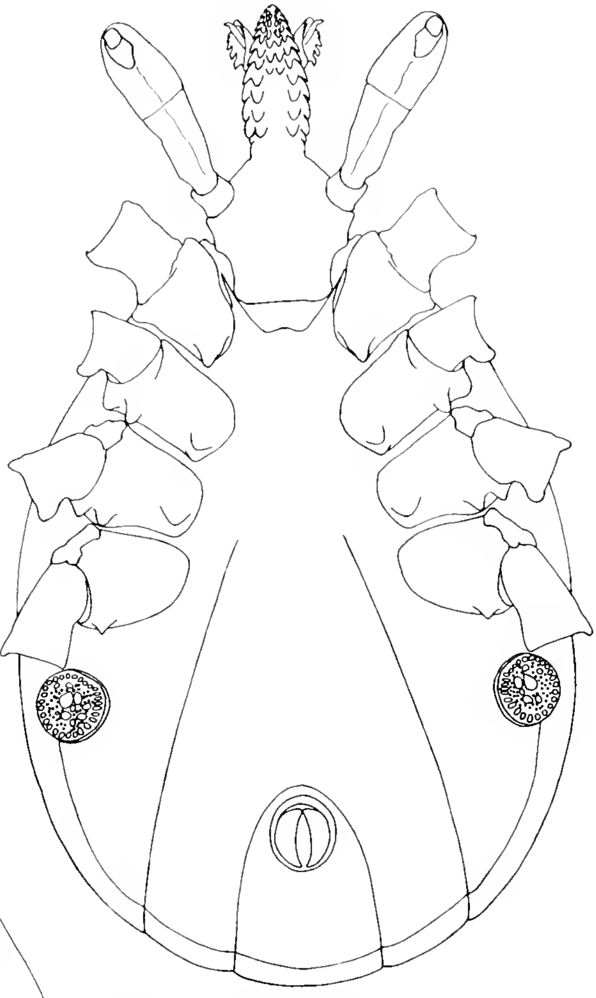


FIG. 22.—Ventral view nymphal *Ixodes*

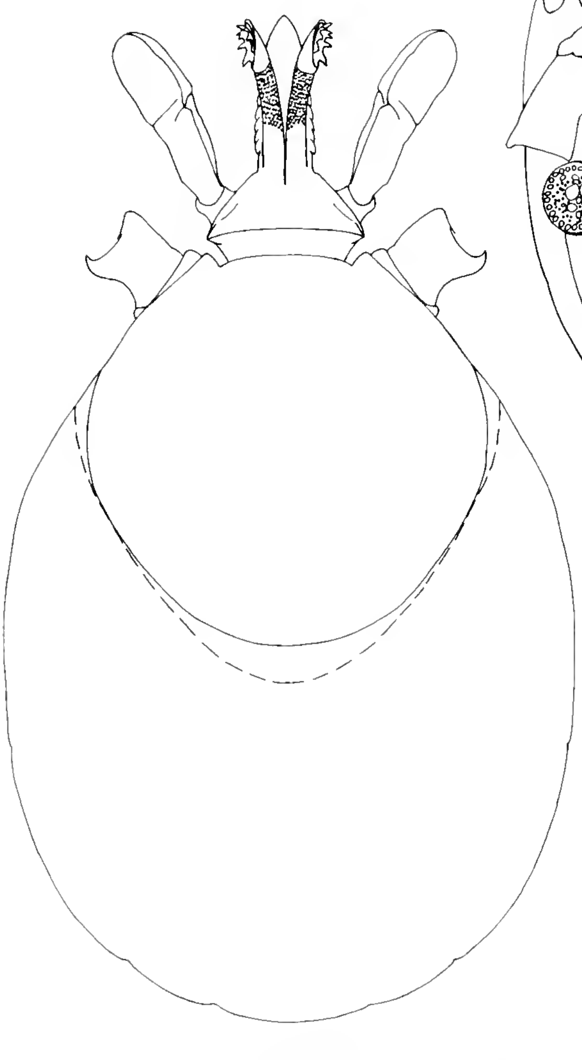


FIG. 21.—Dorsal view nymphal *Ixodes*.

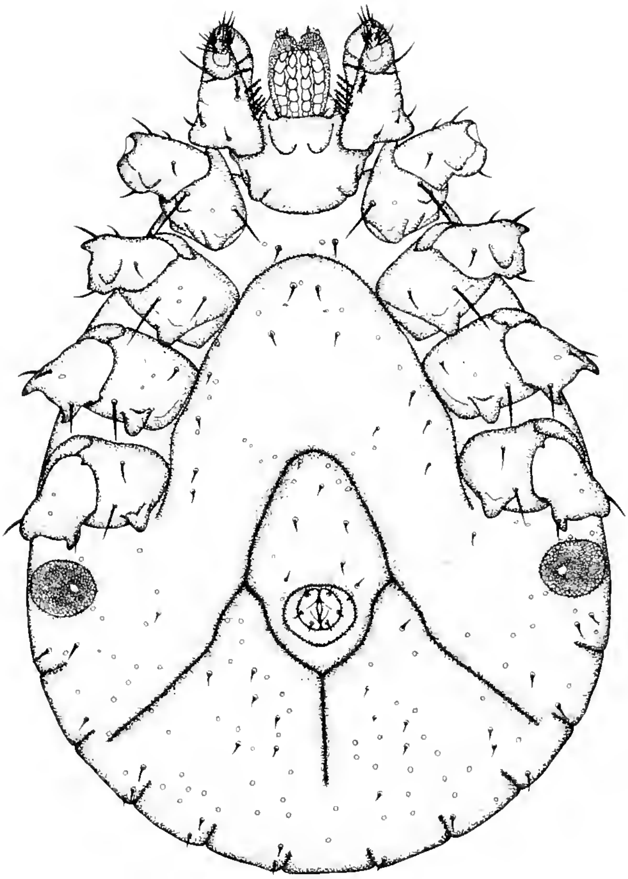


FIG. 24.—Ventral view nymphal *Haemaphysalis*

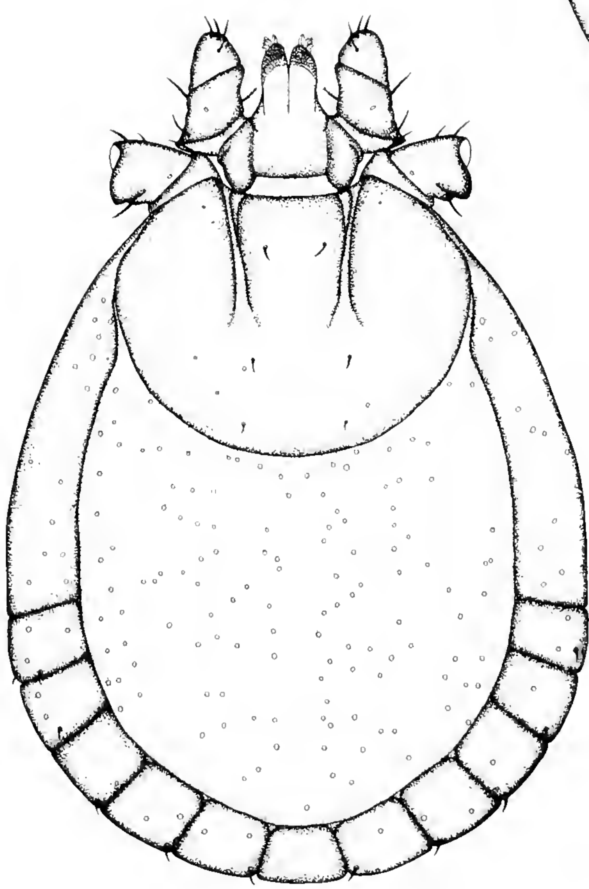


FIG. 23.—Dorsal view of nymphal *Haemaphysalis*

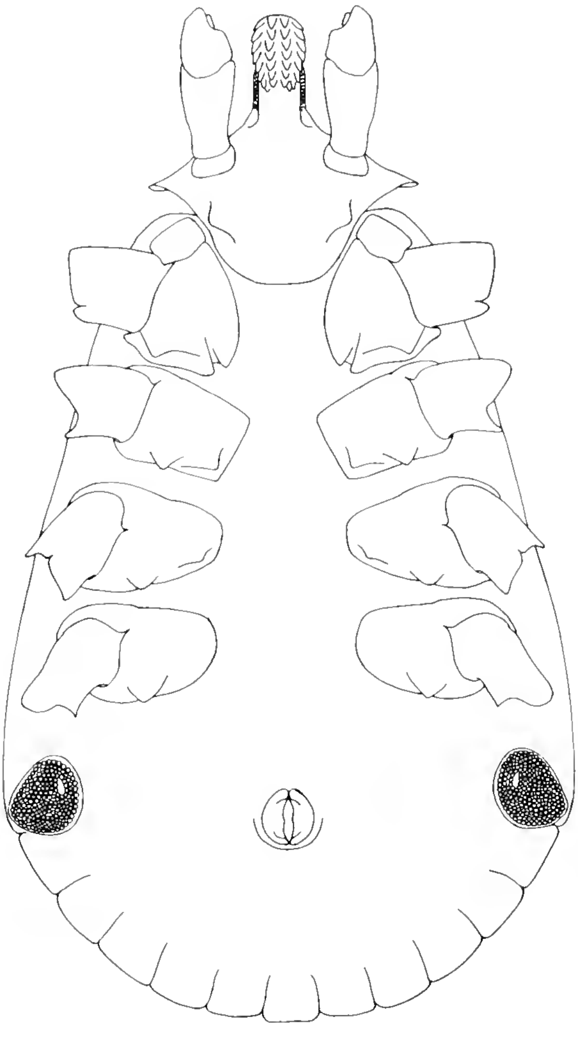


Fig. 26.—Ventral view of nymphal *Dermacentor*

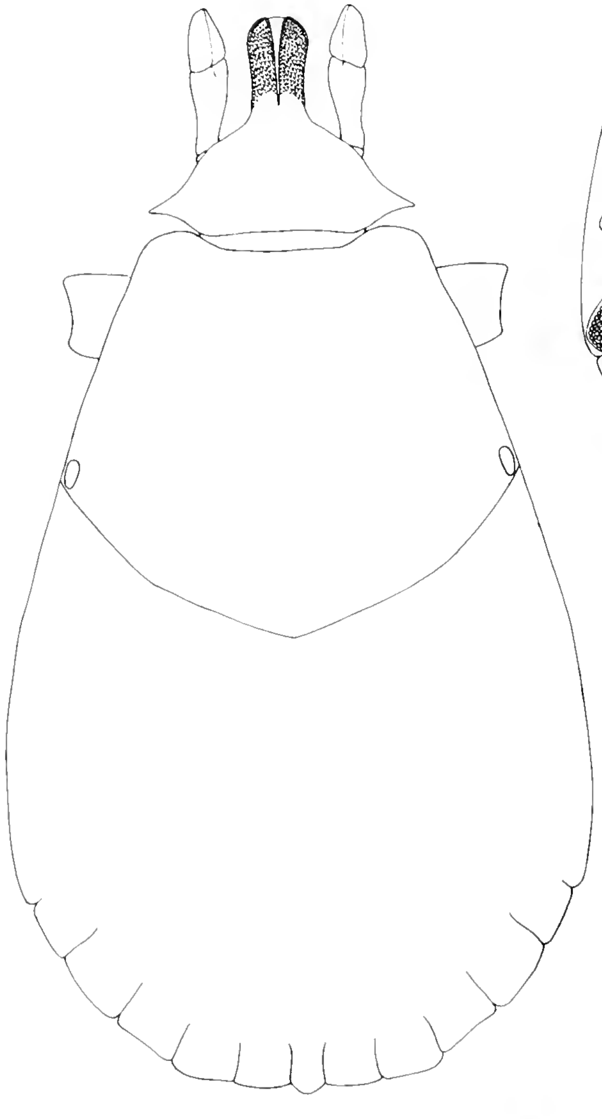


Fig. 25.—Dorsal view of nymphal *Dermacentor*

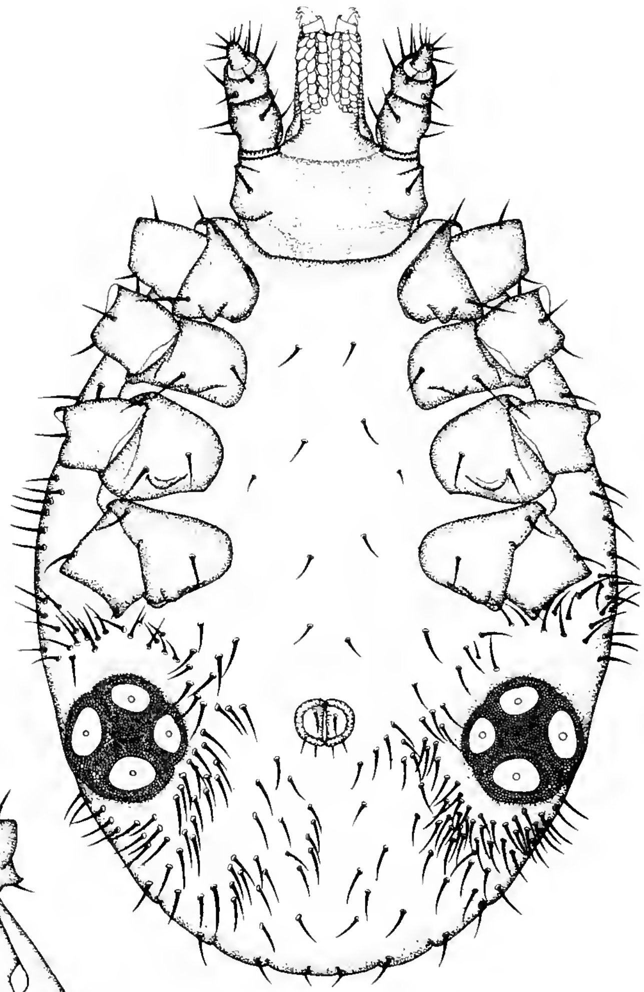


FIG. 28.—Ventral view of nymphal *Anocentor*

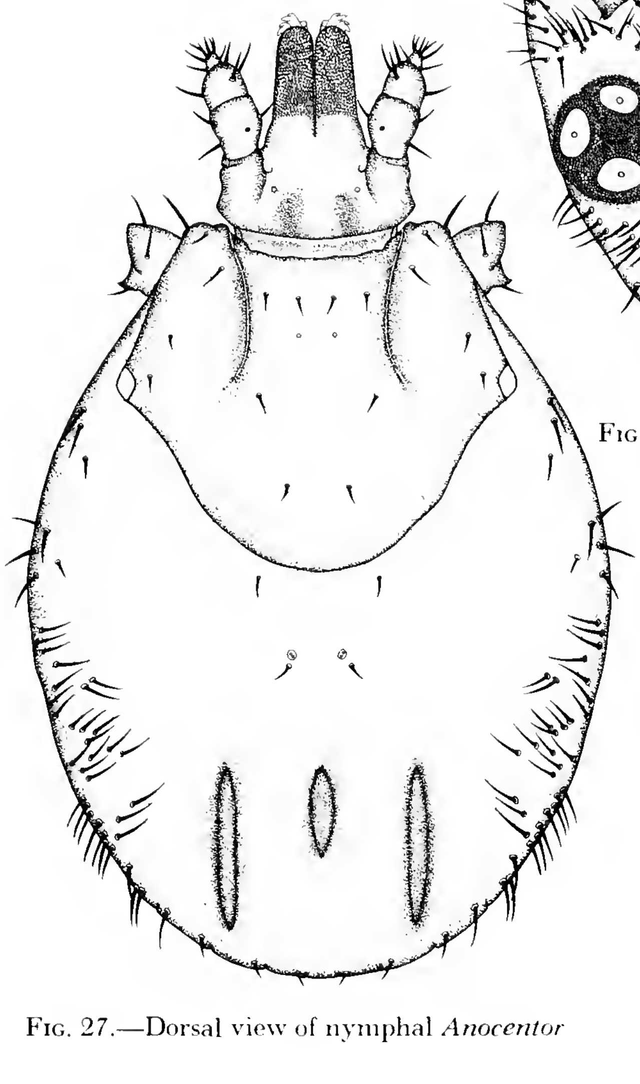


FIG. 27.—Dorsal view of nymphal *Anocentor*

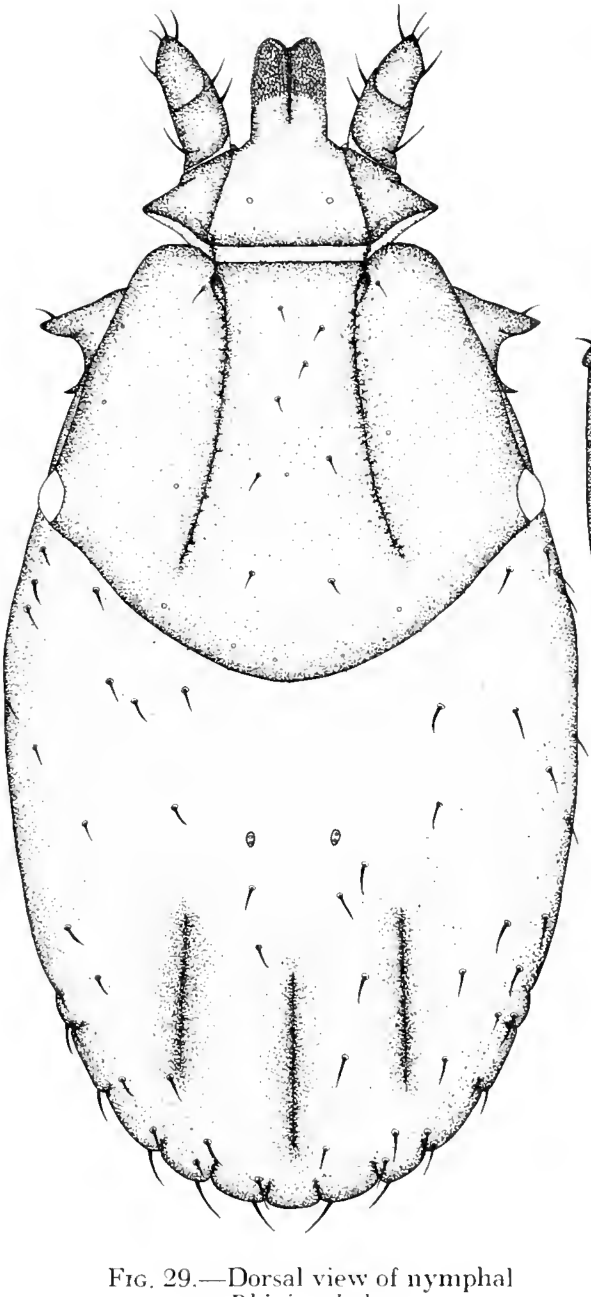


FIG. 29.—Dorsal view of nymphal *Rhipicephalus*

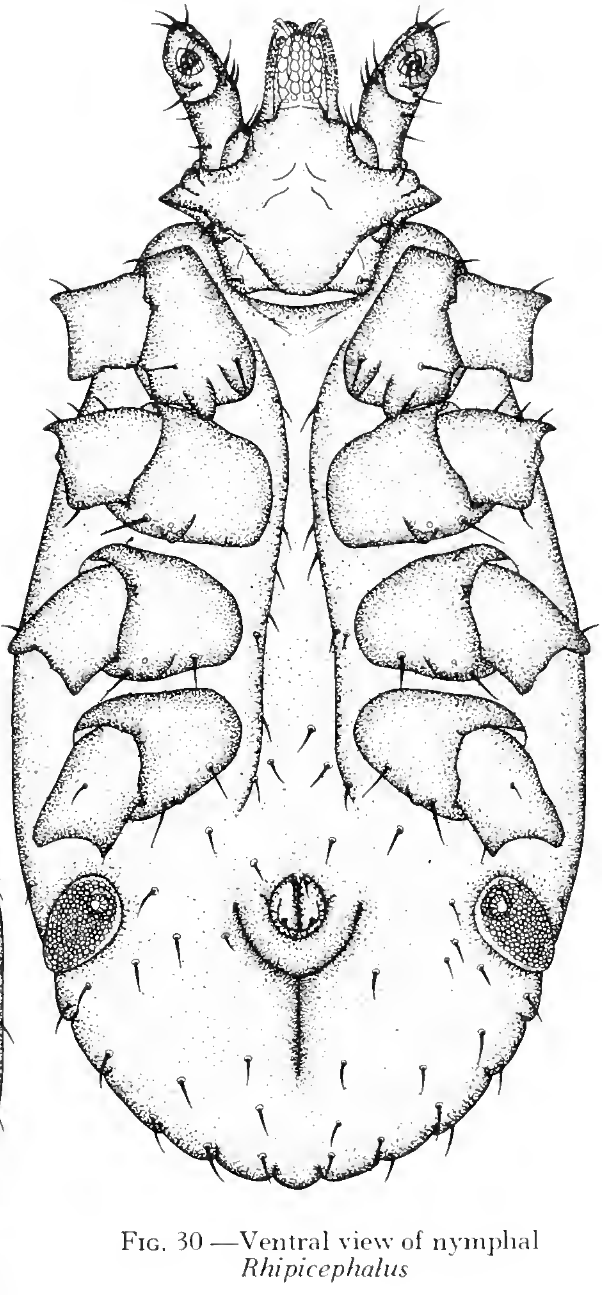


FIG. 30.—Ventral view of nymphal *Rhipicephalus*

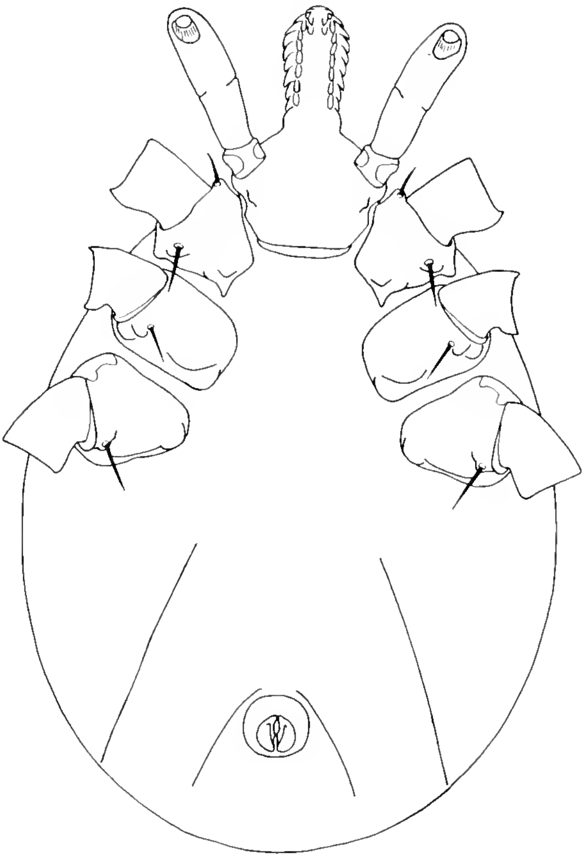


FIG. 32.—Ventral view of larval *Ixodes*

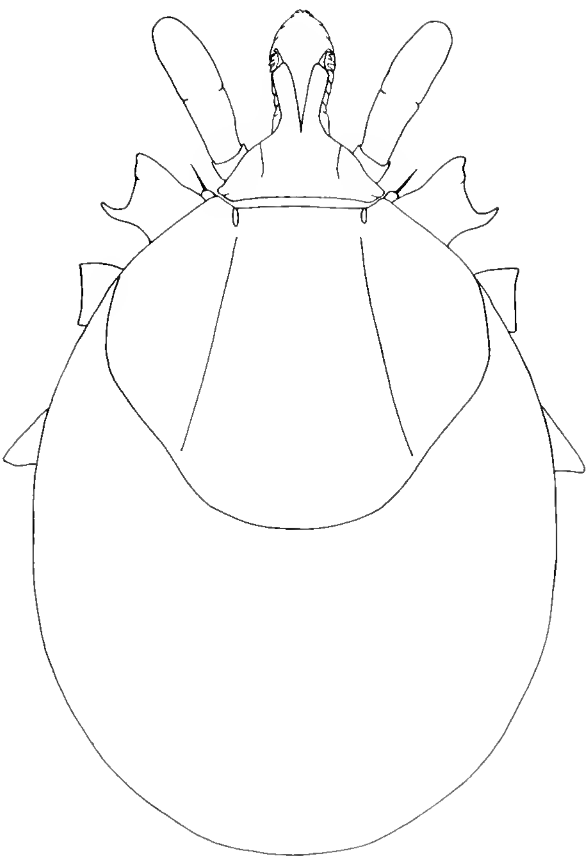


FIG. 31.—Dorsal view of larval *Ixodes*

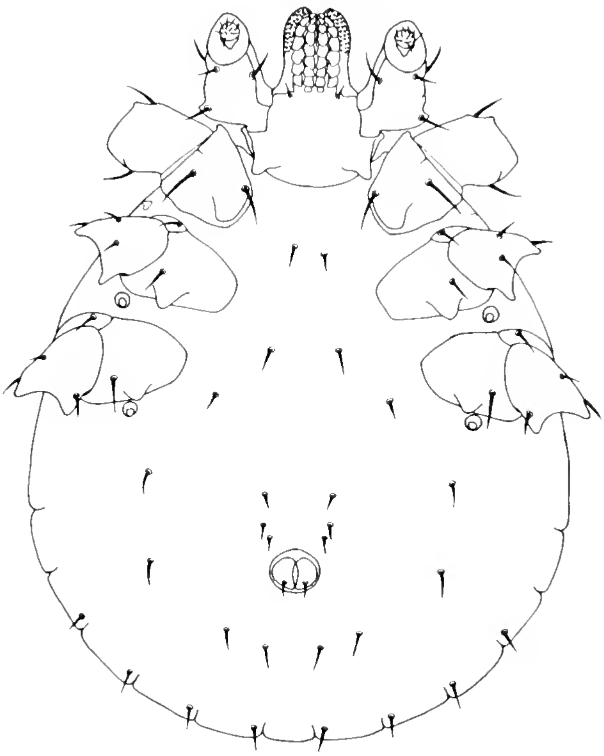


Fig. 34.—Ventral view of larval *Haemaphysalis*

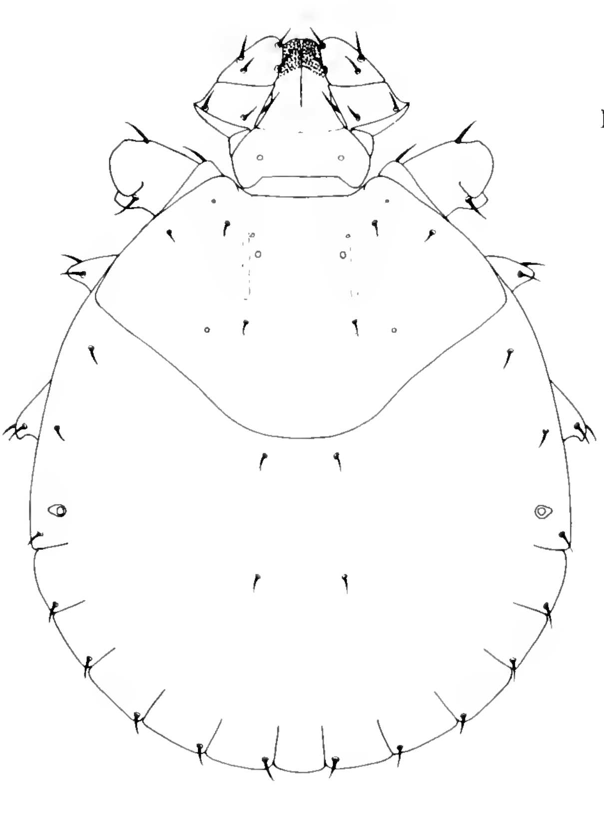


Fig. 33.—Dorsal view of larval *Haemaphysalis*

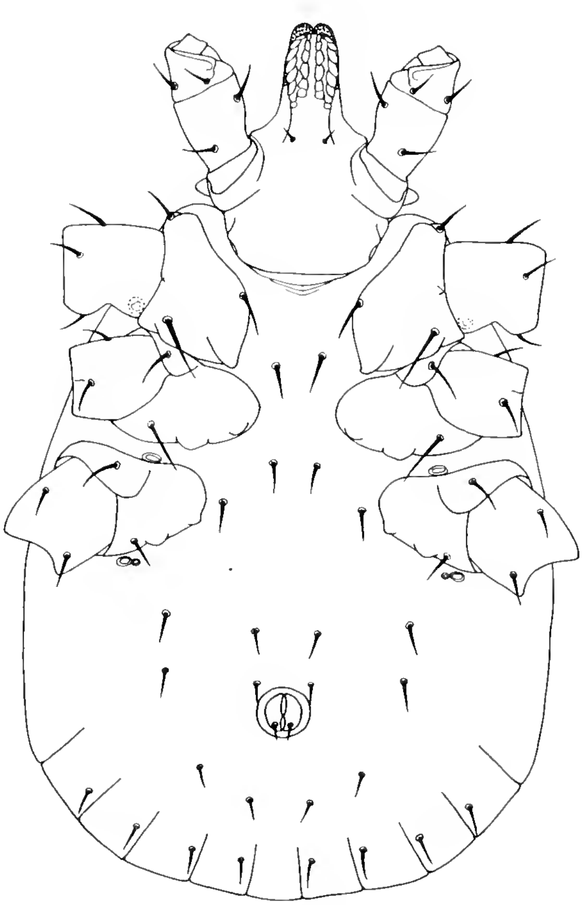


FIG. 36.—Ventral view of larval *Dermacentor*

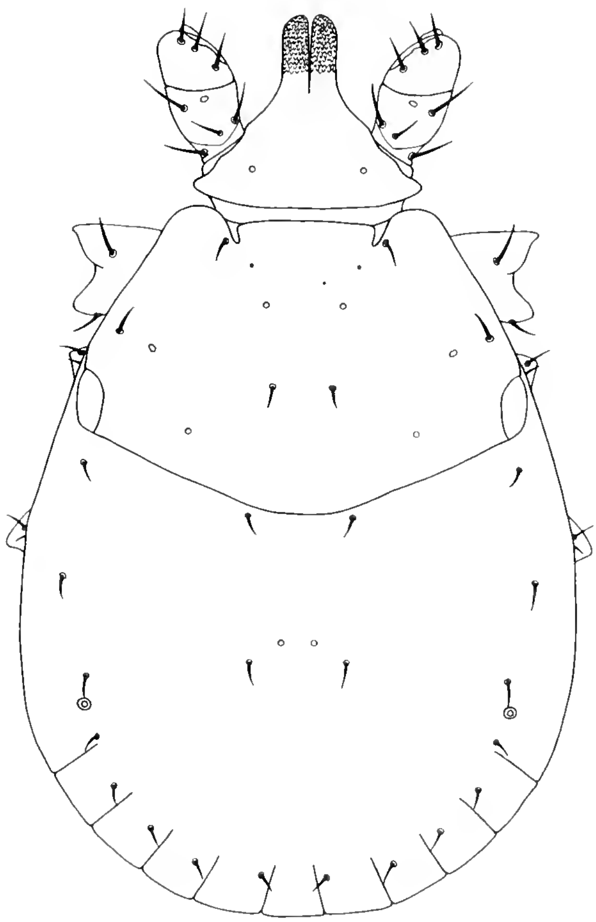


FIG. 35.—Dorsal view of larval *Dermacentor*

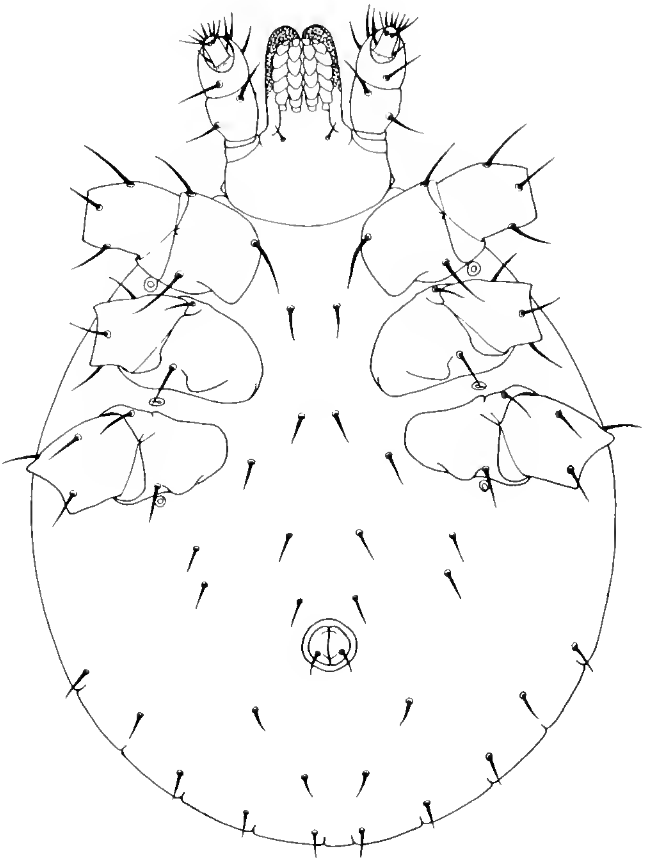


FIG. 38.—Ventral view of larval *Anocentor*

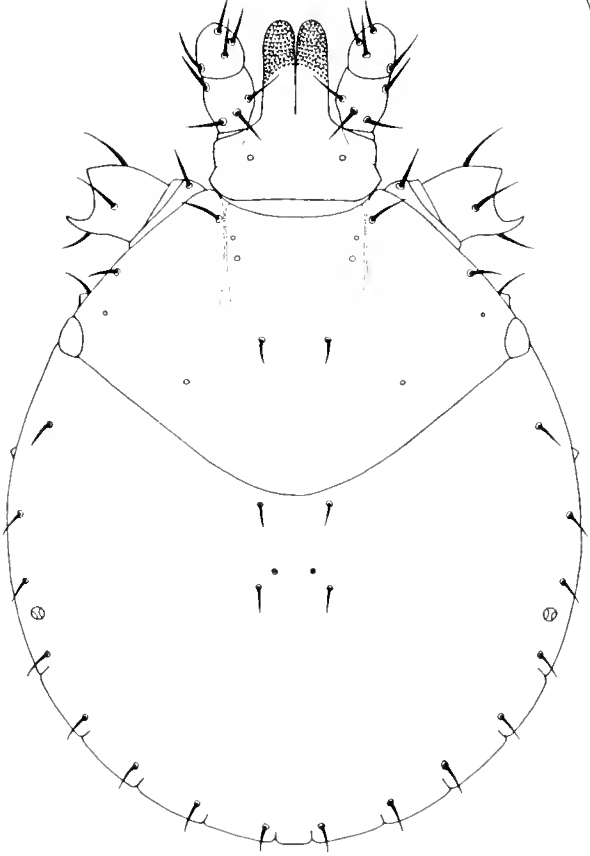


FIG. 37.—Dorsal view of larval *Anocentor*

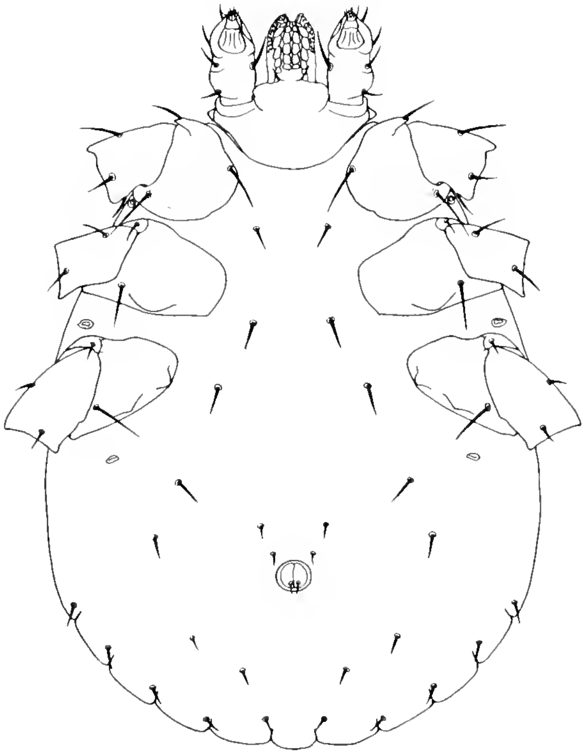


Fig. 40.—Ventral view of larval *Rhipicephalus*

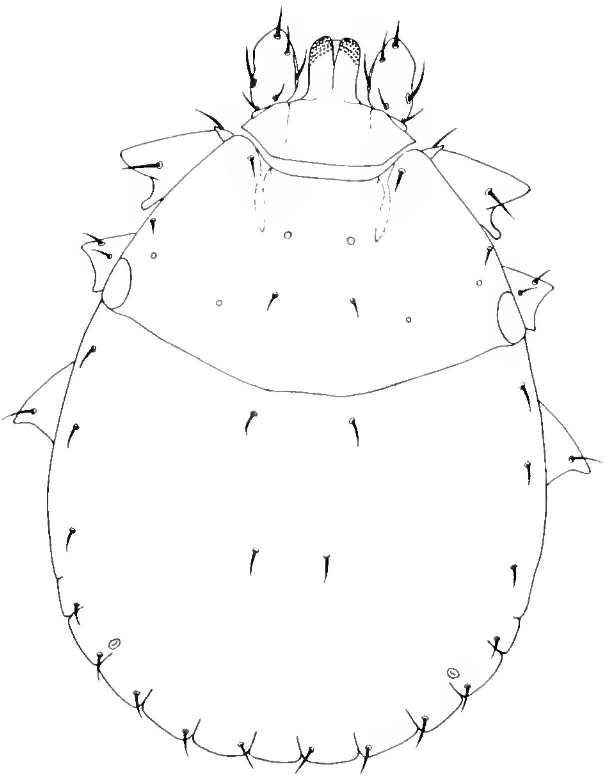


Fig. 39.—Dorsal view of larval *Rhipicephalus*

SELECTED REFERENCES

Allred, D. M., D E. Beck and L. D. White.
1960 Ticks of the genus *Ixodes* in Utah. Brigham ham Young Univ. Sci. Bull., Biol. Ser. 1(4): 1-42.

Bishopp, F. C., and H. L. Trembley.
1945 Distribution and hosts of certain North American ticks. Jour. Parasitol. 31(1):1-54.

Cerny, V.
1957a Morophological differences in larvae and nymphs of the Central European members of the genus *Dermacentor* Koch. (In Czech.) *Folia Zoologica* 6(1):23-28.

Clifford, C. M., G. Anastos and A. Elbl.
1961 The larval Ixodid Ticks of the Eastern United States (Acarina-Ixodidae). Misc. Pub. of the Entom. Soc. of America, 2(3):213-237.

Clifford, C. M. and G. Anastos.
1960 The use of chaetotaxy for identification of larval ticks. Jour. Parasitol. 46(5):567-578.
1946 The genera *Boophilus*, *Rhipicephalus* and *Haemaphysalis* (Ixodidae) of the New World. Natl. Inst. Health Bull. (187) U.S. Publ. Health Serv., 54 pp.

Cooley, R. A.
1938 The genera *Dermacentor* and *Octocentor* (Ixodidae) in the United States, with studies on variation. Nat'l. Inst. Health Bull. (171), U.S. Publ. Health Serv., 89 pp.

Cooley, R. A. and G. M. Kohls.
1945 The genus *Ixodes* in North America. Nat'l. Inst. Health Bull. (184), U.S. Public Health Serv., 246 pp.

Dinnik, J., and F. Zumpt.
1949 The integumentary sense organs of the larvae of Rhipicephalinae (Acarina). Psyche 56(11): 1-11.

Evans, G. O., J. G. Sheals and D. Macfarlane.
1961 The terrestrial acari of the British Isles, Vol. 1. British Museum of Natural History, London, England.

Filippova, N. A.
1954 To the diagnosis of several species of ixodid ticks of genus *Ixodes* Latr. (sub-genus *Ixodes* s. str.) from larvae and nymphs. (In Russian.) Zool. Zhur. 33(1):69-76.

Filippova, N. A.
1955 Studies in morophology and systematics of ixodids (In Russian). Avtoreg. Dissert. M: 3-12.

Glashinskaya-Babenko, L. V.
1949 Chaetotaxy of the body of tick larvae of the family Ixodidae and its taxonomic significance. (In Russian) Dokl. Akad. Nauk, SSSR nov. ser. 62(2):245-248.

Gregson, J. D.
1956 The Ixodoidea of Canada. Canada Dept. of Agric. Pub. 930.

Kohls, G. M.,
1960 Records and new synonymy of new world *Haemaphysalis* ticks, with descriptions of the nymph and larva of *H. juxtakochi* Cooley.

Lototsky, B. V.
1948 To the problems of study of chaetotaxy in ixodid ticks. (In Russian.) Soobshch. Tadzh. fil. Akad. Nauk. SSSR 7:24-27.
1949 Experimental study of chaetotaxy of ticks of genus *Dermacentor*. (In Russian.) Ent. Oboz. 30(3-4):276-286.
1952 Ixodid ticks of Tadzhikiston and new materials concerning the onto- and phylogeny of the family Ixodidae. (In Russian.) Dissert. Zool. Inst. Akad. Nauk. SSSR. pp. 1-530.

Moskatcheva, E. A.
1948 To the question of morphology of the larvae and nymphs of the tick *Dermacentor marginatus* (Sulz). (In Russian.) Trudy Belorussek Cel'Khoz. Inst. 13(2):162-168.

Nuttall, G. H. F., C. Warburton, W. F. Cooper and L. E. Robinson.
1908-1926 Ticks, a monograph of the Ixodoidea. Parts 1-3. Cambridge, England.

Reznik, P. A.
1950 On a comparative, morphological study of the larvae of the ticks of the genus *Dermacentor* Koch. (In Russian.) Dokl. Akad, Nauk, SSSR nov. ser. 75(2):327-328.

Schulze, P.
1942 Die morphologische bedeutung de afters un seinen ungebung bei zechen. Zeitschr. Morphol. u. Okol. Tiere 38(3):630-658.

Serdyukova, G. V.
1955 On the differential characteristics of larvae and nymphs of ixodid ticks (Ixodoidea). (In Russian). Zool. Zhur. 34(5):1037-1051.

Strandtmann, R. W. and G. W. Wharton.
1958 Manual of Mesostigmatid Mites Parasitic on Vertebrates. Institute of Acarology, University of Maryland.

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NEVADA TEST SITE STUDY AREAS AND SPECIMEN DEPOSITORIES

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NEVADA TEST SITE STUDY AREAS AND SPECIMEN DEPOSITORIES

This paper supplements the publication "Biotic Communities of the Nevada Test Site" (Allred, Beck, and Jorgensen, 1963) which delineated the major plant communities; designated the predominant species of animals and their relative abundance, seasonal occurrence, and ecological distribution; and listed all the species known as a result of our ecological studies. The present paper supplies additional information on the specific location and ecological peculiarities of our collection stations, and lists the depositories of the specimens. This will enable the interested worker to locate within a short distance the place where specimens were collected and to know where they have been deposited. Collection data are presented in Table 1, and an explanation of the contents and meanings of the abbreviations of the table columns are given below. Depositories are listed on pages 14-15.

Area column. Early in our studies to facilitate methods of survey, we established study areas. Some areas were established independently of those of the Atomic Energy Commission (Holmes and Narver, Inc., 1961, page 4). Others were closely aligned with the AEC designations (Fig. 1). Those identified by a numeral were established by the Commission, although our boundaries do not necessarily correspond with theirs. Areas identified by letters were selected by us independently of the AEC weapons testing program.

Study site column. Subsequent to area designation specific sites within each area were selected. Single or double capital letter components were used to identify these.

Type of study column. A one- or two-letter component indicates the arrangement of the collecting equipment in the specific study. Meanings of the abbreviations used are as follows:

B	Berlese funnel study, an examination of individual plants of a particular species
M	Miscellaneous techniques
PT	2 parallel transects
Q	Quadrat arrangement consisting of 3 or more parallel transects
RT	4 or more transects radiating from a central point
ST	Single transect

Plant community column. The first 2 letters of the generic name(s) of the plant community are given as follows:

At-Ko	*Atriplex confertifolia* and *Kochia americana*
Co	*Coleogyne ramosissima*
Gr-Ly	*Grayia spinosa* and *Lycium andersonii*
La-Fr	*Larrea divaricata* and *Franseria dumosa*
Mixed	A variety of plants which occur in amounts which makes assignment to one of the major communities impractical
Pi-Ju	*Pinus monophylla* and *Juniperus osteosperma*
Sa	*Salsola kali*

Specific vegetation column. A generic code is given for the predominant species of plant(s) found in greatest abundance at the study site. If a species is not indicated, it is the same as the predominant species listed under the heading Plant Community.

Ar	*Artemisia tridentata*
Atf	*Atriplex confertifolia*
Atn	*Atriplex canescens*
Br	*Bromus rubens*
Ch	*Chrysothamnus paniculatus*
Co	*Coleogyne ramosissima*
Da	*Dalea fremontii*
Ep	*Ephedra nevadensis*
Er	*Eriogonum* spp.
Eu	*Eurotia lanata*
Fr	*Franseria dumosa*
Gr	*Grayia spinosa*
Hy	*Hymenoclea salsola*
Ko	*Kochia americana*
Kr	*Krameria parvifolia*
La	*Larrea divaricata*
Lya	*Lycium andersonii*
Lyp	*Lycium pallidum*
Lyr	*Lycium rickardii*
Me	*Menodora spinescens*
Or	*Oryzopsis hymenoides*
Pi	*Pinus monophylla*

Sa	*Salsola kali*
St	*Stipa speciosa*
Te	*Tetradymia glabrata*
Var	Several species of shrubs with no clearly predominant species
Yub	*Yucca brevifolia*
Yus	*Yucca schidigera*

Map reference location column. The geographic position of a study site may be located on Figure 1 by following the coordinates of the number and letter indicated under this column heading.

Descriptive location column. In conjunction with the Map Reference Location coordinates, this description is designed as a guide to the near vicinity of the study site. Reference points have been used which (1) are indicated on Figure 1, (2) are easily identifiable landmarks, and (3) are expected to be continually identifiable at the Nevada Test Site in future years.

GZ	Ground zero in the area indicated
N	North
E	East
S	South
W	West

Many of our identified specimens have been deposited in museums and institutions of higher learning (see pages 14-15). Specialists who identified these were listed by Allred, Beck, and Jorgensen (1963). Other specimens, as yet unidentified, have been stored at Brigham Young University and are available to interested scientists. In our ecological studies we assigned each specimen a collection code in addition to the usual collection information of date, locality, and collector. The code was used to facilitate computor analyses of our ecological data. Without descriptive interpretation of the code on the label, each specimen is limited in its use by any specialist who may want ecological information about collections made at the test site. Interpretation of our codification may be obtained by examination of two specific examples which follow.

The test site has been divided into areas as discussed above (Fig. 1). In area 5 at study site A we established a quadrat-type study. At specific intervals along each of the 12 transects of the quadrat we established collection stations. At some of the stations we placed can pit-traps. On one of the collecting dates a scorpion was trapped in the can at station 10 on transect L. The collection code assigned to that specimen was 5AL10C. This means: collected at Nevada Test Site area 5, at B.Y.U. study site A, along transect L, at station 10, in a can pit-trap.

Another example of this same codification system is TCAS. This means: collected at Nevada Test Site area T, at B.Y.U. study site C, along transect A, in a Museum Special trap. This particular study was one of many area sampling studies consisting of one or two parallel transects with traps spaced at regular intervals. In sampling studies such as this no record was made of the specific station at which the animal was caught. Consequently, the station number symbol was omitted. Variation in code letters and numbers may occur, but the basic principle of the codification system is the same in all instances.

With the code as a basis, one may obtain specific ecological information about each specimen by referring to Table 1. Letters used in the codes for methods of collection are as follows:

A	Aerial insect net
B	Berlese funnel
C	Can pit-trap
G	Gun
H	Picked up by hand
I	Sight observation
IF	Fecal sign
IS	Sound of voice
IT	Tracks
K	Hava-hart, live-catch trap
L	Allred live-catch trap
M	Japanese mist net
N	Sherman live-catch trap
S	Museum Special or Oneida-Victor trap
T	Incadescent light-trap
TB	Black-light (ultra-violet) trap
U	Wire funnel trap
V	Killed by vehicle
W	Sweep net
Y	Young-type, live-catch trap

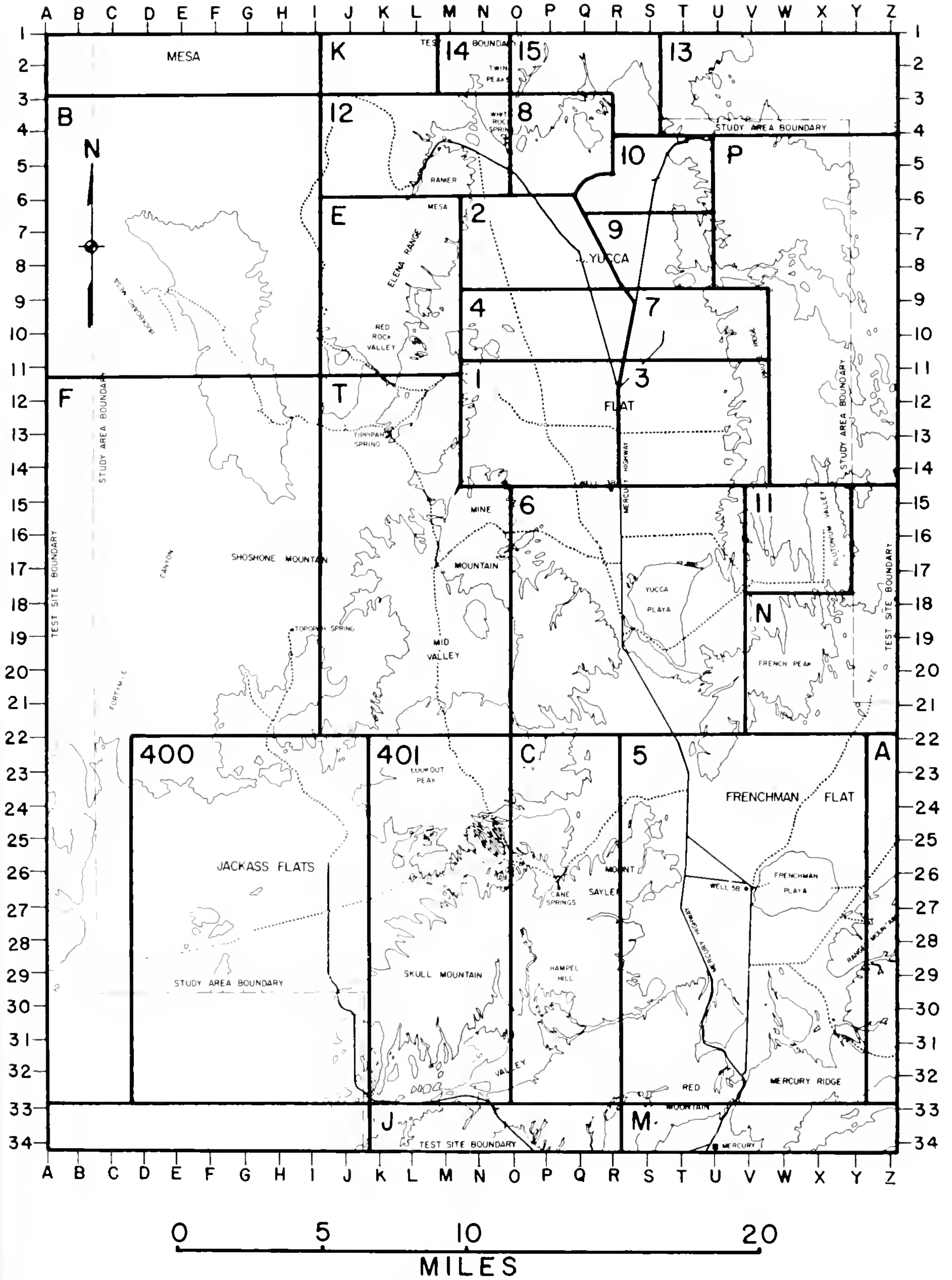

Fig. 1. Study Areas at the Nevada Test Site

Table 1. Study Areas of Brigham Young University at the Nevada Test Site

Area	Study Site and Transect	Type of Study	Plant Community	Specific Vegetation	Map Reference Location	Descriptive Location
1	A	Q	Gr-Ly		Q13	1.3 miles W of Mercury Highway, 100 yards S of GZ-1 road
1	B	RT	Gr-Ly	Var	P13	GZ-1 to radius of 1.5 miles
1	CA	ST	Gr-Ly		Q13	1.5 miles E of GZ-1
1	CB	PT	Gr-Ly		Q13	Same
1	CC	PT	Gr-Ly		N13	2.1 miles S of Tippipah Spring, thence 3.8 miles E
1	CD	ST	Mixed		N12	3 miles W of GZ-1
1	D	Q	Gr-Ly		Q11	2 miles NNE of GZ-1
1	EA	B	Sa		P13	150 yard radius, 1320 ft SE of GZ-1
1	F	Q	Sa		Q13	3168 ft ESE of GZ-1
1	G	Q	Gr-Ly		Q12	0.9 mile ENE of GZ-1
1	H	RT	Gr-Ly		R12	2.6 miles N of Well 3B, thence 0.7 mile W of Mercury Highway
1	I	RT	Gr-Ly		Q12	2.6 miles N of Well 3B, thence 1 mile W of Mercury Highway
1	J	RT	Gr-Ly		R12	2.6 miles N of Well 3B, thence 0.4 mile W of Mercury Highway
2	CA	ST	Co		O6	11 miles N of Well 3B on Rainier Mesa road, thence 100 yards S
2	CB	PT	Co		O6	2.4 miles SE Area 12 residence area, S side of Rainier Mesa road
2	CC	PT	Gr-Ly	Atf-Eu	P8	0.5 mile W of Mercury Highway alongside GZ-2 road
2	CD	PT	Co	Er	O8	2.3 miles W of Mercury Highway alongside GZ-2 road
2	CE	PT	Co		N8	3.3 miles W of Mercury Highway alongside GZ-2 road
2	CF	PT	Co	St	O9	7.7 miles N of Well 3B, thence 2.1 miles W of Rainier Mesa road
2	DA	B	Co		P6	11 miles N of Well 3B on Rainier Mesa road, thence 100 yards S
3	CA	ST	Gr-Ly	Atf-Eu	R13	1.5 miles N of Well 3B, thence 0.6 mile E
3	CB	ST	Sa		S13	1 mile E of Mercury Highway alongside GZ-3 road
3	CC	ST	Sa		T13	1 mile E of GZ-3
3	CD	PT	Co	Yub-La	V14	1.4 miles N of Well 3B, thence 0.3 mile NE, thence 3.8 miles E
3	CE	PT	Co	Kr-Da	V14	1.4 miles N of Well 3B, thence 0.3 mile NE, thence 3.6 miles E
3	CF	PT	Co	Yub-Te	V14	1.4 miles N of Well 3B, thence 0.3 mile NE, thence 3.1 miles E
3	CG	PT	Gr-Ly	Te-Lya	T14	1.4 miles N of Well 3B, thence 0.3 mile NE, thence 2.8 miles E
3	CH	PT	Mixed		T14	1.4 miles N of Well 3B, thence 0.3 mile NE, thence 2.5 miles E
3	CI	PT	At-Ko		T14	1.4 miles N of Well 3B, thence 0.3 mile NE, thence 2.3 miles E
3	CJ	ST	Sa		S13	2 miles E of Mercury Highway alongside GZ-3 road

Area	Study Site and Transect	Type of Study	Plant Com-munity	Specific Vege-tation	Map Reference Location	Descriptive Location
3	CK	PT	Sa		T13	2.3 miles E of Mercury Highway alongside GZ-3 road
3	CL	PT	Sa	Me	T13	2 miles E of Mercury Highway alongside GZ-3 road
3	CM	PT	Sa		S13	0.7 mile E of Mercury Highway alongside GZ-3 road
4	A	Q	Gr-Ly		Q11	4.6 miles N of Well 3B along Rainier Mesa road, thence 1 mile W
4	CA	ST	Gr-Ly		P9	0.5 mile W of Mercury Highway alongside GZ-4 road
4	CB	ST	Gr-Ly		P11	4.2 miles N of Well 3B along Rainier Mesa road, thence 2 miles W
4	CC	ST	Gr-Ly		N9	2.4 miles W of GZ-4
4	CD	ST	Gr-Ly		N9	2.1 miles W of GZ-4
4	CE	ST	Gr-Ly		N9	1.8 miles W of GZ-4
4	CF	ST	Gr-Ly		N9	1.5 miles W of GZ-4
4	CG	ST	Gr-Ly		P11	4.2 miles N of Well 3B along Rainier Mesa road, thence 1 mile W
4	CH	PT	Gr-Ly		Q11	4.2 miles N of Well 3B along Rainier Mesa road, thence 0.5 mile W
4	CI	ST	Sa		P9	0.6 mile NE of GZ-4
4	CJ	PT	Co	St	O10	3.5 miles N of Well 3B, thence 2.1 miles W of Rainier Mesa road
4	CK	PT	Co	Hy	P11	3.4 miles N of Well 3B, thence 2.1 miles W of Rainier Mesa road
4	DA	B	Gr-Ly	Gr	Q11	4.2 miles N of Well 3B along Rainier Mesa road, thence 1 mile W
4	DB	B	Gr-Ly	Lya	Q11	Same
5	A	Q	La-Fr	La	T26	0.2 mile E of Mercury Highway S of Well 5B road
5	B	RT	La-Fr	La	T24	0.2 mile W of Mercury Highway and 0.2 mile N of Cane Springs road
5	CA	ST	La-Fr	La	T26	0.2 mile E of Mercury Highway S of Well 5B road
5	CB	ST	La-Fr	Lyp	T27	0.3 mile E of Mercury Highway, 1 mile S of Well 5B road
5	CC	ST	La-Fr	Er	T26	0.5 mile S of Well 5B road, W of Mercury Highway
5	CD	ST	La-Fr	Er-La	T26	Same
5	CE	ST	La-Fr	La	T26	Same
5	CF	ST	La-Fr	Er	T26	Same
5	CG	ST	La-Fr	Atn	X27	SE corner Frenchman playa, alongside deep fissure
5	CH	ST	Mixed		V33	1.9 miles NE of Mercury along Mercury Highway, thence 0.2 mile E
5	CI	ST	Mixed		X27	2.5 miles ESE of Well 5B on Frenchman playa
5	CJ	ST	Mixed		W27	1.3 miles ESE of Well 5B on Frenchman playa
5	CK	ST	Mixed		V32	2.9 miles NE of Mercury along Mercury Highway, thence 0.3 mile E

Area	Study Site and Transect	Type of Study	Plant Community	Specific Vegetation	Map Reference Location	Descriptive Location
5	CL	ST	Mixed		V33	1.9 miles NE of Mercury along Mercury Highway, thence 0.5 mile E
5	CM	ST	La-Fr	La	T24	W of Mercury Highway 0.1 mile N of Cane Springs road
5	CN	ST	La-Fr		Z26	6 miles E of Well 5B
5	CO	ST	La-Fr	Lyp	U27	0.7 mile E of Mercury Highway, 1 mile S of Well 5B road
5	CP	PT	La-Fr	Lyp	U27	1 mile E of Mercury Highway, 1 mile S of Well 5B road
5	CQ	ST	La-Fr'	La	T26	0.3 mile E of Mercury Highway, N of Well 5B road
5	CR	PT	La-Fr	Lyp	T29	8.5 miles N of Mercury along Mercury Highway, thence 1.1 miles W
5	CS	PT	La-Fr	Lyp	U27	1.5 miles SW of Well 5B, thence 0.2 mile S
5	CT	PT	La-Fr	Lyp	V28	1.7 miles S of Well 5B
5	CU	PT	La-Fr	Atf	V26	0.9 mile NE of Well 5B
5	CV	PT	La-Fr	Atn	V26	1 mile NE of Well 5B
5	CW	PT	Mixed		V26	0.6 mile NE of Well 5B
5	CX	PT	La-Fr	La	U26	1.1 miles NW of Well 5B
5	CY	PT	La-Fr	Atf-Lyp	V27	0.3 mile S of Well 5B
5	CZ	PT	La-Fr	Lyp-La	V28	2.1 miles S of Well 5B
5	DA	B	La-Fr	La	U26	0.3 mile E of Mercury Highway, N of Well 5B road
5	DB	B	La-Fr	Lyp	U27	1.1 miles E of Mercury Highway, thence 1 mile S of Well 5B road
5	E	Q	La-Fr	Lyp	U27	Same
5	F	M	La-Fr	La	V26	Environs of Well 5B
5	G	M	La-Fr	La	S24	2 miles W of Mercury Highway alongside Cane Springs road
5	HA	PT	La-Fr	La	V29	2.8 miles S of Well 5B
5	HB	PT	Mixed		V30	4.3 miles S of Well 5B
5	HC	PT	Mixed		T31	5.5 miles N of Mercury, 0.5 mile W of Mercury Highway
5	HD	PT	La-Fr	Co-La	U31	4.8 miles N of Mercury alongside Mercury Highway
5	HE	PT	La-Fr	Co	U32	3.8 miles N of Mercury, 0.8 mile SW of Mercury Highway
5	HF	PT	La-Fr	Atn	X27	2.3 miles E of Well 5B, thence 0.8 mile SE
5	HG	PT	La-Fr		X27	2.3 miles E of Well 5B, thence 1.1 miles SE
5	HH	PT	La-Fr	Lyr	Y27	2.3 miles E of Well 5B, thence 1.6 miles SE
5	HI	PT	La-Fr	La	X24	4 miles NE of Well 5B
5	HJ	PT	La-Fr	La	Y25	4 miles NE of Well 5B, thence 1.9 miles SE
5	HK	PT	La-Fr		W24	2.4 miles NE of Well 5B, thence 2 miles N
5	HL	PT	La-Fr	Ep	W23	2.4 miles NE of Well 5B, thence 2.8 miles N

Area	Study Site and Transect	Type of Study	Plant Community	Specific Vegetation	Map Reference Location	Descriptive Location
5	HM	PT	La-Fr	Ep-Fr	W22	2.4 miles NE of Well 5B, thence 4 miles N
5	HN	PT	Mixed		Y27	2.3 miles E of Well 5B, thence 2.1 miles SE, thence 0.3 mile E
5	HO	PT	Mixed		V33	1.9 miles NE of Mercury along Mercury Highway, thence 1 mile E
5	HP	ST	La-Fr	La	U23	0.9 mile N of Cane Springs road, 1 mile E of Mercury Highway
5	HQ	ST	Sa		X27	2.4 miles E of Well 5B in center of Frenchman playa
5	HR	ST	Mixed		U31	4.4 miles NE of Mercury along Mercury Highway, thence 0.2 mile S
5	HS	ST	Mixed		T26	0.2 mile W of junction of Well 5B road and Mercury Highway
5	P	M	Playa		W26	Frenchman playa
6	A	Q	At-Ko		S15	0.5 mile S of Well 3B, thence 0.6 mile E
6	B	RT	At-Ko		S15	0.2 mile S of Well 3B, thence 1.2 miles E
6	CA	ST	At-Ko		S15	0.5 mile S of Well 3B, thence 0.6 mile E
6	CB	ST	Co	Yub-Co	R17	3.2 miles S of Well 3B, thence 0.8 mile W
6	CC	ST	Co	Yub-Co	R17	Same
6	CD	ST	Co	Yub-Co	R17	Same
6	CE	ST	Co	Yub-Co	R17	Same
6	CF	ST	Gr-Ly	Atf-Te	U15	1.2 miles S of Well 3B, thence 3.5 miles E
6	CG	ST	Gr-Ly	Atf	U15	Same
6	CH	ST	Mixed		S17	3.7 miles S of Well 3B, thence 0.5 mile E
6	CI	ST	Mixed		R17	3.7 miles S of Well 3B, thence 0.5 mile W
6	CJ	ST	Gr-Ly	Atf-Te	U15	1.2 miles S of Well 3B, thence 3.5 miles E
6	CK	ST	Mixed		R17	3.7 miles S of Well 3B, thence 0.1 mile E
6	CL	ST	Mixed		S17	3.7 miles S of Well 3B, thence 1 mile E
6	CM	ST	Mixed		S17	Same
6	CN	ST	Mixed		S17	Same
6	CO	ST	Mixed		S17	Same
6	CP	ST	At-Ko		S17	Same
6	CQ	ST	La-Fr	La	S17	Same
6	CR	PT	Co		O15	0.7 mile S of Well 3B, thence 4.6 miles W
6	CS	PT	Gr-Ly		O15	0.7 mile S of Well 3B, thence 3.5 miles W
6	CT	PT	La-Fr	Co-La	O15	0.7 mile S of Well 3B, thence 3.4 miles W

Area	Study Site and Transect	Type of Study	Plant Community	Specific Vegetation	Map Reference Location	Descriptive Location
6	CU[1]	PT	Co	Co-Atf	P15	0.7 mile S of Well 3B, thence 3.1 miles W
6	CV	PT	Gr-Ly		Q15	0.7 mile S of Well 3B, thence 1.1 miles W
6	CW	PT	Gr-Ly	Atf-Eu	Q15	0.6 mile W of Well 3B
6	CX	PT	Gr-Ly	Atf	Q15	0.7 mile S of Well 3B, thence 0.6 mile W
6	CY	PT	Gr-Ly	Atf	Q15	0.7 mile S of Well 3B, thence 0.4 mile W
6	CZ	PT	Co	Yub-Co	Q17	1.8 miles S of Well 3B, thence 0.8 mile W, thence 0.3 mile SW
6	DA	B	At-Ko	Atf	S15	0.5 mile S of Well 3B, thence 0.6 mile E
6	DB	B	At-Ko	Ko	S15	Same
6	DC	B	Gr-Ly	Eu	R15	Environs of Well 3B
6	DD	B	Gr-Ly	Atn	R17	3.2 miles S of Well 3B
6	DE	B	Co	Yub	R18	4.7 miles S of Well 3B
6	E	M	Gr-Ly		R15	Environs of Well 3B
6	FA	PT	Co	Yub-Co	Q17	2.7 miles S of Well 3B, thence 0.8 mile W
6	FB	PT	Co	Yub-Atf	R17	1.8 miles S of Well 3B, thence 0.7 mile W
6	FC	PT	Mixed		T20	SE corner Yucca playa
6	FD	PT	At-Ko	Ko	T19	1.4 miles N of SE corner of Yucca playa
6	FE	PT	At-Ko		T18	2.3 miles N of SE corner of Yucca playa
6	FF	PT	Mixed		U18	2.3 miles N of SE corner of Yucca playa, thence 0.7 mile E
6	FG	PT	La-Fr	La	S22	3.2 miles N of Cane Springs road, thence 100 yards W of Mercury Highway
6	FH	PT	La-Fr	Co-La	S21	4.6 miles N of Cane Springs road, thence 100 yards W of Mercury Highway
6	FI	PT	La-Fr	Co-La	R20	5.8 miles N of Cane Springs road, thence 100 yards W of Mercury Highway
6	FJ	ST	Mixed		P19	5.7 miles S of Well 3B, thence 3.4 miles W
6	FK	ST	Mixed		P19	Same
6	FL	ST	Mixed		T20	0.7 mile ESE of SE corner of Yucca playa
6	FM	ST	Mixed		U15	0.5 mile S of Well 3B, thence 3.1 miles E
6	P	M	Playa		S18	Yucca playa
7	CA	ST	Sa		S10	5.9 miles N of Well 3B alongside Groom Lake road
7	CB	ST	Mixed		U9	3.2 miles N of Well 3B, thence 5.5 miles NE
7	CC	PT	Sa		S11	3.2 miles N of Well 3B, thence 1.2 miles NE

Area	Study Site and Transect	Type of Study	Plant Community	Specific Vegetation	Map Reference Location	Descriptive Location
7	CD	PT	Sa		S11	3.2 miles N of Well 3B, thence 1.7 miles NE
7	CE	PT	Sa		T9	3.2 miles N of Well 3B, thence 3.4 miles NE
8	CA	ST	Sa		Q5	0.3 mile S of GZ-8
8	CB	ST	Sa		Q5	0.2 mile SE of GZ-8
8	CC	PT	Sa		P5	1.2 miles W of Scooter crater, thence 1.1 miles N
9	CA	ST	Sa		S8	8.9 miles N of Well 3B alongside Groom Lake road
9	CB	PT	Sa		S8	7.9 miles N of Well 3B along Groom Lake road, thence 1.1 miles NE
9	CC	PT	Sa		S8	7.9 miles N of Well 3B along Groom Lake road, thence 0.4 mile NE
9	CD	PT	Mixed		S9	6.8 miles N of Well 3B along Groom Lake road, thence 0.5 mile E
9	CE	PT	Sa		S9	6.8 miles N of Well 3B along Groom Lake road, thence 0.2 mile E
9	CF	PT	Sa	Sa-Atf	R10	5.4 miles N of Well 3B alongside Groom Lake road
10	A	Q	Sa		S7	9 miles N of Well 3B alongside Groom Lake road
10	B	RT	Mixed		R7	9 miles N of Well 3B along Groom Lake road, thence 0.4 mile W
10	CA	ST	Gr-Ly		R7	9.5 miles N of Well 3B along Groom Lake road, thence 1 mile W
10	CB	ST	Co	Co-La	R7	10 miles N of Well 3B along Groom Lake road, thence 0.6 mile W
10	CC	ST	Co	La	S7	9.5 miles N of Well 3B alongside Groom Lake road
10	CD	ST	Gr-Ly		S7	9.2 miles N of Well 3B alongside Groom Lake road
10	CE	ST	Sa		S7	9 miles N of Well 3B along Groom Lake road, thence 0.5 mile E
10	CF	ST	Gr-Ly	Lya-Atf	T7	9 miles N of Well 3B along Groom Lake road, thence 0.6 mile W
10	CG	ST	Co	Or	S7	9 miles N of Well 3B alongside Groom Lake road
10	CH	ST	Co		T7	9 miles N of Well 3B along Groom Lake road, thence 1 mile E
10	CI	ST	Co		T7	Same
10	CJ	ST	Mixed		R5	11.5 miles N of Well 3B along Groom Lake road, thence 1.6 miles NW
10	CK	PT	Sa		S5	Environs N of Scooter crater
10	CL	PT	Sa		R5	0.6 mile W of Scooter crater
10	CM	PT	Co	St	Q6	1.2 miles W of Scooter crater
10	CN	PT	Gr-Ly	St-Gr	Q6	1.2 miles WSW of Scooter crater
10	D	Q	Co		S7	9.5 miles N of Well 3B along Groom Lake road, thence 0.5 mile E
10	E	RT	Gr-Ly		R5	0.6 mile NNE of Sedan crater

Area	Study Site and Transect	Type of Study	Plant Community	Specific Vegetation	Map Reference Location	Descriptive Location
10	S	Q, ST	Gr-Ly		R5	10.5 miles N of Well 3B along Groom Lake road, thence 0.3 mile W
11	CA	ST	Mixed		W16	GZ station 11-D
11	CB	ST	Mixed		W16	GZ station 11-C
12	A	Q	Pi-Ju		L5	0.7 mile S of Y on E edge of Rainier Mesa
12	B	PT	Pi-Ju		L5	0.5 mile S of Y on E edge of Rainier Mesa
12	CA	ST	Pi-Ju		L5	Same
12	CB	ST	Pi-Ju		L5	Same
12	CC	ST	Pi-Ju		L4	0.3 mile W of Y on Rainier Mesa
12	CD	ST	Pi-Ju	Grasses	L5	0.5 mile S of Y along E edge of Rainier Mesa, thence 0.1 mile W
12	CE	ST	Pi-Ju		L5	0.7 mile S of Y on E edge of Rainer Mesa
12	CF	PT	Pi-Ju	Ar	J4	3.2 miles W of Y on Rainier Mesa
12	CG	PT	Pi-Ju	Ar	I4	3.7 miles W of Y on Rainier Mesa
12	CH	PT	Co		N4	S of Rainier Mesa road near Area 12 residence area
12	CI	ST	Mixed		O4	Environs of White Rock Spring
12	CJ	ST	Mixed		O4	0.3 mile S of White Rock Spring
12	CK	ST	Pi-Ju		L5	0.7 mile S of Y along E edge of Rainier Mesa, thence 0.5 mile W
12	CL	ST	Pi-Ju	Ar	L6	1.4 miles S of Y along E edge of Rainier Mesa
12	CM	ST	Pi-Ju		L6	1.8 miles S of Y along E edge of Rainier Mesa
12	CN	ST	Pi-Ju		J4	2.4 miles W of Y on Rainier Mesa
12	D	M	Mixed		O4	Environs of White Rock Spring
12	E	Q	Pi-Ju		L4	0.5 mile W of Y on Rainier Mesa, thence 0.5 mile S
12	F	M	Pi-Ju	Pi	*	Gold Meadow *(off map N of symbol K)
12	G	M	Pi-Ju		L4	Semi-permanent puddle, 100 yards W of Y on Rainier Mesa
13	CA	ST	Gr-Ly	Eu-Atf	U3	15.8 miles NE of Well 3B along Groom Lake road, thence 1 mile N
13	E	M	Pi-Ju		*	Environs of Bald Mountain *(off map N of symbol Y)
15	CA	ST	Mixed		R3	14 miles N of Well 3B, thence 1.2 miles NW
15	CB	ST	Mixed		R3	14 miles N of Well 3B, thence 1 mile NW
15	CC	ST	Mixed		S4	11 miles NE of Well 3B along Groom Lake road, thence 1.5 miles N
400	CA	PT	La-Fr	La	J27	0.7 mile E of Jackass Flats Highway, alongside Cane Springs road
400	CB	PT	La-Fr		J27	0.3 mile E of Jackass Flats Highway, alongside Cane Springs road

Area	Study Site and Transect	Type of Study	Plant Com-munity	Specific Vege-tation	Map Reference Location	Descriptive Location
400	CC	PT	La-Fr		I27	0.4 mile W of Jackass Flats Highway, W of Cane Springs road junction
400	CD	PT	La-Fr		H27	1.5 miles W of Jackass Flats Highway, W of Cane Springs road junction
400	CE	PT	La-Fr		F28	4 miles W of Jackass Flats Highway, W of Cane Springs road junction
400	CF	ST	Mixed		J29	3.3 miles SSE of junction of Jackass Flats Highway and Cane Springs road
400	CG	PT	La-Fr	Lya	J33	13.5 miles NW of Mercury along Jackass Flats Highway, thence 1.5 miles W
400	CH	PT	La-Fr	Me-Eu	J25	2.9 miles N of junction of Jackass Flats Highway and Cane Springs road alongside Topopah Spring road
400	CI	PT	La-Fr	Co	J25	3.1 miles N of junction of Jackass Flats Highway and Cane Springs road alongside Topopah Spring road
400	CJ	PT	La-Fr	Co	H24	5.1 miles N of junction of Jackass Flats Highway and Cane Springs road alongside Topopah Spring road
400	E	M	La-Fr	La	J27	1.3 miles E of Jackass Flats Highway alongside Cane Springs road
401	CA	PT	La-Fr		K33	13.9 miles NW of Mercury alongside Jackass Flats Highway
401	CB	PT	Mixed		M26	4.1 miles E of Jackass Flats Highway alongside Cane Springs road
401	CC	PT	La-Fr	Co-Gr	M26	3 miles W of Cane Springs alongside Cane Springs road
401	CD	PT	La-Fr	Lya	N30	10.5 miles W of Mercury along Jackass Flats Highway, thence 4 miles N
401	CE	PT	Mixed		M31	10.5 miles W of Mercury along Jackass Flats Highway, thence 3.8 miles N
401	CF	PT	Mixed		M32	10.5 miles W of Mercury along Jackass Flats Highway, thence 1 mile N
401	CG	PT	La-Fr	Lya	L33	13.5 miles W of Mercury along Jackass Flats Highway, thence 0.3 mile SW
401	CH	PT	La-Fr	Lya	L33	13.5 miles W of Mercury along Jackass Flats Highway, thence 0.6 mile SW
A	CA	PT	Mixed		Z27	2.3 miles E of Well 5B, thence 2.1 miles SE, thence 0.6 mile E
A	CB	PT	Mixed		Z27	2.3 miles E of Well 5B, thence 2.1 miles SE, thence 1.3 miles E

Area	Study Site and Transect	Type of Study	Plant Community	Specific Vegetation	Map Reference Location	Descriptive Location
A	CC	ST	Mixed		Z27	5.3 miles ESE of Well 5B
B	CA	PT	Gr-Ly		G11	8.4 miles NW of Tippipah Spring alongside Basalt Area road
B	CB	PT	Gr-Ly	Ar	F10	11.1 miles NW of Tippipah Spring alongside Basalt Area road
B	CC	PT	Gr-Ly	Gr-Ar	E9	12.3 miles NW of Tippipah Spring alongside Basalt Area road
B	CD	PT	Gr-Ly		D10	13.7 miles NW of Tippipah Spring along Basalt Area road, thence 1.5 miles S
B	CE	PT	Gr-Ly	Ar	D10	Same
B	CF	PT	Gr-Ly	Ar	D9	17.4 miles NW of Tippipah Spring alongside Basalt Area road
C	B	ST	Mixed		P26	Environs of Cane Springs
C	CA	ST	Co		O25	1.9 miles NW of Cane Springs, thence 1.2 miles NE
C	CB	PT	La-Fr	Co-Ep	O26	1.5 miles W of Cane Springs along Cane Springs road, thence 200 yards S
C	CC	PT	La-Fr	Co	O26	1.5 miles W of Cane Springs along Cane Springs road, thence 400 yards S
C	CD	ST	Mixed		P29	6 miles W of Mercury along Jackass Flats Highway, thence 8.3 miles N
C	E	V	Aquatic		P26	Cane Springs pond
E	CA	PT	Co	Var	J11	0.5 mile NE of Tippipah Spring, thence 5.6 miles NW
E	CB	PT	Co	Ar	J11	0.5 mile NE of Tippipah Spring, thence 7.5 miles NW
E	CC	PT	Co	Ar	K11	0.5 mile NE of Tippipah Spring, thence 5 miles NW
E	CD	PT	Pi-Ju		M6	0.8 mile SW of Area 12 residence area, thence 2.2 miles S
E	CE	PT	Pi-Ju	Ar-Pi	M6	0.8 mile SW of Area 12 residence area, thence 1.8 miles S
E	CF	PT	Co	Ar	M6	0.8 mile SW of Area 12 residence area, thence 1.4 miles S
E	CG	ST	Pi-Ju		L6	2.5 miles SW of Area 12 residence area
E	CH	ST	Mixed		L6	1.5 miles S of Area 12 garbage dump
E	CI	ST	Mixed		I11	0.5 mile NE of Tippipah Spring, thence 3.4 miles NW, thence 1 mile SW
E	CJ	ST	Co	Ar	L7	2 miles S of Area 12 garbage dump
F	CA	ST	La-Fr	Hy	C26	6.7 miles W of Jackass Flats Highway, opposite junction of Cane Springs road, thence 3 miles N
F	CB	PT	La-Fr	Fr	D28	5.8 miles W of Jackass Flats Highway, opposite junction of Cane Springs road

Area	Study Site and Transect	Type of Study	Plant Community	Specific Vegetation	Map Reference Location	Descriptive Location
F	CC	PT	La-Fr	Fr	C28	6.7 miles W of Jackass Flats Highway, opposite junction of Cane Springs road
F	CD	ST	Mixed		C28	6.8 miles W of Jackass Flats Highway, opposite junction of Cane Springs road, thence 1 mile N
F	CE	ST	Mixed		C25	6.8 miles W of Jackass Flats Highway, opposite junction of Cane Springs road, thence 4 miles N
F	CF	PT	Co	Ar	H12	3.7 miles NW of Tippipah Spring along Basalt Area road, thence 0.1 mile N
F	CG	PT	Co	Br	H21	7.8 miles N of junction of Jackass Flats Highway and Cane Springs road, alongside Topopah Spring road
F	CH	PT	Co		H21	Same
F	CI	PT	Co	St-Ep	G21	8.9 miles N of junction of Jackass Flats Highway and Cane Springs road, alongside Topopah Spring road
F	CJ	PT	Co	St-Ep	G20	10 miles N of junction of Jackass Flats Highway and Cane Springs road, alongside Topopah Spring road
J	A	Q	Mixed		N34	9.3 miles W of Mercury along Jackass Flats Highway, thence 1000 ft SW
J	CA	ST	Mixed		N34	9.3 miles W of Mercury along Jackass Flats Highway, thence 500 ft W
J	CB	ST	Mixed		*	3.8 miles W of Mercury alongside Jackass Flats Highway *(off map S of symbol Q)
J	CC	ST	La-Fr	Yus-La	*	2.3 miles W of Mercury alongside Jackass Flats Highway *(off map S of symbol R)
J	CD	PT	Mixed		*	3.5 miles W of Mercury alongside Jackass Flats Highway *(off map S of symbol Q)
J	CE	PT	Mixed		O33	8.9 miles W of Mercury alongside Jackass Flats Highway
K	E	M	Ar	Ar-Ju	*	8 miles N of Gold Meadow *(off map N of symbol K)
M	CA	ST	Mixed		U33	1 mile NE of Mercury alongside Mercury Highway
M	CC	PT	Mixed		T33	0.6 mile NE of Mercury along Mercury Highway, thence 1.5 miles W
M	CD	ST	Mixed		*	3.5 miles S of Mercury along Mercury Highway toward Highway 95, thence 4.3 miles NE *(off map S of symbol S)
M	D	M	Mixed		U34	Environs of Mercury
M	E	M	Mixed		U34	Mercury sewage disposal area

Area	Study Site and Transect	Type of Study	Plant Community	Specific Vegetation	Map Reference Location	Descriptive Location
M	F	M	Mixed		*	Spotted Mountain Range, SE of Mercury *(off map S of symbol X)
N	CA	PT	La-Fr		Y22	2.4 miles NE of Well 5B, thence 5.3 miles N
N	CB	ST	Mixed		Y21	7.8 miles NE of Well 5B
N	CC	ST	Mixed		Y21	7.5 miles NE of Well 5B
T	A	Q	Co	Ar	M16	4.4 miles S of Tippipah Spring
T	CA	ST	Co	Ar	K13	Environs of Tippipah Spring
T	CB	ST	Co	Ch	K13	Same
T	CC	PT	Co	Ar	L16	3.7 miles S of Tippipah Spring
T	CD	PT	Co	Ar	L16	4.1 miles S of Tippipah Spring
T	CE	PT	Co	Ar	L17	4.7 miles S of Tippipah Spring
T	CF	PT	Co	Co-Ar	M17	5 miles S of Tippipah Spring
T	CG	PT	Co		M17	5.3 miles S of Tippipah Spring
T	CH	PT	Co		L15	2.4 miles S of Tippipah Spring
T	CI	PT	Co	Co-Ar	L14	2.2 miles S of Tippipah Spring
T	CJ	PT	Mixed		M14	2.1 miles S of Tippipah Spring along Mid Valley road, thence 1.4 miles E
T	CK	PT	Mixed		M14	Same
T	CL	ST	Mixed		M16	1.9 miles S of Well 3B, thence 6.5 miles W
T	CM	ST	Mixed		K13	0.3 mile S of Tippipah Spring
T	CN	ST	Mixed		J13	2 miles W of Tippipah Spring, thence 0.3 mile S
T	CO	ST	Mixed		K13	0.2 mile W of Tippipah Spring
T	CP	ST	Mixed		L17	4.4 miles S of Tippipah Spring, thence 1 mile SW
T	CQ	ST	Mixed		K18	4.4 miles S of Tippipah Spring, thence 3 miles SW
T	E	M	Mixed		K13	Environs of Tippipah Spring

DEPOSITORIES OF NEVADA TEST SITE ANIMAL SPECIMENS

1. American Museum of Natural History, New York, New York
   Isopods, scorpions, ants, beetles, grasshoppers and other orthopterans
2. Brigham Young University, Provo, Utah
   All taxonomic groups
3. California Academy of Sciences, San Francisco, California
   Isopods, scorpions, ants, beetles, grasshoppers and other orthopterans
4. Canada Department of Agriculture, Ottawa, Ontario, Canada
   Beetles, mainly Scarabaeidae
5. Chicago Natural History Museum, Chicago, Illinois
   Isopods, scorpions, ants, beetles, grasshoppers and other orthopterans
6. Dixie College, St. George, Utah
   Lizards, scorpions, ants, beetles, grasshoppers and other orthopterans
7. Museum of Comparative Zoology (Harvard), Cambridge, Massachusetts
   Isopods, scorpions, ants, beetles, grasshoppers and other orthopterans
8. New Mexico Highlands University, Las Vegas, New Mexico
   Lizards

9. Philadelphia Academy of Natural Sciences, Philadelphia, Pennsylvania
   Isopods, scorpions, ants, beetles, grasshoppers and other orthopterans
10. University of California, Los Angeles, California
    Mammals
11. University of Michigan, Ann Arbor, Michigan
    Scorpions, ants, beetles, grasshoppers and other orthopterans
12. University of Nevada, Las Vegas, Nevada
    Mammals, isopods, scorpions, ants, beetles, grasshoppers and other orthopterans
13. University of Nevada, Reno, Nevada
    Isopods, scorpions, ants, beetles, grasshoppers and other orthopterans
14. University of Tennessee, Knoxville, Tennessee
    Ants
15. University of Utah, Salt Lake City, Utah
    Isopods, ants, beetles, grasshoppers and other orthopterans
16. United States National Museum, Washington, D. C.
    Isopods, scorpions, ants, beetles, grasshoppers and other orthopterans
17. Utah State University, Logan, Utah
    Scorpions, ants, beetles, grasshoppers and other orthopterans

LITERATURE CITED

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

Holmes and Narver, Inc. 1961. Orientation Brochure of the Nevada Test Site. U.S. Atomic Energy Commission, Office of Information, 2753 S. Highland Drive, Las Vegas, Nevada.

Brigham Young University
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BIRDS OF THE NEVADA TEST SITE

During the course of ecological studies conducted at the Atomic Energy Commission test site since 1959 in the vicinity of Mercury, Nevada, collections and observations of the birds of the area were made. Although the work on birds was somewhat incidental to other phases of the study, a considerable amount of information nevertheless was assembled, and it would seem to be desirable to publish it at this time. Most of the collecting and observing was done during 1961 and 1962, at which time about 900 specimens were collected and prepared as study skins and several thousand individual observations were recorded.

The overall project at Mercury was carried on under a contract (AT(11-1)786) between the Atomic Energy Commission and Brigham Young University. Dr. Dorald M. Allred of the Department of Zoology at Brigham Young University was the principal investigator and served as general supervisor of the project. Clive D. Jorgensen, who was at the time the immediate director of the work at the site, made some of the collections and observations of the birds. The work of the authors was as follows: Hayward did some collecting and observing at the site during the summer of 1960 and has been responsible for cataloguing and identifying the specimens and for writing most of this manuscript. Killpack and Richards, both of whom worked at intervals on the site, were responsible for most of the field collecting and recording, particularly during the 1961 and 1962 seasons. Killpack has also done most of the work on the bibliography. Prior to the time of this project, W. H. Rickard made some observations on the nesting of birds at the test site. His data were available to us through his publication (1961). Richards (1962) has published a short paper on the wintering of certain birds in the area. Our own information has been recorded on IBM cards and reproduced so as to indicate numbers, seasonal occurrence, and habitat relations for each species. This information has been used extensively in preparing this report. Considering the fact that the study of birds was somewhat of a sideline to other aspects of the project a remarkable amount of data was assembled. It is especially important that most of the species known to occur in the area are represented by collected specimens.

Allred, Beck and Jorgensen (1963) have described in considerable detail the principal biotic communities of the Nevada Test Site. They have also included a list of the known species of birds and indicated their habitat preferences. For this reason it will not be necessary here to comment extensively on the biotic communities and their ecological significance. It may be desirable, however, to point out certain features of the physical and biotic habitats that influence the distribution and occurrence of the avifauna of the area.

Considering the generally desert condition of the area, it is rather remarkable that so many different kinds of water and shore birds have been recorded. Nearly all of these birds are transients and their occurrence is dependent upon the availability of open water, which is variable from season to season and from year to year. The playa basins of Frenchman and Yucca Flats sometimes contain considerable water. In fact, the basin at Frenchman Flat was partially dammed off and during the winter of 1960-61 and the following summer contained a lake several feet deep. Run-off from local cloudbursts frequently collects in these basins, and the water may remain for several weeks or months. Nearly all of the common species of local and transient water birds stop on these lakes. Most of the kinds of shore and wading birds that ordinarily migrate across the area also stop for varying lengths of time at the playa lakes. At wells 3B and 5B there are small reservoirs which contain water most of the time and also attract a few water and shore birds. Over the entire test site there are a few small natural springs including Topopah Spring, Tippipah Spring, White Rock Spring and Cane Springs.

Although these springs and reservoirs are limited both in size and in number, they represent scattered oases in an otherwise waterless area, and often attract large concentrations of small land birds that come in especially in the evening to feed and drink. Most characteristic of these aggregations are horned larks, mourning doves, and nighthawks. In addition to these large, conspicuous concentrations of certain species there is a steady stream of small passerines as well as large birds in and out of the spring areas. This is particularly evident at Cane

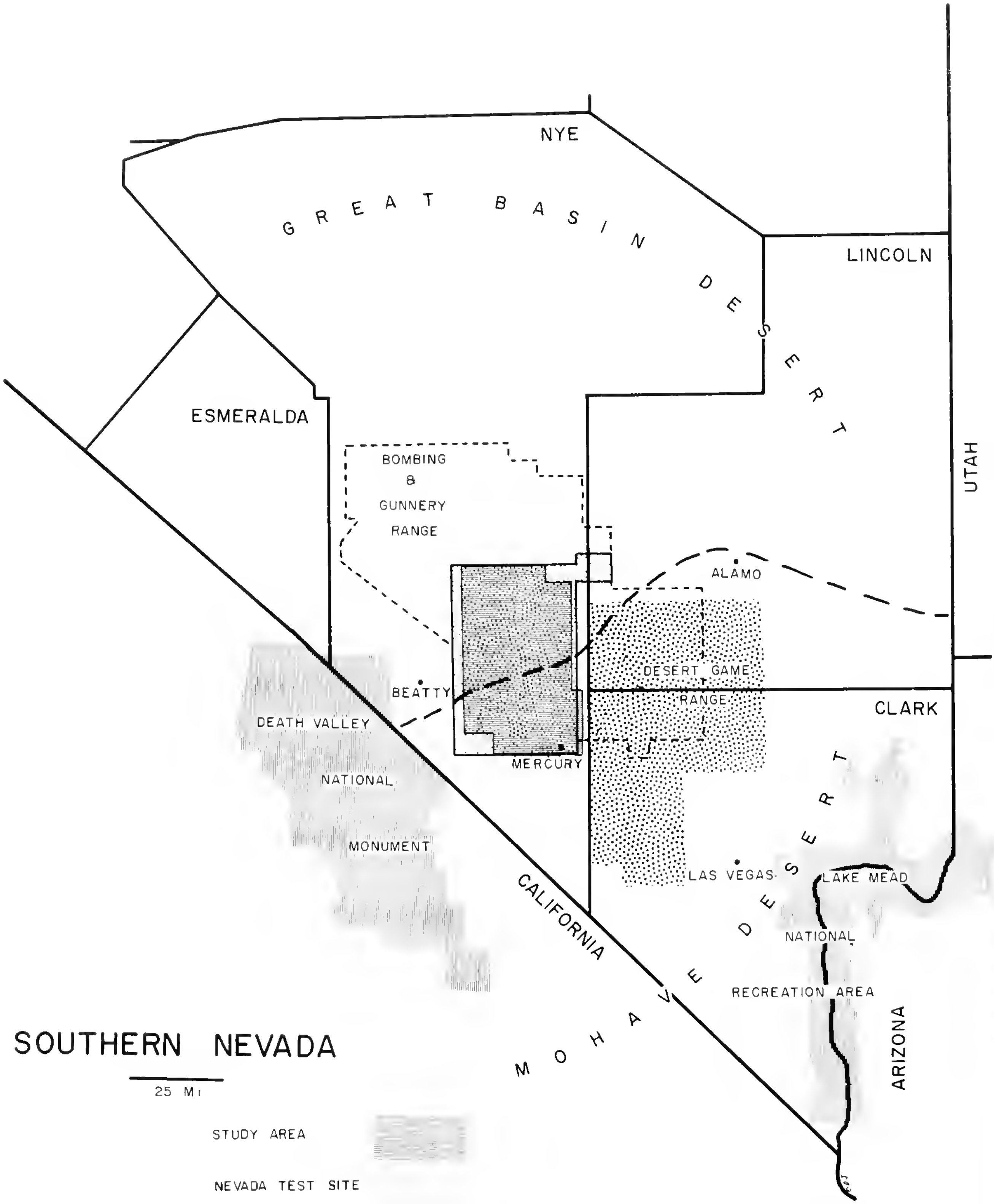

Fig. 1 Map of Southern Nevada

Springs, where there is some cover as well as water. These water sources, small as they are, are responsible for the presence of many species of birds that would not otherwise find the habitat suitable to their survival

The atomic testing activities and the building of roadways within the test site have resulted in localized changes in the natural desert vegetation that undoubtedly have influenced the numbers and distribution of certain kinds of birds. When the natural desert vegetation is destroyed, either by an atomic explosion or by road building or other construction work, it is typically replaced within a short time by Russian thistle (*Salsola kali*) This weed serves as a source of food and cover for many small birds, notably the house finch, which feeds on it in great flocks, especially during the winter. It seems likely that this species is far more abundant in the area, owing to these community modifications, than it otherwise would be. Utility poles along the roadways serve as convenient perches for several kinds of hawks, falcons and the raven, as well as some other species.

From the point of view of the avifauna, the natural, undisturbed communities fall into two general types. The higher plateau areas exemplified by Rainier Mesa and Pahute Mesa are characterized by a predominance of Pinyon-Juniper woodland in which such species as the piñon Jay (*Gymnorhinus cyanocephalus*), Mountain Chickadee (*Parus gambeli*), Plain Titmouse (*Parus inornatus*), Solitary Vireo (*Vireo solitarius*), and Black- throated Gray Warbler (*Dendroica nigrescens*) are characteristic residents. The lower type, occupying wide valleys typified by Frenchman, Yucca and Jackass Flats, is vegetated predominantly by a variety of low growing shrubs in which can be recognized several distinct types of plant communities. The Nevada Test Site occupies an area which lies in a position of transition between what has been called the Southern Desert Shrub Biome and Northern Desert Shrub Biome (Fautin, 1946) or the Lower Sonoran and Upper Sonoran Life Zones (Merriam, 1910). As would be expected, elements of both of these major communities are to be found in the flora and fauna of the test site area. Typical resident birds of the Southern Desert Shrub include the Lesser Nighthawk (*Chordeiles acutipennis*), Costa's Hummingbird (*Calypte costae*), Ladder-backed Woodpecker (*Dendrocopos scalaris*), Cactus Wren (*Campylorhynchus brunneicapillum*) and LeConte's Thrasher (*Toxostoma lecontei*). All of these are present at the Nevada Test Site. The Sage Thrasher (*Oreoscoptes montanus*), Green-tailed Towhee (*Chlorura chlorura*), and Brewer's Sparrow (*Spizella breweri*), typical resident birds of the Northern Desert Shrub, also occur. During the breeding season the Southern Desert Shrub element seems to be predominant in these lower valleys.

In winter the open and warmer valleys afford a suitable feeding ground for thousands of small passerine birds, many of which move in from higher altitudes or more northern latitudes. Typical of these wintering birds are the Sage Sparrow (*Amphispiza belli*), House Finch (*Carpodacus mexicanus*), several kinds of juncos (*Junco caniceps, Junco oreganus, Junco hyemalis*), Mountain Bluebird (*Sialia currucoides*), Starling (*Sturnus vulgaris*), White-crowned Sparrow (*Zonotrichia leucophrys*), and Horned Lark (*Eremophila alpestris*). Some of these, such as the House Finch and Horned Lark, are continuously resident in the area but occur in greater numbers during the winter season.

In this paper the kinds of birds known from the Nevada Test Site will be treated individually under two or three principal headings depending upon the kind and amount of information available to us and the status of each species. Collection records are indicated in each case where specimens are available, and general comments will be made on sight records. Although many thousands of sight records are available to us, we have not attempted to make use of these to indicate populations except in a very general way, since the data were assembled rather haphazardly and do not appear to be statistically reliable. Data assembled relative to seasonal occurrence appear to present a rather accurate picture of aspection in the birds, and this information will be summarized for each species. From the information at hand it is possible to draw some conclusions as to the general habitat relations of the several species, but there is a need for more uniform observation and data recording on this particular subject. Whenever more than one subspecies is present in the area, or is likely to occur there, a brief analysis of the taxonomic relationships of the specimens available is given. The present paper reports on about 192 kinds of birds of which six are presumably new records for Nevada. The new records are as follows: American Golden Plover (*Pluvialis dominica*); Pectoral Sandpiper (*Erolia melanotos*); a race of Hermit Thrush (*Hylocichla guttata oromela*); a race of Swainson's Thrush (*Hylocichla ustulata ustulata*); Lapland Longspur (*Calcarius lapponicus lapponicus*); and Purple Finch (*Carpodacus purpureus californicus*).

A selected bibliography of the papers known to us that deal with the birds of the test site and southern Nevada is included. No attempt is made to cite all published records for each species except in a limited number of cases where the occurrence is unusual. Some of the sources included in the bibliography are not specifically cited in the report. The names of the birds and the order of their presentation follow the 1957 A.O.U. "Check-list of North American Birds" with a few exceptions.

Our appreciation is extended to the personnel of the Atomic Energy Commission, who granted financial support to the project and to their personnel at Mercury who furnished space, vehicles and other items necessary for the work there. We are also grateful for the constant support of Dr. Dorald M. Allred, the general supervisor and principal investigator of the entire project, and to his field supervisors, Clive D. Jorgensen, Dr. J. Richard Murdock, and Leland White, who collected specimens or made observations that were of great value. In addition, we appreciate the cooperation of Dr. Philip S. Humphrey and Dr. John Aldrich of the U.S. National Museum, who made the collection of that institution available to us for the identification of some of the doubtful specimens. We also are grateful for the assistance of Dr. William H. Behle, University of Utah, for the identification of the Horned Larks and Red-winged Blackbirds.

ACCOUNTS OF THE SPECIES

Podiceps caspicus (Hablizl)
Eared Grebe

Collection records: Four specimens, March 3, October 4, September 22, 1961; December 14, 1960.

Status: The Eared Grebe is an irregular winter visitant and was noted particularly on the small reservoir at Well 5B. Specimens were observed as early as September 22 and as late as March 3.

Aechmophorus occidentalis (Lawrence)
Western Grebe

Collection records: Three specimens, November 11, 16, June 9, 1961.

Status: Only the three birds collected were seen on the test site. Two were collected on water at Frenchman Playa, and one sick bird was picked up along one of the roadways.

Podilymbus podiceps (Linnaeus)
Pied-billed Grebe

Collection records: One specimen, April 1, 1961.

Status: Eight sight records were made for this grebe. Present evidence indicates that it is a spring and autumn transient occurring on the playa lakes and at Well 5B. The earliest spring record is for March 26, while the latest autumn record is for September 11.

Pelecanus erythrorhynchos Gmelin
White Pelican

Collection records: None.

Status: A small flock was seen April 10, 1961, circling over water at Frenchman Playa. None was seen to light and there are no other records of this species for the test site.

Ardea herodias treganzai Court
Great Blue Heron

Collection records: One specimen, August 14, 1961.

Status: The Great Blue Heron is probably to be regarded as a casual and irregular visitor at the Nevada Test Site. Records are available for March, August and September with the earliest being March 10 and the latest September 10. The one specimen taken was collected at Frenchman Playa, and there are four sight records for the same locality.

Butorides virescens anthonyi (Mearns)
Green Heron

Collection records: One specimen, October 24, 1961.

Status: Only the one record of the specimen collected is available to us. This bird was sick and unable to fly. Although the Green Heron is reported to nest in southern Nevada (A.O.U. Check-list, 1957, p. 44), we have not found any indication of breeding on the test site.

Casmerodius albus egretta (Gmelin)
Common Egret

Collection records: One specimen, April 29, 1961.

Status: A Common Egret was seen on several different occasions between April 27 and April 29, 1961, in company with snowy egrets. It was seen first at Well 5B, and presumably the same one was collected later at Yucca Playa.

Leucophoyx thula brewsteri (Thayer and Bangs)
Snowy Egret

Collection records: Two specimens, July 29, 1960; April 23, 1961.

Status: The Snowy Egret is a consistent summer resident at the test site although it does not breed there. It is seen about the playa lakes and around the wells from April into September.

Nycticorax nycticorax hoactli (Gmelin)
Black-crowned Night Heron

Collection records: One specimen, May 7, 1961.

Status: This species seems to be an uncommon spring visitor at the test site. Besides the single collection noted above three sight records are available between April 14 and May 7 at Yucca Playa.

Ixobrychus exilis hesperis Dickey and van Rossem
Least Bittern

Collection record: One specimen, May 19, 1961.

Status: The specimen collected was the only one recorded during our study. It was taken at Yucca Playa. The larger measurements of beak and wing place our specimen definitely with the race *hesperis* rather than *exilis* (Gmelin.) The Least Bittern seems to be an uncommon visitor to southern Nevada. Grater (1939) has published sight records for Hemenway Wash and St. Thomas, Clarke County, for August and September (1938). Alcorn (1940) has published a record for Fallon, Churchill County, farther to the north.

Plegadis chihi (Vieillot)
White-faced Ibis

Collection record: One specimen, May 13, 1961.

Status: Three birds were together at Frenchman Playa when the above specimen was collected. This is the only record available to us from the test site area.

Branta canadensis (Linnaeus)
Canada Goose

Collection record: One specimen, December 6, 1959.

Status: The Canada Goose is an uncommon visitor on the test site. Two records for March 26 and December 6 are available at which time birds were seen on the playa lakes. The one specimen collected was sick and unable to fly.

Anas platyrhynchos Linnaeus
Mallard

Collection records: Two specimens, April 4, and November 15, 1961.

Status: Mallards were irregular visitors from November 11 to April 4. They were observed mostly on the playa lakes but were also encountered occasionally on the reservoirs. The birds were most abundant in March.

Anas acuta Linnaeus
Pintail

Collection records: Two specimens, August 17, 1960, and October 4, 1961.

Status: Pintails appear to visit the test site during autumn and spring migration. We have no records for May, June or July or for December and January. The playa lakes are the favored resting places for these ducks.

Anas carolinensis Gmelin
Green-winged Teal

Collection records: Three specimens, March 3, October 7, 1961; February 14, 1962.

Status: Green-winged Teal may be seen on the playa lakes and reservoirs rather regularly from August into May. The concentrations are greatest during spring and autumn migration and especially in February and March. They may also be regarded as occasional winter visitors.

Anas discors Linnaeus
Blue-winged Teal

Collection records: Three specimens, April 28 and October 8, 1961.

Status: This bird is an irregular vsitor that may appear at most any month of the year. We have records for every month except February, March and September. The greatest numbers were seen in May. They were only about 10% as common on the test site as the Green-winged Teal.

Anas cyanoptera Vieillot
Cinnamon Teal

Collection records: Six specimens, March 31, April 1, 7, 16, 1961; April 13, 1962.

Status: The Cinnamon Teal seems to be primarily a spring migrant through the test site area. Most of the records are from March 31 into June with the greatest concentration in April. There is a possibility that a pair may have nested at Cane Springs during the summer of 1959. However, the frequent visits of people at the spring undoubtedly would discourage the regular breeding of the ducks at that place.

Mareca americana (Gmelin)
American Widgeon

Collection records: Three specimens, March 28, October 9, November 5, 1961.

Status: These ducks are regular but rather uncommon spring and autumn migrants. They may be seen on playa lakes and reservoirs from mid-March into May and again in October and November.

Spatula clypeata (Linnaeus)
Shoveler

Collection records: Three specimens, May 4, November 3, 1961; April 11, 1962.

Status: Shovelers are known to occur rather sparingly on the reservoirs and playa lakes as spring and autumn transients. Our records are from March 8 into May and from October into early November.

Aythya americana (Eyton)
Redhead

Collection records: Three specimens, June 28, 1960; March 3, 26, 1961.

Status: This duck is a rare visitor at playa lakes and reservoirs. Besides the collection records, nine sight records are available from February 10 to April 23.

Aythya affinis (Eyton)
Lesser Scaup

Collection record: One specimen, April 10, 1961.

Status: The Lesser Scaup is an uncommon spring migrant seen on playa lakes and on reservoirs. We have nine records, all between April 10 and April 22.

Bucephala clangula (Linnaeus)
Common Goldeneye

Collection records: None.

Status: We have only one sight record for December 17, 1961.

Bucephala albeola (Linnaeus)
Bufflehead

Collection records: Three specimens, March 29 and November 11, 1961.

Status: The Bufflehead is a fairly common spring and fall migrant, where it is to be seen on playa lakes and reservoirs at the wells. We have 32 records for March and April and for September through November.

Melanitta perspicillata (Linnaeus)
Surf Scoter

Collection records: Two specimens, October 22, 23, 1961.

Status: Only the two specimens collected have been seen on the Nevada Test Site. Published records for Nevada include its occurrence at Soda Lake in October and November, 1940 (Alcorn 1941:119). Alcorn obtained three specimens during this period.

Oxyura jamaicensis (Gmelin)
Ruddy Duck

Collection records: Three specimens, April 4, 7, 1961.

Status: The Ruddy Duck is a fairly common spring and autumn migrant. It is seen on playa lakes and on reservoirs from mid-March into May and again in October and November.

Mergus serrator Linnaeus
Red-breasted Merganser

Collection records. None.

Status: We have only one sight record for May 12, 1961.

Cathartes aura teter Friedmann
Turkey Vulture

Collection records: One specimen, June 26, 1961.

Status: The Turkey Vulture is a common spring and summer resident at the test site. Our records extend from April 13 to September 12. It was most commonly seen in the Yucca Flat area.

Accipiter striatus velox (Wilson)
Sparp-shinned Hawk

Collection records: None.

Status: We have four sight records of this hawk for April, September and December. Most of them were seen at Cane Springs. At this place one was observed to capture a Western Tanager.

Accipiter cooperii (Bonaparte)
Cooper's Hawk

Collection records: Two specimens, July 28, 1960; May 6, 1961.

Status: There are 24 records of Cooper's Hawk for the test site area. It seems to be more common than the Sharp-shinned. The records are scattered from January 2 to October 8, but most of them were for the summer months. Many of the birds were seen in the Pinyon-Juniper on the mesas, but they also frequently visited Cane Springs.

Buteo jamaicensis calurus (Cassin)
Red-tailed Hawk

Collection records: Two specimens, October 9, November 6, 1959.

Status: The observations of this species were rather evenly distributed throughout every month of the year, and it may therefore be considered a permanent resident. It was observed over all of the types of communities and was common.

Buteo swainsoni Bonaparte
Swainson's Hawk

Collection records: Four specimens, April 30 and May 23, 1961; August 6, 9, 1960.

Status: Records of observation extend from February 17 to November 17, but most of the birds were seen from April through August. Swainson's Hawks were most frequently seen perching on utility poles along the roadways, especially in Yucca Flat. Rickard (1961) mentions a nest containing 2 eggs and 2 young in a Joshua tree, but gives no exact locality or date.

Buteo lagopus s. johannis (Gmelin)
Rough-legged Hawk

Collection record: One specimen, February 15, 1960.

Status: The Rough-legged Hawk was recorded in the test site area from November 2 to May 6. It was regarded as the most common hawk in late winter and early spring, perching on utility poles, especially at Yucca Flat. On several occasions pellets were found to contain remains of Jerusalem crickets.

Buteo regalis (Gray)
Ferruginous Hawk

Collection records: One specimen, November 11, 1959.

Status: This species is regarded as a rather uncommon and irregular visitor at the test site. Nine scattered sight records are available from September 5 to June 14. The birds were most frequently seen perched on utility poles in Yucca Flat.

Aquila chrysaetos canadensis (Linnaeus)
Golden Eagle

Collection records: Two specimans, July 28, 1960, and June 30, 1961.

Status: There are 49 sight records of the Golden Eagle scattered rather evenly through all the months of the year. The species is regarded as an uncommon permanent resident in the area, although no nesting sites have been located.

Circus cyaneus hudsonius (Linnaeus)
Marsh Hawk

Collection records: None.

Status: One hundred twenty-six sight records were made, distributed through all the months of the year except June. The greatest number of recordings were made from October through March.

Pandion haliaetus (Linnaeus)
Osprey

Collection records: None.

Status: The osprey was seen flying over the tree tops on the mesa, May 6, 1961. Two sight records are also available for the Frenchman Flat area September 5 and 12, 1961.

Falco mexicanus Schlegel
Prairie Falcon

Collection records: Two specimens, November 26 and December 10, 1960.

Status: The Prairie Falcon is a rather common permanent resident of the test site. It nests in the cliffs around the mesas. On June 26, 1961, a nest was examined that contained two young with pin feathers. Mourning Dove feathers were found in the nest. The young were out of the nest and flying by July 19.

Falco sparverius sparverius Linnaeus
Sparrow Hawk

Collection records: Six specimens, November 6, 1959; April 3, 13, February 12, October 24, 1961.

Status: Sparrow Hawks were common in the test site area every month of the year but were most abundant in April. There was conclusive evidence that they nested in the ledges around the margins of the mesas although no nests were actually examined.

Lophortyx gambelii gambelii Gambel
Gambel's Quail

Collection records: Ten specimens. February 11, 1960; May 14 and November 10, 1961.

Status: Gambel's Quail is a permanent resident in the Pinyon-Juniper woodland and around all of the springs. Occasionally the birds have been seen far removed from water on the open desert.

Alectoris graeca (Meisner)
Chukar

Collection records: Three specimens, August 1, 1960; November 14, 1961.

Status: These birds, introduced into the area, are now well established as permanent residents and are very abundant on the mesas and around the springs. Killpack observed a large number of birds at Topopah Spring. Young birds were seen on June 1, 1962.

Fulica americana americana Gmelin
American Coot

Collection records: One specimen, October 26, 1961.

Status: The American Coot was an uncommon and irregular visitor at the test site. Birds were seen in March, July, September, November, and December at well reservoirs and on playa lakes.

Charadrius semipalmatus Bonaparte
Semipalmated Plover

Collection records: Four specimens, April 23, 29 and May 2, 1961.

Status: This species is known at the test site only as a spring migrant from March 30 to May 13. Birds were seen on playas at Yucca Flat and around the edges of well reservoirs. Several published records for the Truckee and Reno area are available (Christensen and Trelease, 1941; Johnson, 1954). Alcorn (1946) and Marshall (1951) reported specimens from Lahontan Valley. The only records known to us for southern Nevada are those for Lake Mead reported by Grater (1939).

Charadrius alexandrinus nivosus (Cassin)
Snowy Plover

Collection records: Two specimens, March 30 and April 2, 1961.

Status: We have 35 records of this species for the test site with the earliest record March 30 and the latest May 13. Most of the records were for April. There is no evidence of breeding or autumn migration in the area. Birds were found around the playa lakes.

Charadrius vociferus vociferus Linnaeus
Killdeer

Collection records: Three specimens, July 29, 1960; March 16, 1961.

Status: The killdeer is a common bird at the test site and has been recorded every month of the year except December. Birds are most abundant in March and April and again in August, September, and October. Whether or not they breed in the area is unknown to us. It seems likely that they are principally spring and autumn migrants. They occur regularly at playas and around the well reservoirs, but they are occasionally seen on the open desert.

Eupoda montana (Townsend)
Mountain Plover

Collection records: Three specimens, September 12, 16, 1961.

Status: The Mountain Plover is known to us as an autumn migrant. The species has apparently been rarely recorded for Nevada. The only published record of which we are aware is that of Alcorn (1941:119) when he collected three specimens in November at Carson Lake Pasture near Fallon. We know of no previous records for southern Nevada.

Pluvialis dominica dominica Müller
American Golden Plover

Collection records: Two specimens, September 14, 1961.

Status: The occurrence of the Golden Plover at the Nevada Test Site is known only from the two specimens collected. The birds were taken at Frenchman Flat Playa. We have not been able to find any other published record of this species for the state of Nevada.

On the basis of the lesser amount of yellow spotting on the back and the shorter beaks our specimens definitely belong to the subspecies *dominica*.

Squatarola squatarola (Linnaeus)
Black-bellied Plover

Collection records: None.

Status: We have only one sight record for May 6, 1961.

Capella gallinago delicata (Ord)
Common Snipe

Collection records: Four specimens, October 11, 1960; March 25 and October 9, 1961; March 28, 1962.

Status: The Common Snipe is a rather uncommon spring and autumn transient. It has been recorded in the area from March 17 to April 8 and again from September 18 to October 25. Observations have been made at Cane Springs, at playa lakes and around the well reservoirs.

Actitis macularia (Linnaeus)
Spotted Sandpiper

Collection records: Six specimens, May 2, 23, 15 and September 4, 1961; May 11, 1962.

Status: Spotted Sandpipers migrate in fairly large numbers through the test site in spring and autumn, especially in April and May. There are also often records of occurrence in summer when they may be seen on playas or around well reservoirs.

Tringa solitaria cinnamomea (Brewster)
Solitary Sandpiper

Collection records: Two specimens, April 23, 28, 1961.

Status: This species is an uncommon spring and autumn transient at the test site. Six records are available for April 23 to 28 and again August 11 to 27. The birds were seen around playa lakes.

According to the A.O.U. Check-list (1957) it is possible that either the races *solitaria* or *cinnamomea* could occur as transients in Nevada. Comparing our specimens with series of both races in the U.S. National Museum makes it clear that they are *cinnamomea*. Late summer adults of *cinnamomea* can be easily distinguished on the basis of the buffy rather than white spotting on the back. The narrower dark tail bands of *cinnamomea* in comparison with the wider ones of *solitaria* are also distinctive. The wing measurements of our specimens also fall more nearly within the range of *cinnamomea*

Totanus melanoleucus (Gmelin)
Greater Yellowlegs

Collection records: Three specimens, March 18 and April 14, 1961.

Status: Fairly common spring and autumn transients around playa lakes and well reservoirs. We have 39 records from March 18 to May and again from August to October 9. This species is much more common in the area than the Lesser Yellowlegs.

Totanus flavipes (Gmelin)
Lesser Yellowlegs

Collection records: Two specimens, August 21 and October 10, 1961.

Status: The Lesser Yellowlegs is an uncommon transient in spring and fall. We have five records scattered from March 9 to May 7 and again from August 21 to October 10. All were seen at the playa lakes.

Erolia melanotos (Vieillot)
Pectoral Sandpiper

Collection record: One specimen, October 3, 1961.

Status: A rare migrant in the test site area. Only the one specimen collected was seen. To our knowledge this is the first record of the Pectoral Sandpiper for Nevada.

Erolia bairdii (Coues)
Baird's Sandpiper

Collection records: Three specimens, April 9, August 12, September 30, 1961.

Status: This species is an uncommon spring and autumn transient. We have a total of 9 records for April 9 and again for August 4 to October 6. The birds were seen mostly at the playa lakes but occasionally at the well reservoirs.

Erolia minutilla (Vieillot)
Least Sandpiper

Collection records: Twelve specimens, March 18, 29, April 7, 16, 22, 23, October 26, 1961.

Status: This is a common spring and autumn transient species in the test site area. We have records of its occurrence from February 11 to October 3 except for June and September. The largest concentrations are in April and May at which time small flocks occur at the playa lakes.

Erolia alpina pacifica (Coues)
Dunlin

Collection records: Two specimens, May 13 and October 10, 1961.

Status: The Dunlin or Red-backed Sandpiper is a rare spring and autumn migrant at the test site where it was seen and collected at the playa lakes. In addition to the collection records, we have a sight record of three individuals for April 1. Linsdale (1951) cites only 4 records for Nevada, all of which are for the northern and central parts of the state.

Limnodromus scolopaceus (Say)
Long-billed Dowitcher

Collection records. Four specimens, March 26, 29, April 15, 1961; April 11, 1962.

Status: Long-billed Dowitchers appear to be uncommon spring and autumm migrants when they are seen at the playa lakes and the well reservoirs. In addition to the birds collected, one was seen on August 1, 1961.

Micropalama himantopus (Bonaparte)
Stilt Sandpiper

Collection records: None.

Status: Seven birds were observed at one of the playa lakes, October 8, 1961. Linsdale (1951) indicates only one other record for Nevada by Slipp (1952:62) between Hazen and Mahala, July 30, 1939.

Ereunetes mauri Cabanis
Western Sandpiper

Collection records: Ten specimens, April 15, 22, 27, 23, 1961.

Status: The Western Sandpiper is perhaps the most common of the small transient shore birds to visit the test site area. We have numerous records from April 15 into May and again from July to October 8. It was found exclusively around the playa lakes.

One of our specimens collected on April 22, 1961, has an exceptionally short bill, placing it well within the range of *E. pusillus*. However, on the basis of the distinctly brown back and heavier and more extensive streaking of the underparts, we have placed it with *E. mauri*.

Limosa fedoa (Linnaeus)
Marbled Godwit

Collection record: One specimen, July 20, 1961.

Status. The Marbled Godwit was a rare visitor at the test site during the period of this study. Only the one specimen collected was observed. Linsdale's (1951) summary of the Nevada records indicates that this species is not common in the state although it is a consistent visitor.

Himantopus mexicanus (Müller)
Black-necked Stilt

Collection record: One specimen, April 27, 1961.

Status: This species is an uncommon spring and autumn transient around the playa lakes. We have a total of six records from April 27 through May and again on September 16.

Recurvirostra americana Gmelin
American Avocet

Collection records: Two specimens, March 29 and August 5, 1961.

Status: Avocets are rather common spring and autumn transients at the playas, especially Yucca Flat. One hundred eighty recordings were made for this species from March 7 into May and again from August to November 22.

Steganopus tricolor Vieillot
Wilson's Phalarope

Collection records: Nine specimens, April 29 and 30, and May 3, 4, 11, 1962; May 5, 1962.

Status: A fairly common transient in spring and autumn around playa lakes and well reservoirs. We have a total of 44 records from April 29 to May 11 and again on August 12. By far the greater number of recordings are for April and May.

Lobipes lobatus (Linnaeus)
Northern Phalarope

Collection records: Three specimens, May 14, July 5 and September 3, 1961.

Status: Northern Phalaropes are rather uncommon spring and autumn migrants seen at playa lakes, well reservoirs, and occasionally at Cane Springs. We have 34 records mostly from May 14 to May 22 and from September 3 to September 19.

Larus californicus Lawrence
California Gull

Collection records. None.

Status. The California Gull is a somewhat common, although irregular visitor to the test site, where it was seen on the playa lakes from March 7 into April and again in October. The species was far more common in the spring than in autumn. We have no records for summer or winter.

Larus delawarensis Ord
Ring-billed Gull

Collection record: One specimen, March 12, 1961.

Status: We have numerous records for this gull from March 12 into June and again from September to November 15. It was seen on the playa lakes, frequently in company with the California Gull.

Larus philadelphia (Ord)
Bonaparte's Gull

Collection records: Three specimens, April 15, May 3, October 23, 1961.

Status: These gulls are uncommon spring and autumn migrants. They were seen at Yucca Flat. An occurrence at Mead Lake was reported by Grater (1939:30).

Zenaidura macroura marginella (Woodhouse)
Mourning Dove

Collection records: Four specimens, May 21, 22, June 14, 29, 1961.

Status: Several thousand recordings were made for this species from April 2 to November 1. Birds were most abundant in April, May and June. It was common to see large numbers, estimated to be as many as 5,000, come into water sources in the evening. During the heat of the day in midsummer, many would go into caves, particularly at Tippipah Spring, where some would die or become incapacitated.

Nests were most commonly found in *Yucca* trees or on the ground in the *Coleogyne* community. Nests were found as follows: June 29 with week-old young; June 23 with young; June 15 with eggs.

Geococcyx californianus (Lesson)
Roadrunner

Collection records: Three specimens, June 15, August 6, October 12, 1961.

Status: Fairly common permanent residents in the area. They seemed to occur most commonly in *Yucca, Coleogyne* and *Larrea* communities, although one was seen on the mesa in Pinyon-Juniper. A nest containing four eggs was found in an old abandoned bomber south of Yucca Flat. It was built in the engine and contained four eggs on April 12, 1961.

Bubo virginianus occidentalis Stone
Great Horned Owl

Collection record: One specimen, November 13, 1959.

Status: In addition to the specimen collected, one sight record for December 17 is available. The species seems to be a rare winter visitor at the test site.

Although the resident race of the Horned Owl in southern Nevada is supposed to be *pallescens* (A.O.U. Check-list, 1957), our single specimen is much closer in wing length (378mm) and coloration to *occidentalis* when compared with specimens from central Utah. Gabrielson (1949) recorded a specimen that he referred to the subspecies *lagophonus* from northern Nye County (Potts).

Speotyto cunicularia hypugaea (Bonaparte)
Burrowing Owl

Collection records: Three specimens, July 7, 1961; June 16 and July 27, 1962.

Status: The Burrowing Owl is a permanent resident at the test site. It has been noted in the *Coleogyne and Yucca* communities and is more common in open country where the vegetation is not in a dense growth.

Asio otus wilsonianus (Lesson)
Long-eared Owl

Collection records: Five specimens, December 4, 1960; January 25, 1960; September 6, October 7 and January 30, 1961.

Status: We have a total of 10 records of this owl from September 6 to March 31. There are no observations for April through August, indicating that it may be a winter visitor only. However, more careful investigation may show that it breeds in the Pinyon-Juniper community or in scrub oak. Specimens that have been observed were found mostly in the scrub oak of the small canyons and also at Cane Springs.

Asio flammeus (Pontoppidan)
Short-eared Owl

Collection records: One specimen, April 11, 1961.

Status: This owl is an uncommon visitor at the test site. Besides the collection record we have one sight record for February 13. Birds were seen in the *Coleogyne* community.

Phalaenoptilus nuttallii nuttallii (Audubon)
Poor-will

Collection records: Two specimens, July 20, 1961.

Status: The Poor-will is a rather common summer resident on the mesas and in small canyons adjacent to them. There are no records for the low desert communities.

Chordeiles minor hesperis Grinnell
Common Nighthawk

Collection records: Two specimens, June 16 and July 20, 1962.

Status: Judging from confirmed records available the Common Nighthawk is rather rare in the test site area. However, it may occur more frequently than we know in flocks of the much more abundant Lesser Nighthawk, which feed commonly over the well reservoirs and playa lakes during the summer.

The two specimens collected are nearly identical with examples of the subspecies *hesperis* from the Great Basin in Utah and are undoubtedly of that race.

Chordeiles acutipennis texensis Lawrence
Lesser Nighthawk

Collection records: Eighteen specimens, July 7, 10, 28, 29, 1960; May 20, June 18, July 1, 1961.

Status: The Lesser Nighthawk is a common summer resident at the test site, where it is most frequently seen feeding over well reservoirs and playa lakes in the evening. Birds have been recorded from June 18 to August 8 but are most abundant in June and July. We have no information on the daytime habits of this species in the area.

Aëronautes saxatalis saxatalis (Woodhouse)
White-throated Swift

Collection records: Two specimens, August 1, 1960.

Status: We have 27 sight records from April to August 1, with the greatest number being seen in May. Birds are fairly common on the mesas and high ridges, but rarely occur over the lower open deserts.

Calypte costae (Bourcier)
Costa's Hummingbird

Collection records: Seven specimens, March 22, April 15, May 13, June 12, 15, 1961; July 23, 1962.

Status: Costa's Hummingbird is the most common hummer in the area. There are numerous records extending from March 22 to July 23. The birds are most often encountered around the springs, particularly Cane Springs and Tippipah Spring. On April 28, 1962, a nest containing two eggs was located in an *Atriplex canescens* bush on a steep bank at Cane Springs.

Selasphorus platycercus (Swainson)
Broad-tailed Hummingbird

Collection records: None.

Status: We have only 2 sight records for this species. It was observed at Cane Springs, September 8, 1961.

Selasphorus rufus (Gmelin)
Rufous Hummingbird

Collection records: Two specimens, July 23, 1962.

Status: Only the two collection records noted above are available. The birds were taken in a burned Pinyon-Juniper area where they were feeding at blossoms of *Pentstemon* and *Gilea*.

Megaceryle alcyon caurina (Grinnell)
Belted Kingfisher

Collection records: None.

Status: Two sight records were made on April 6 and April 20, 1961.

Colaptes cafer collaris Vigors
Red-shafted Flicker

Collection records: Four specimens, October 24, 1960; October 7, 20, 1961; April 13, 1962.

Status: The Red-shafted Flicker was recorded for every month of the year except January. It is regarded as a permanent resident in Pinyon-Juniper on the mesas. It was also frequently seen perching on utility poles along the roadways and at Cane Springs.

Asyndesmus lewis (Gray)
Lewis' Woodpecker

Collection records: Two specimens, May 1, 1961; May 6, 1962.

Status: This species is presently known only as a spring and early summer transient. It has been recorded from May 1 to June 29. It was noted at Cane Springs and in the Pinyon-Juniper on the mesas.

Sphyrapicus varius nuchalis Baird
Yellow-bellied Sapsucker

Collection records: Five specimens, June 23, 1960; September 28, 29, October 4, 1961.

Status: This sapsucker appears to be a spring and fall transient although further field work may reveal that it nests in the Pinyon-Juniper of the mesas. Most of our observations have been made in the autumn at Cane Springs, where the birds stop for brief periods.

Dendroecopos villosus (Linnaeus)
Hairy Woodpecker

Collection records: Two specimens, November 14 and January 29, 1961.

Status: Hairy Woodpeckers are permanent residents in the Pinyon-Juniper community of the mesas. They have been noted from March through August and again in November and January. They have been noted only in the Pinyon-Juniper community of the mesas.

There are insufficient data to indicate the breeding subspecies in the test site area. Linsdale (1951, p. 237) states that *leucothorectis* is resident in the southern part of Nevada at higher elevations. Of our two specimens, one is clearly *leucothorectis*. The other has a wing measurement (134 mm) that falls within the range of *monticola* however, it lacks the white spots on the wing coverts and the bill is shorter than in typical *monticola*. It is possible that this individual is intermediate between the two races and has drifted farther south in the winter.

Dendrocopos scalaris cactophilus (Oberholser)
Ladder-backed Woodpecker

Collection records: Four specimens, June 12, 1961; July 23 and August 3, 1960.

Status: This woodpecker is an uncommon spring and summer resident in *Yucca* and *Coleogyne* communities and occasionally in oakbrush at the base of the mesas. We have recorded it from March 18 to August 3.

Tyrannus verticalis Say
Western Kingbird

Collection records: Seven specimens, April 12, 24, May 7, June 12, 14, 15, 1961.

Status: We have more than 200 records of the Western Kingbird from April 12 to September 11. They are common summer residents in the *Yucca-Coleogyne* community and occasionally are found on the mesas in Pinyon-Juniper. In the latter area a nest was found May 27, 1962, about 12 feet up from the ground in a dead pinyon.

Tyrannus vociferans Swainson
Cassin's Kingbird

Collection records: Eight specimens, May 7, June 27, July 2, 1961; July 20, 24, 1962.

Status: Records of Cassin's Kingbird from Nevada seem to be rather few. Grater (1939: 221) reported two individuals at Saint Thomas, June 28, 1938. We found the species to be a fairly common summer resident in brushy canyons and in the Pinyon-Juniper. Besides the collection records indicated above, we have 42 sight records between May 6 and August 22. Young birds were found in the Pinyon-Juniper on July 20.

Myiarchus cinerascens cinerascens (Lawrence)
Ash-throated Flycatcher

Collection records: Four specimens, May 27, 1960; April 29, May 7, 26, 1961.

Status: This species was a common summer resident in a small canyon in oakbrush and in the Pinyon-Juniper on the mesas. A few were also seen at Cane Springs. The records extend from April 6 to August 24 but the birds were most common in May and June.

Sayornis nigricans semiatra (Vigors)
Black Phoebe

Collection records: Four specimens, July 28, 1960; May 28, August 9, 1961.

Status: Black Phoebes are uncommon summer residents around the wells and at Cane Springs. Our records extend from March 31 into May and again in July and August.

Sayornis saya saya (Bonaparte)
Say's Phoebe

Collection records: Eleven specimens, July 27, 1960; May 10, 24, February 7, April 14, June 2, 15, 1961; March 13, 1962.

Status: This phoebe is a very common resident in all types of communities at the test site. We have records for every month of the year except October and December. It is likely that some individuals remain in the area as permanent residents although we have found them to be more common in March through June. A nest containing 4 fresh eggs was found at Mid Valley, May 27, 1961, on a ledge about 5 feet up. An old nest was also found at Cane Springs and another in a cave at Tippipah Spring on July 27, 1962.

Empidonax hammondii (Xantus)
Hammond's Flycatcher

Collection records: Three specimens, April 30, May 21, 1961; May 13, 1962.

Status: Owing to the difficulty in making sight identifications of the *Empidonax* flycatchers the status of this species in the area is somewhat in doubt. However, it is believed to be a fairly common summer resident in the Pinyon-Juniper and Oakbrush communities.

Empidonax oberholseri Phillips
Dusky Flycatcher

Collection records: Nine specimens, April 30, May 7, 11 ,13, 23, June 4, 1961; April 28, May 6, 1962.

Status: The Dusky Flycatcher is at present known only as a spring transient through the test site area.

Empidonax wrightii Baird
Gray Flycatcher

Collection records: Fourteen specimens, April 29, May 2, 7, 13, 24, 26, July 2, 1961; April 28, June 5, 1962.

Status: It is likely that the Gray Flycatcher is a summer resident in the Pinyon-Juniper and Oakbrush communities of the mesas and small canyons. Since *E. oberholseri* and *E. wrightii* are difficult to separate in the field, we have not attempted to record sight data.

Contopus sordidulus veliei Coues
Western Wood Pewee

Collection records: Twelve specimens, July 27, 1960; May 11, 20, 23, 24, 26, June 2, 4, 16, 1961; May 5, 1962.

Status: The Wood Pewee is a common migrant in May and is resident in summer in oakbrush of the small canyons and in the Pinyon-Juniper of the mesas. Records are available from May 5 to September 7. During the peak of migration in May these birds are occasionally seen in the *Yucca-Coleogyne* community of the lower deserts.

Nuttallornis borealis (Swainson)
Olive-sided Flycatcher

Collection records: Four specimens, May 24, 26, June 2, September 18, 1961.

Status: The Olive-sided Flycatcher is a rather uncommon migrant at the test site in spring and autumn. The earliest record is for May 24 and the latest September 18. There are no records for July but 12 recordings were made for late August. Birds were seen in the Pinyon-Juniper of the mesas and in oakbrush of the small canyons.

Pyrocephalus rubinus flammeus van Rossem
Vermilion Flycatcher

Collection record: One specimen, July 22, 1962.

Status: Only the one record of the specimen collected is available. The collection was made in Pinyon-Juniper on the east rim of the mesas.

Eremophila alpestris (Linnaeus)
Horned Lark

Collection records: Twenty-five specimens, January 28, June 9, July 27, December 2, 9, 1960; January 3, 28, February 24, April 22, May 20, July 1, 1961; March 18, July 16, 1962.

Status: The Horned Lark is a permanent resident in all of the lowland desert communities. Although it has been recorded for every month of the year, it is most abundant in large flocks from October through March. In summer, large concentrations of the birds were seen around well reservoirs in the evening when they came in to drink. Young birds were frequently caught in mammal traps in the *Atriplex confertifolia* community, which seems to be their preferred nesting habitat.

The subspecific status of the horned lark population at the Nevada Test Site is of considerable interest. From the information at hand it seems rather clear that neither the wintering nor breeding birds are of the race *utahensis*, which is supposedly the breeding subspecies of the eastern Great Basin. Both young and adult test site specimens are on the whole decidedly lighter, less grayish and brighter on the upper parts than Great Basin specimens. Only one of our specimens approaches characteristic *utahensis*. Most of our wintering specimens appear to be identical with the race *leucolaema* from eastern Utah. Our breeding specimens are rather paler than the latter race and are temporarily assigned to the race *ammophila*, the breeding range of which includes southwestern Nevada (A.O.U. Check-list, 1957, p. 357).

Tachycineta thallassina lepida Mearns
Violet-green Swallow

Collection records: Five specimens, April 2, June 30, 1961; May 12, 1962.

Status: This species is fairly common at the test site in spring and summer. We have recorded it from March 11 to August 8, when it is most often seen feeding over water at playa lakes and reservoirs. The birds were also occasionally seen in the Pinyon-Juniper in July, and there is a possibility that they nest there.

Iridoprocne bicolor (Vieillot)
Tree Swallow

Collection records: Two specimens, April 2, 23, 1961.

Status: The Tree Swallow is an uncommon spring transient through the test site, where it was seen feeding over and near open water. We have 18 records from March 28 to April 25.

Riparia riparia riparia (Linnaeus)
Bank Swallow

Collection records: One specimen, May 13, 1961.

Status: The Bank Swallow is an uncommon spring transient and summer visitor. We have 18 records made on May 12 and 13 and on July 30. It was observed feeding over and near open water.

Stelgidopteryx ruficollis serripennis (Audubon)
Rough-winged Swallow

Collection record: One specimen, April 12, 1961.

Status: We have 14 records of this species, all in spring, from March 8 to May 11. They were seen feeding near and over open water.

Hirundo rustica erythrogaster Boddaert
Barn Swallow

Collection records: None.

Status: The Barn Swallow is an uncommon spring and autumn transient at the test site. We have a total of 17 sight records from April 22 to June 6 and again from September 10 to October 7. The birds were seen around open water.

Petrochelidon pyrrhonota (Vieillot)
Cliff Swallow

Collection records: None.

Status: Twelve sight records are available from April 23 to May 24 and again on August 9. We have no records for June and July. Lacking specimens we have not been able to determine the subspecific status although on the basis of known distribution it could be either *P. p. pyrrhonota* or *P. p. hypopolia*.

Cyanocitta stelleri (Gmelin)
Steller's Jay

Collection records: None.

Status: Steller's Jay appears to be an uncommon resident of the Pinyon-Juniper and Oakbrush communities. We have 8 sight records for August 22 and 23 and October 25. Owing to the lack of specimens we have been unable to determine the subspecific status of the resident population.

Aphelocoma coerulescens nevadae Pitelka
Scrub Jay

Collection records: Four specimens, August 1, 1960; March 16, May 14, July 2, 1961.

Status: The Scrub Jay is a rather common resident in the Pinyon-Juniper and oakbrush communities. We have recorded it from February 22 to October 10, with the greatest number of records being in May. We have no records as yet for the months of November, December and January.

Pica pica hudsonia (Sabine)
Black-billed Magpie

Collection records: None.

Status: We have only one sight record of the magpie for December 5, 1961.

Corvus corax sinuatus Wagler
Common Raven

Collection records: Five specimens, November 13, December 15, 1959; August 31, October 14, 1960; April 21, 1961.

Status: Ravens are consistent residents of the test site and have been recorded for every month of the year. They are most often seen in pairs along the roadways, but they have also been noted on the mesas and around springs. On June 1, 1961, two nesting sites were located on cliffs bordering the mesa; however, it was not possible to reach the nests for close observation.

Corvus brachyrhynchos hesperis Ridgway
Common Crow

Collection records: None.

Status: The Common Crow is an uncommon winter visitor to the test site. Four records are available from November 5 to December 6. The birds were seen on the mesa and also near the town of Mercury.

Gymnorhinus cyanocephala Wied
Piñon Jay

Collection records: Four specimens, July 31, August 1, 1960; July 7, 1961.

Status: This jay is a fairly common resident of the Pinyon-Juniper on the mesas and in canyons bordering the mesas. Our records extend from April 9 to December 11, although it is likely that the birds also occur during the midwinter months. Most of our records are for April through August.

Nucifraga columbiana (Wilson)
Clark's Nutcracker

Collection records: Two specimens, September 28, 1961.

Status: This species has been observed uncommonly in the Pinyon-Juniper community. We have only autumn records from September 28 to October 20.

Parus gambeli inyoensis (Grinnell)
Mountain Chickadee

Collection records: Seven specimens, July 3, 1960; March 31, April 15, June 16, July 2, 1961.

Status: Mountain Chickadees appear to be permanent residents in the Pinyon-Juniper community. We have records of them for every month of the year except January, but they were most commonly seen in April through July.

Parus inornatus ridgwayi Richmond
Plain Titmouse

Collection records: Two specimens, March 5 and June 29, 1961.

Status: We have rather few records of this species in comparison with the Mountain Chicadee. We have recorded it from March 5 to June 29 in the Pinyon-Juniper community of the mesas.

Psaltriparus minimus plumbeus (Baird)
Common Bushtit

Collection records: Five specimens, April 16, May 24, June 16, October 8, 1961.

Status: This bushtit is a common resident at the test site throughout most of the year. We have records for every month except September, November, January, and February. It is found both in Pinyon-Juniper and in the *Grayia-Lycium* community. Young of this species were frequently observed.

Sitta carolinensis tenuissima Grinnell
White-breasted Nuthatch

Collection records: One specimen, May 13, 1961.

Status: The White-breasted Nuthatch seems to be rare in the Pinyon-Juniper community. In addition to the specimen collected, we have one other sight record for May 14.

Troglodytes aedon parkmanii Audubon
House Wren

Collection records: None.

Status: The status of the House Wren for the Nevada Test Site is known only from two sight records, April 29 and August 20, 1961.

Thryomanes bewickii eremophilus Oberholser
Bewick's Wren

Collection records: Four specimens, June 27, July 30, August 20, December 5, 1961.

Status: This wren is fairly common in Pinyon-Juniper on the mesas from April 15 to August 20. It is likely that some individuals remain all winter since we have records for December.

Camphlorhynchus brunneicapillum couesi Sharpe
Cactus Wren

Collection records: Five specimens, January 5, 1962 and July 23, 25, 1962.

Status: The Cactus Wren seems to be confined exclusively to communities where the yucca is present. In addition to the five specimens collected we have eight sight records for January 3, 1962. The specimens collected in July were young birds of the year. Apparently the species is confined to the *Yucca* and *Yucca-Colcogyne* communities.

Cistothorus palustris aestuarinus Swarth
Long-billed Marsh Wren

Collection records: Two specimens, March 31 and September 29, 1961.

Status: The Marsh Wren is an uncommon spring and autumn transient at the test site. It was seen around the well reservoirs.

The two specimens collected were placed in the subspecies *aestuarinus* rather than *plesius* in the basis of their shorter beaks. One of the specimens has the typical dark crown of *aestuarinus*, but neither of them is as richly chestnut on the back as *aestuarinus*.

Salpinctes obsoletus obsoletus (Say)
Rock Wren

Collection records: Seven specimens, April 16, May 5, June 16, July 24, August 24, 1961.

Status: Rock Wrens are permanent residents in rocky situations in the Pinyon-Juniper and around the mesas. We have recorded them for every month of the year except February and September. However, they are more commonly seen in March through June.

Mimus polyglottos leucopterus (Vigors)
Mockingbird

Collection records: Two specimens, April 15, June 15, 1961.

Status: The Mockingbird has been recorded in the area from April 2 to August 15, with the greatest number of recordings in May and June. It is seen most often in the *Yucca* habitat but is also found in the small canyons around the borders of the mesas.

Dumetella carolinensis (Linnaeus)
Catbird

Collection records: One specimen, June 6, 1961.

Status: This species seems to be rare at the test site and has been reported only a few times for the state of Nevada. Linsdale (1951) cites only two records. The one specimen obtained by us was taken at Cane Springs and was probably a transient bird.

Toxostoma lecontei lecontei Lawrence
Le Conte's Thrasher

Collection records: Eleven specimens, December 18, 1959; February 12, August 17, December 3, 1960; May 2, 3, 4, June 1, 29, July 10, 1961; February 12, 1962.

Status: We have records of this thrasher for every month of the year. Most of the records are for June. In winter they seem to move about in small flocks in a nomadic fashion. They appear to be equally at home in all of the types of desert communities but were never seen on the higher mesas.

Oreoscoptes montanus (Townsend)
Sage Thrasher

Collection records: Nine specimens, March 5, 22, April 12, May 20, 21, September 14, 1961; January 16, 1962.

Status: A few sage thrashers apparently winter in the test site area, but they are more commonly seen in early spring (March and April). There is some evidence of nesting. The preferred habitat seems to be *Grayia-Lyicum* and *Larrea*, but they also occur in sage and in Pinyon-Juniper.

Turdus migratorius propinquus Ridgway
Robin

Collection records: Four specimens, October 19, 1960; May 24, 26, 1961; January 1, February 27, 1962.

Status: Robins were recorded in the area from January 1 to July 2 and again from October to November 14. Although a few birds winter at the test site, they are more common as spring and autumn migrants. Most of the records were for Cane Springs and the mesa.

Hylocichla guttata oromela Oberholser
Hermit Thrush

Collection records: Five specimens, April 29, October 12, 1961; April 28, May 5, 1962.

Status: The Hermit Thrush is known only as a spring and autumn transient through the test site area. The earliest record is for April 28 and the latest October 20.

All our specimens were identified by Dr. John W. Aldrich as belonging to the race *oromela*. This race was not recognized in the A.O.U. checklist (1957) and was not included by Linsdale (1951) in his list of Nevada birds.

Hylocichla ustulata ustulata (Nuttall)
Swainson's Thrush

Collection records: Two specimens, June 6, 1961; May 12, 1962.

Status: Swainson's Thrush is at present known only as a spring transient. Specimens were collected at Cane Springs and Tippipah Spring.

On the basis of the distinct olive brown rather than the olive or more grayish upper parts our two specimens are definitely of the race *ustulata* rather than *swainsoni*. Compared with *swainsoni* our specimens also have brighter and more buffy throats and upper breasts and their under tail coverts are decidedly buffy rather than whitish. In his list of Nevada birds Linsdale (1951) lists only the races *swainsoni* and *almae* from the state. The latter subspecies is now considered to be a synonym of *swainsoni* (A.O.U. Check-list, 1957). Our record of *ustulata* may therefore be considered as an additional subspecies for Nevada.

Sialia mexicana bairdi Ridgway
Western Bluebird

Collection record: One specimen, May 21, 1961.

Status: This species is an uncommon bird found thus far only in the Pinyon-Juniper of the mesas. We have only 16 records from March 31 to May 21 and again in November.

Sialia currucoides (Bechstein)
Mountain Bluebird

Collection records: Six specimens, March 16, April 26, 27, May 23, 1961; June 14, 1962.

Status: We have many records of the Mountain Bluebird from November to July 2. They were most abundant in March through May. In winter they were seen in the lower deserts along the roadways, but in spring they were more common in the Pinyon-Juniper of the mesas. We have no positive record of their nesting and no observation records for August through October.

Myadestes townsendi townsendi (Audubon)
Townsend's Solitaire

Collection records: Four specimens, October 5, 1959; April 23, 24, September 28, 1961.

Status: Solitaires are considered to be spring and autumn migrants through the test site area. We have records from April 23 to June and from September to October 25. Birds have been noted only in the Pinyon-Juniper of the mesas.

Polioptila caerulea amoenissima Grinnell
Blue-gray Gnatcatcher

Collection records. Six specimens, April 25, 30, June 16, July 2, 1961; April 1, 1962.

Status: This gnatcatcher is a common spring and summer resident. Our records extend from April 14 to September 8, although the birds are most abundant in April and May. Their usual habitat is the Pinyon-Juniper of the mesas or the oakbrush of the bordering slopes and canyons. A few were also noted at Cane Springs.

Regulus calendula cineaceus Grinnell
Ruby-crowned Kinglet

Collection records: Four specimens, April 9, 24, 30, October 28, 1961.

Status: Our records of the Ruby-crowned Kinglet extend from October 5 to May 7 with most of the records in April. The bird is considered to be an uncommon winter resident and a common spring and autumn migrant. Most of the records are for Cane Springs.

Anthus spinoletta (Linnaeus)
Water Pipit

Collection records: Ten specimens, April 7, 16, March 30, May 13, September 29, October 8, November 1, 1961; January 26, 1962.

Status: Pipits are common spring and autumn migrants in the area and a few remain throughout the winter. The periods of most common occurrence are from March into May and from September through November. They are seen near the playa lakes and around the well reservoirs.

The subspecific composition of the test site population based upon the ten specimens available to us seems to consist of both *A. s. alticola* and *A. s. pacificus*. Seven out of the 10 seem to be *alticola* and the remaining 3 are placed in *pacificus*. However, it seems difficult to separate these two in the nonbreeding plumage. The three specimens assigned to *pacificus* were taken in late fall and winter; all of those save one that are placed in *alticola* were collected in the spring. The underparts of *alticola* are somewhat brighter buff and the streaks on the breast and flanks are less extensive and individually paler and narrower. Judging from specimens of *alticola* taken in northern Utah in the autumn there is a tendency for the streaks to be larger, darker, and more extensively distributed at that season and to gradually wear away during the winter. However, the bright buffy ground color of the underparts seems to remain fairly constant toward spring. There is still a possibility that the three specimens called *pacificus* are actually young *alticola* that have not yet had the streaking reduced; however, the fact that the ground color of the underparts is paler has indicated that they are closer to *pacificus*. Linsdale (1951) has indicated that *pacificus* is the wintering subspecies in Nevada.

Bombycilla cedrorum Vieillot
Cedar Waxwing

Collection records: Six specimens, March 16, October 23, 1961; May 13, June 5, 1962.

Status: We have a total of sixteen records from March 16 to October 23, with most of them in May and June. This waxwing seems to be an irregular visitor at Cane Springs, Tippipah Spring, and on the mesa.

Phainopepla nitens lepida Van Tyne
Phainopepla

Collection record: One specimen, May 6, 1961.

Status: We have record of only the one specimen which was collected at Cane Springs.

Lanius ludovicianus Linnaeus
Loggerhead Shrike

Collection records: Fifteen specimens, August 24, November 19, 1959; June 9, July 27, 1960; March 7, April 15, 25, May 21, June 28, 1961; February 14, March 7, June 5, 1962.

Status: We have many records including every month of the year, but shrikes were most commonly seen in March through June. The birds were observed in all of the types of plant communities. Nesting activity was observed as follows: A nest containing 6 eggs was found in an *Antriplex confertifolia* about 3 feet up from the ground, April 28, 1962; another, also containing 6 eggs was located at Tippipah Spring in a *Purshia tridentata* about 4 feet up, April 28, 1962; another nest containing young about a week old was found on May 5, 1962. These young were banded on May 12.

The subspecific status of the breeding population is somewhat in doubt. The race *nevadensis* proposed by Miller is not recognized in A.O.U. Check-list (1957) and is presumably considered to be a synonym of *sonoriensis*. Most of our specimens have the clear white rump and lighter upperparts of *sonoriensis*, but a few adults have the grayish rumps and darker backs more typical of *gambeli*. Measurement of 9 specimens from the test site shows a wing length varying from 98 to 102 mm., with an average of 100.3. This is somewhat smaller than the average of 103.3 accorded to *sonoriensis* (Miller, 1930, p. 155). If the race *nevadensis* is to be discounted, it seems likely from the data at hand that the test site population consists of intergrades between *gambeli* and *sonoriensis*, being closer to *gambeli* in wing measurement but nearer to *sonoriensis* in the white underparts and usually lighter backs.

Sturnus vulgaris Linnaeus
Starling

Collection records: Six specimens, November 19, 1959; July 6, 1960; February 13, March 14, October 18, 1961.

Status: The Starling appears to be primarily a winter and early spring visitor to the test site. It was recorded most often in November but was common in later winter and early spring. Occasional birds also occur in the summer as indicated by the collection made in July. They are most frequently observed in the lower desert communities and were especially common along the roadways at Yucca Flat.

Vireo vicinior Coues
Gray Vireo

Collection records: One specimen, July 7, 1961.

Status: The Gray Vireo has been recorded four times at the test site from May 7 to July 7. It was noted only in the Pinyon-Juniper community.

Vireo solitarius (Wilson)
Solitary Vireo

Collection records: Five specimens, May 13, 26, 1961; April 28, May 12, 1962.

Status: This vireo is a spring and summer resident in the Pinyon-Juniper of the mesas. We have records extending from April 28 to July 2.

Four of our five specimens are of the subspecies *cassinii*, with typical yellowish green flanks and back. The other specimen is of the race *plumbeus*.

Vireo gilvus swainsonii Baird
Warbling Vireo

Collection records: Four specimens, May 24, June 16, July 30, 1961; April 28, 1962.

Status: The Warbling Vireo is a fairly common spring and summer resident, when it is to be found at Cane Springs and in the Pinyon-Juniper of the mesas. It also occurs in the oakbrush in canyons around the mesas.

Vermivora celata orestera Oberholser
Orange-crowned Warbler

Collection records: Ten specimens, April 30, May 6, June 19, September 21, 1961; April 28, 1962.

Status: All of our records of this species were made at Cane Springs. It seems to be mainly a spring and autumn migrant through the area although the June 19 record is rather late for a migrant and may indicate that some remain through the summer.

Vermivora ruficapilla ridgwayi van Rossem
Nashville Warbler

Collection records: Two specimens, August 20, 30, 1961.

Status: Our only knowledge of this species at the test site is from the two collection records noted above. The birds were taken in Pinyon-Juniper and oakbrush.

Vermivora virginiae (Baird)
Virginia's Warbler

Collection records: Two specimens, June 28, July 2, 1961.

Status: We have a limited number of records of Virginia's Warbler extending from April 14 to August 20. They are spring and summer residents in the Pinyon-Juniper of the mesas and in the oakbrush of adjacent canyons.

Dendroica petechia morcomi Coale
Yellow Warbler

Collection records: Seven specimens, April 29, 30, May 14, 10, 20, 21, 1961.

Status: The yellow warbler is a fairly common spring and autumn migrant at the test site. It has been recorded from April 28 to May 6 and again from August 10 to September 19. Birds were most commonly seen at Cane Springs and at Whiterock Spring.

Dendroica coronata (Linnaeus)
Myrtle Warbler

Collection records: Two specimens, March 23, April 16, 1961.

Status: Known only as a spring migrant from the two collection records. Linsdale (1951, p. 243) mentions it as a transient in Nye County.

Dendroica auduboni memorabilis Oberholser
Audubon's Warbler

Collection records: Eight specimens, October 5, 1969; March 24, April 14, 24, 28, June 28, July 2, 1961.

Status: This warbler is a common spring and autumn transient. It is especially abundant in April, when it is found at Cane Springs, in the Pinyon-Juniper of the mesas, and also in the lower desert shrub communities. The collection of one young bird on the mesa in July would indicate that it also breeds in the area.

Our specimens are assigned to the subspecies *memorabilis* rather than *auduboni* on the basis of greater wing length. The Nevada specimens compared with Oberholser's (1921) measurements are as follows:

	Test Site Birds Wing	
D. a. memorabilis	78 (male)	73.6 (fem.)
D. a. auduboni	——	——
	Oberholser (1921) Wing	
D. a memorabilis	80.5 (male)	73.9 (fem.)
D. a. auduboni	74.9 (male)	71.6 (fem.)

Dendroica nigrescens (Townsend)
Black-throated Gray Warbler

Collection records: Nine specimens, April 30, May 7, 24, 26, June 4, 29, 1961.

Status: This warbler is a common spring and summer resident of the Pinyon-Juniper of the mesas, where it no doubt breeds. Our collection and sight records extend from April 28 to September 6, with most of the observation being made in May and June.

Dendroica townsendi (Townsend)
Townsend's Warbler

Collection records: One specimen, May 13, 1963.

Status: Townsend's Warbler is an uncommon spring transient through the test site. It was seen at Cane Springs and in sagebrush at the edge of the Pinyon-Juniper. We have six sight records from April 28 to May 13 and in October.

Oporornis tolmiei (Townsend)
MacGillivray's Warbler

Collection records: Six specimens, May 13, 14, 20, June 2, 1961; June 5, 1962.

Status: MacGillivray's Warbler is known to be a spring and autumn transient through the test site area. We have records for May and early June and again for August and September. There are no records for July, but the species may yet be found breeding around some of the springs. The earliest record is for May 4 and the latest for September 10. The birds were seen around Cane Springs and in *Purshia tridentata* and other brush at Tippipah Spring.

The subspecific status of our specimens is somewhat doubtful since both *O. t. tolmiei* and *O. t. monticola* might be found as transients through this area. Our specimens are rather variable in the gray and black of the forward parts, but the yellow underparts and yellowish green of the back are quite uniform and very much like a series of breeding birds from northern Utah. The tail measurements of our small series seem to be decidedly less than those given by Phillips (Auk, 64(2): p. 297, 1947) for *monticola* (50.3 in males as compared to 58.4), but we cannot be sure that our method of measurement was the same as his. Linsdale (1951) lists *monticola* as the resident bird of Nevada.

Geothlypis trichas scirpicola Grinnell
Yellowthroat

Collection records: Ten specimens, April 26, 27, 30, May 9, 19, 20, 21, June 9, 1961.

Status: The Yellowthroat is a spring and autumn transient through the area. It has been found from late April into early June and again in September at Cane Springs and Whiterock Spring. It is not known to breed at either of these places.

Linsdale (1951) states that *scirpicola* is the resident subspecies of southern Nevada. Our male specimens with respect to smaller size, smaller bills, and greater diffusion of the yellow over the abdomen seem close to *scirpicola* rather than the more northern race, *occidentalis*. However, our females show considerable variation in color from both of the above subspecies in that they have brighter yellow throats, grayish rather than brownish flanks, and paler backs.

Wilsonia pusilla (Wilson)
Wilson's Warbler

Collection records: Ten specimens, April 26, 30, May 11, 23, 27, June 2, 1961.

Status: Wilson's Warblers are rather common spring and autumn migrants. They were recorded from April 26 to June 6 and again in September, but they were most abundant in May. They were seen at Cane Springs and around the well reservoirs as well as in Pinyon-Juniper and oakbrush on the mesas.

From the material at hand it would seem that both *W. p. pileolata* and *W. p. chryseola* migrate through the test site area. Three males of our series exhibit more intense yellow underparts, a tendency toward orange in the forehead, and more yellowish backs characteristic of *chryseola*. Comparative wing measurements seem not to show any consistent pattern in the two races as represented in our material.

Passer domesticus domesticus (Linnaeus)
House Sparrow

Collection records: Three specimens, January 30, March 26, 1961.

Status: We have records of the House Sparrow at the town of Mercury and around the wells from October into June. We have no records for July, August, or September.

Sturnella neglecta neglecta Audubon
Western Meadowlark

Collection records: Two specimens, December 8, 1959; May 3, 1961.

Status: The meadowlark seems to be primarily an autumn, winter and spring resident at the test site, when it occurs in small numbers in sagebrush and other lower desert shrub communities. Our earliest records are for mid-September and our latest for mid-May.

Xanthocephalus xanthocephalus (Bonaparte)
Yellow-headed Blackbird

Collection records: Four specimens, April 16, 26, 29, May 31, 1961.

Status: This blackbird is an irregular transient at the test site. Our earliest record is for March 31 and our latest September 19. The birds were most common in April and May but a few were noted in June, July, and August. They were seen around the wells and springs and on the playas.

Agelaius phoeniceus (Linnaeus)
Redwinged Blackbird

Collection records: Nine specimens, July 28, October 13, 1960; May 20, October 8, 1961; March 16, April 1, 1962.

Status: The Redwinged Blackbird is the most common icterid at the test site. We have records for all months of the year except December, January and June. Birds are most abundant in April and again in October; at other times only scattered records were made. During the height of their migration they are common in flocks around the wells and springs and near water on the playas.

According to the A.O.U. Check-list (1957) any of the races *fortis*, *nevadensis*, and *sonoriensis* might occur at one time or another in southern Nevada. Most of the birds at the test site are transients, and we have not as yet been able to determine the breeding subspecies if any in that area. Our small series of females show considerable variation as to coloration and size of the beak. The length of the exposed culmen varies from 15.3 to 18.7 millimeters. Few reach the minimum of this measurement for females of either *fortis*, *nevadensis* or *sonoriensis* and none reaches the maximum of these races given by Bishop (1938, Trans. San Diego Soc. Nat. Hist., 9 (1): 1-4). For the present, therefore, it is thought best to leave the subspecific identity of the test site specimens in doubt.

Icterus parisorum Bonaparte
Scott's Oriole

Collection records: Seven specimens, July 27, 1960; June 19, 27, 28, 1961; April 28, 1962.

Status: Our records extend from April 15 to August 9. Scott's Oriole is consistently present at the test site in spring and summer, when it appears to occupy a variety of habitats. It has been observed in *Yucca*, Pinyon-Juniper, sagebrush, and the mixed vegetation around springs.

Icterus bullockii bullockii (Swainson)
Bullock's Oriole

Collection records: Six specimens, July 28, 1960; May 4, 7, 14, July 26, 1961.

Status: Bullock's Oriole is a fairly common spring and summer resident at the test site. We have records from April 14 to September 9, with most of them being in May. The birds were most commonly seen at Cane Springs, in the Pinyon-Juniper of the mesas, and in oakbrush vegetated canyons.

Euphagus cyanocephalus (Wagler)
Brewer's Blackbird

Collection records: Three specimens, April 16, 26, 1961.

Status: This blackbird is a common bird at the test site in spring and autumn, when it is most often seen around the wells and springs. Large numbers were observed in April and again in September and October. They were sparse during the summer months and seemingly absent in winter.

Molothrus ater obscurus (Gmelin)
Brown-headed Cowbird

Collection records: Eighteen specimens, August 27, 28, 1959; July 28, 1960; April 6, 16, 26, 30, 1961; April 28, 1962.

Status: Our records for the cowbird extend from April 6 to November 27, with the greatest numbers being in April and May. Birds were seen around springs and wells and also in the Pinyon-Juniper.

Our specimens are somewhat intermediate in size between *M. a. artemesiae* and *M. a. obscurus*. However, they have the shorter and more slender bills characteristic of *obscurus* and on that basis are referred to that subspecies.

Piranga ludoviciana (Wilson)
Western Tanager

Collection records: Eleven specimens, July 28, August 1, 1960; May 14, 24, 26, June 1961; May 27, 1962.

Status: Western Tanagers have been recorded for the test site from May 13 to September 8 although they are most common in May and September. They are frequently seen in the Pinyon-Juniper of the mesas, and a few may nest there. They are also present at Cane Springs and other springs of the area.

Pheucticus melanocephalus melanocephalus (Swainson)
Black-headed Grosbeak

Collection records: Seven specimens, May 20, June 4, 30, July 7, 1961.

Status: Our records of the Black-headed Grosbeak extend from April 11 to October 4. Birds are more common in May and June. They inhabit the oakbush around the mesas as well as the Pinyon-Juniper. They were also frequently seen at Cane Springs.

Guiraca caerulea interfusa Dwight and Griscom
Blue Grosbeak

Collection record: One specimen, May 21, 1961.

Status: The Blue Grosbeak seems to be an uncommon visitor to the test site. We have a total of 20 records all from the vicinity of Cane Springs and all for May.

Passerina amoena (Say)
Lazula Bunting

Collection records: Nine specimens, April 30, May 2, 7, 12, June 19, July 2, September 13, 29, 1961; May 12, June 6, 1962.

Status: This species is a fairly common spring, summer, and early autumn resident. Our records extend from April 30 to September 29, but most of them are for May and June. The birds are most commonly seen around Cane Springs, but they are also found in the Pinyon-Juniper of the mesas where there is some evidence of nesting.

Hesperiphona verpertina brooksi Grinnell
Evening Grosbeak

Collection records: Two specimens, October 24, 25, 1961.

Status: The Evening Grosbeak is a rare autumn and winter visitor at the test site. Birds have been noted around the wells and in the Pinyon-Juniper.

Carpodacus purpureus californicus Baird
Purple Finch

Collection records: Two specimens, October 24, 25, 1961.

Status: This species appears to be a rare autumn and spring transient. It has been noted only in the Pinyon-Juniper of the mesas. Neither Linsdale (1951) nor Gullion, *et al.* (1959) have included this species in their lists of Nevada birds.

Carpodacus cassinii Baird
Cassin's Finch

Collection records: Twelve specimens, April 15, 27, May 21, 23, 26, 27, June 16, October 25, November 14, 1961.

Status: Cassin's Finch is a fairly common resident in the area in spring, summer, and autumn. Our records extended from March 18 to November 14, with the greatest numbers noted in March through June. The birds are almost invariably seen in Pinyon-Juniper but have been recorded occasionally in *Larrea*.

Carpodacus mexicanus (Muller)
House Finch

Collection records: Thirty-nine specimens, October 1, November 18, 1959; December 9, 1960; January 20, 25, 30, 31, February 15, 17, March 10, 11, 19, 26, April 23, 29, May 10, 11, 19, June 15, November 12, 1961.

Status: The House Finch is an abundant resident at the test site throughout the year. Birds are especially abundant in winter, when large flocks are mostly restricted to disturbed areas where Russian thistle is predominant. In summer these birds scatter into the Pinyon-Juniper and *Yucca* where they nest. We have the following nesting records: On May 26, 1961, a nest containing five young recently hatched was found in the top of a *Yucca* about 7 feet from the ground; on June 1, 1961, a nest containing four eggs was found in a juniper.

Moore (Proc. Biol. Soc. Washington, 52:105, 1939) proposed the name *solitudinis* for the Nevada race of House Finch mainly on the basis of less extensive distribution of red in the male. However, his name was not accepted in the A.O.U. checklist (1957), and the name *frontalis* has usually been applied to the Nevada population (Linsdale, 1951). Our series of males taken mostly in winter and early spring show a great amount of variation in both the extent and shade of red. Some of the brighter specimens are near Nopal Red of Ridgeway but range to Peach Red in one specimen. In another group where the coloring is usually far less extensive the color is near Zinc Orange or Ochraceous-orange. In one specimen the throat, forehead, and rump are Yellow Ocher, and there is a distinct grayish brown band across the upper breast.

Spinus pinus pinus (Wilson)
Pine Siskin

Collection records: Five specimens, October 19, 1960; March 30, April 30, November 1, 1961.

Status: The Pine Siskin is an autumn, winter and spring resident of the area. Our records extend from October 19 to April 30, when the birds were seen in the Pinyon-Juniper of the mesas and around Cane Springs. We have no evidence of summer occurrence.

Spinus tristis pallidus Mearns
American Goldfinch

Collection records: Three specimens, February 15, 17, April 30, 1961.

Status: Three birds have been noted at the test site, mainly in winter and early spring, when they occur in flocks in disturbed areas in the desert where Russian thistle is predominant. In spring there are often heavy concentrations around the wells.

Spinus psaltria hesperophilus (Oberholser)
Lesser Goldfinch

Collection records: Two specimens, April 28, 29, 1962.

Status: The occurrence of this bird at the test site is known only from the two collection records. The specimens were taken at Cane Springs.

Chlorura chlorura (Audubon)
Green-tailed Towhee

Collection records: Seven specimens, April 28, May 13, 21, 23, 24, June 1, 16, 1961.

Status: Our records of this species extend from April 15 to November 14, with the greatest numbers occurring in May. The birds inhabit the Pinyon-Juniper of the mesas and the oakbrush in canyons around their borders.

Pipilo erythropthalmus montanus Swarth
Rufous-sided Towhee

Collection records: Six specimens, January 4, 16, May 24, 26, October 8, 1961.

Status: This towhee seems to occur the year around in the Pinyon-Juniper of the mesas and in areas where oakbrush is predominant. These birds are, however, rather uncommon.

Passerculus sandwichensis nevadensis Grinnell
Savannah Sparrow

Collection records: Twelve specimens, March 11, 22, 30, 31, April 7, 27, May 6, 26, September 6, 1961; March 9, 1962.

Status: Our records extend from March 11 into May and again from mid-September to October 28. We have no evidence of the presence of this species in winter or summer. It has been noted on the playas and in desert shrub communities near water.

Pooecetes gramineus confinis Baird
Vesper Sparrow

Collection record: One specimen, March 13, 1961.

Status: Our records of the Vesper Sparrow are rather unevenly scattered between March 13 and September 10 except in the month of June. We regard them as transients through the test site area. They have been noted around the wells, at Cane Springs, and in several types of desert shrub communities.

Chondestes grammacus strigatus Swainson
Lark Sparrow

Collection records: Six specimens, April 9, 25, 27, May 2, 13, 1961.

Status: Most of our records for this species are from April 9 to May 27. We have a single record for August. Our present evidence indicates that they are principally spring migrants through the test site. We have observed them in brushy areas near springs and on the mesas where there is a mixture of Pinyon-Juniper and sagebrush.

Amphispiza bilineata deserticola Ridgway
Black-throated Sparrow

Collection records: Fourteen specimens, April 20, 26, 27, 28, June 22, 29, July 27, 1960; March 15, June 2, 12, 1961; June 29, 1962.

Status: The Black-throated Sparrow is a common spring and summer resident of the test site. We have abundant records of its occurrence from March 18 to August 22, with the highest concentration in April, May and June. Rickard (1961) mentions its nesting in shrubs on the test site and we have records of young birds of the year. The birds inhabit all of the types of desert shrubs and also occur less commonly in the Pinyon-Juniper of the mesas.

Amphispiza belli nevadensis (Ridgway)
Sage Sparrow

Collection records: Twenty-two specimens, October 1, 23, 1959; December 3, 1960; January 9, 23, 29, 30, February 1, 17, April 27, October 4, 1961; January 9, April 24, 1962.

Status: Our records of the sage sparrow extend from mid-September to May. The species is one of the most common wintering birds in the area; during the winter it is found in the several types of desert shrub communities. The greatest concentrations occur in December and January.

Junco hyemalis cismontanus Dwight
Slate-colored Junco

Collection records: Two specimens, October 23, 25, 1961.

Status: The Slate-colored Junco is apparently rare at the test site. Only the two collection records and one or two other sight records are indicated in our data. Judging from the records summarized by Linsdale (1951) there are relatively few indications of its occurrence in Nevada. The specimens collected were taken on the mesa in Pinyon-Juniper.

Junco oreganus (Townsend)
Oregon Junco

Collection records: Seven specimens, March 16, April 23, October 8, 1961; January 26, March 2, 18, 1962.

Status: During the winter large flocks of juncos occur on the test site, principally in the Pinyon-Juniper of the mesas. We have records from October 7 to April 14, but they are most abundant in October and November.

Since various species and subspecies usually flock together, it is difficult to give an accurate indication of the relative abundance of the several kinds. However, our observations indicate that the great majority of them are *J. oregonus*. In our material we have representatives of both *J. o. montanus* and *J. o. mearnsi*, with the former apparently being the more common.

Junco caniceps caniceps (Woodhouse)
Gray-headed Junco

Collection records: Four specimens, May 26, June 16, September 29, 1961.

Status: We have a small number of records of the junco, all of which are for spring and summer. Birds have been found in the Pinyon-Juniper of the mesas, and there is some indication that they may nest there.

Spizella passerina arizonae Coues
Chipping Sparrow

Collection records: Six specimens, April 24, 25, May 9, 23, June 4, 27, 1961.

Status: Chipping Sparrows are common in spring and summer in the Pinyon-Juniper of the mesas and are often frequently found at Cane Springs. We have records from April 14 to November 6, but most of them are for April and May when migration is at its highest. Immature specimens were collected on the mesa, indicating that the birds nest there.

Spizella breweri breweri Cassin
Brewer's Sparrow

Collection records: Eight specimens, April 14, June 4, 16, 19, 28, 1961; April 14, 1962.

Status: We have numerous records of this species between February 10 and September 9. The birds are most abundant in April, May and June. Their favored habitat seems to be in areas where sagebrush is predominant. Young have been taken, indicating that they should be listed among the breeding birds of the area.

Spizella atrogularis evura Coues
Black-chinned Sparrow

Collection record: One specimen, July 2, 1961.

Status: We have only the one record of this species on the test site. It was taken from a thicket of scrub oak on the mesa. Linsdale (1951) indicates that the Black-chinned Sparrow is not common in Nevada and is known only from the southern part of the state.

Zonotrichia leucophrys (Forster)
White-crowned Sparrow

Collection records: Seventeen specimens, November 5, 1959; October 19, 1960; February 1, 15, 17, 20, March 6, 9, September 21, October 13, 1961; April 28, 1962.

Status: White-crowned sparrows are in residence in large numbers from September through May. During this period they are found around the springs and wells and in all types of desert shrubs. They are especially common in the *Larrea* community.

Both *Z. l. gambeli* and *Z. l. oriantha* are present in the wintering flocks. Of our 17 specimens 12 are *gambeli* and 5 are *oriantha*. From the material at hand there would appear to be no seasonal separation of the two races.

Zonotrichia atricapilla (Gmelin)
Golden-crowned Sparrow

Collection record: One specimen, April 28, 1962.

Status: The occurrence of this species at the test site is known only from the single specimen cited above. Records of this bird in Nevada seem to be rare (Linsdale, 1961). Gullion (1959) recorded the first specimen from southern Nevada which was taken 26 miles southeast of Overton, March 31, 1943.

Melospiza lincolnii (Audubon)
Lincoln's Sparrow

Collection records: Six specimens, March 4, 6, 14, 22, April 30, 1961.

Status: Lincoln's Sparrow is a regular spring migrant at the test site, when it was seen near the wells and at Cane Springs from March 18 to April 30. We also have one sight record for October 11.

The subspecific position of our six specimens is somewhat in doubt owing to the fact that some of them were not sexed, making wing measurement data of little value. In color they seem to be identical with breeding birds from central Utah. However, such wing measurements as are available indicate that our Nevada series averages a little smaller in this measurement than our series of *alticola*. This would indicate that they may be migrating *lincolnii*.

Melospiza melodia montana Henshaw
Song Sparrow

Collection records: Two specimens, January 9 and November 15, 1961.

Status: This bird appears to be an uncommon winter resident in the area. In addition to the collection records we have three sight records for January 30, March 31 and October 19. Most of the individuals were seen at Cane Springs and near the wells, but was noted at Frenchman Playa in a flock of sage sparrows.

Calcarius lapponicus lapponicus Linnaeus
Lapland Longspur

Collection records: One specimen, October 10, 1961.

Status: The occurrence of the Lapland Longspur at the test site is known only from the single specimen listed above. Linsdale (1951, p. 247) records *C. l. alascensis* from the Carson City, Nevada, area. As far as we are aware our record of *C. l. lappanicus* is the first recorded for the state. The specimen was taken near water on the playa at Frenchman Flat.

SELECTED REFERENCES

Alcorn, J. R. 1940. New and noteworthy records of birds for the state of Nevada. Condor, 42:169-170.

Alcorn, J. R. 1941. New and additional Nevada bird records. Condor, 43:118-119.

Alcorn, J. R. 1946. The birds of Lahontan Valley, Nevada. Condor, 48:129-138.

Allred, D. M., D E. Beck, and C. D. Jorgensen. 1963. Biotic communities of the Nevada Test Site. Brigham Young University, Science Bull., Biol. Series, 2(2):1-52, one map.

American Ornithologists' Union. 1957. Check-list of North American Birds.

Behle, W. H. 1942. Distribution and variation of the horned larks (*Otocoris alpestris*) of Western North America. Univ. Calif. Publ. Zool., 46:205-316.

Christensen, G., and T. Trelease. 1941. A new record of the Semipalmated Plover in Nevada. Condor, 43:156.

Cottam, C. C. 1936. Notes on the birds of Nevada. Condor, 38:122-123.

Cottam, C. C. 1947. Some bird records for southern Nevada. Condor, 49:244.

Fautin, R. W. 1946. Biotic communities of the Northern Desert Shrub Biome in western Utah. Ecological Monographs, 16:251-310.

Gabrielson, I. N. 1949. Bird notes from Nevada. Condor, 51:179-187.

Grater, R. K. 1939a. New bird records for Nevada. Condor, 41:30.

Grater, R. K. 1939b. New bird records for Nevada. Condor, 41:121.

Grater, R. K. 1939c. New bird records for Clark County, Nevada. Condor, 41:220-221.

Gullion, G. W. 1953. Additional records from southern Nevada. Condor, 55:160.

Gullion, G. W. and G. C. Christensen. 1957. A review of the distribution of gallinaceous game birds in Nevada. Condor, 59:128-138.

Gullion, G. W., et. al. 1959. Notes on the occurrence of birds in southern Nevada. Condor, 61:278-297.

Jaeger, E. C. 1927. Birds of the Charleston Mountains of Nevada. Occas. Papers Riverside Jr. Coll., 2:1-8.

Johnson, N. F. 1956. Recent bird records in Nevada. Condor, 58:449-452.

Johnson, N. K. 1954. Notes on some Nevada Birds. Great Basin Naturalist, 14:15-18.

Johnson, N. K. 1956. Birds of the Pinon Association of the Kawich Mountains, Nevada. Great Basin Naturalist, 16:32-33.

Linsdale, J. M. 1936. The birds of Nevada. Pac. Coast Avifauna, 23:1-145. 1 map.

Linsdale, J. M. 1951. A list of the birds of Nevada. Condor, 53:228-249.

Marshall, D. B. 1951. New bird records for western Nevada. Condor, 53:157-158.

Merriam, C. H. 1898. Life zones and crop zones in the United States. U.S. Biol. Survey, Bull. 10.

Miller, A. H. 1930. Two new races of the Loggerhead Shrike from western North America. Condor, 32:155-156.

Moore. 1939. Two new races of *Carpodacus mexicanus*. Proc. Biol. Soc. Wash., 52:195.

Oberholser, H. C. 1921. A revision of the races of *Dendroica auduboni*. Ohio Jr. of Sci., 21:243.

Phillips. 1947. The races of MacGillivray's warbler. Auk, 64(2):297.

Pulich, W. M. and A. R. Phillips. 1961. Autumn bird notes from the Charleston Mountains, Nevada. Condor, 53:205-206.

Richards, Gerald. 1962. Wintering habits of some birds at the Nevada Atomic Test Site. Great Basin Naturalist, 22(1-33:30-31).

Rickard, W. H. 1961. Notes on birds nests found in a desert shrub community following nuclear detonations. Condor, 63:265-266.

Slipp, J. W. 1942. Notes on the Stilt Sandpiper in Washington and Nevada. Murrelet, 22:61-62.

van Rossem, A. J. 1931. Description of new birds from the mountains of southern Nevada. Trans. San Diego Soc. Nat. Hist., 6:325-332.

van Rossem, A. J. 1936. Birds of the Charleston Mountains, Nevada. Pac. Coast Avifuna, 24:1-65.

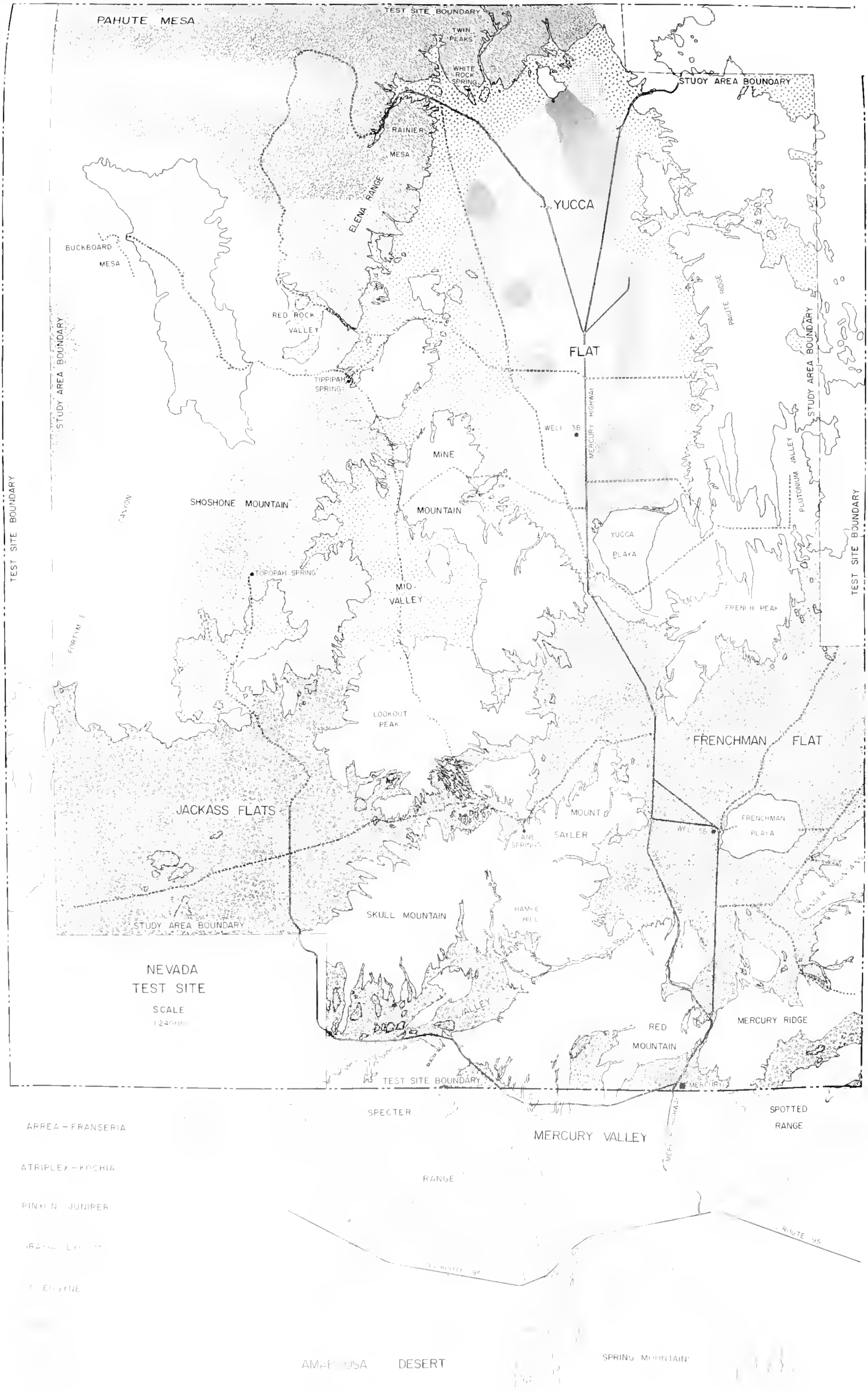

Fig. 2 Extent of the Major Plant Communities of the Nevada Test Site.

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SOLPUGIDA OF THE NEVADA TEST SITE

by

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SOLPUGIDA OF THE NEVADA TEST SITE[1, 2]

Martin H. Muma

University of Florida, Citrus Experiment Station, Lake Alfred, Florida

This paper is based on nearly 1,000 specimens of solpugids that were collected from 1960 through 1962 in a relatively small study area at Mercury, Nevada. I would like to thank Dr. D. M. Allred and Dr. D Elden Beck of Brigham Young University, Provo, Utah, and Dr. Willis J. Gertsch of the American Museum of Natural History, New York City, New York, for the opportunity to identify and study this material.

The collection contained 395 adult specimens. Although this number would not be considered large for most orders of arthropods, it is more than half the total number of adults that were available for study at the time of my 1951 review of the order in the United States. In this light the Mercury material must be considered the most extensive single collection of these curious arachnids ever taken in the United States. Altogether 28 species, 9 undescribed, were represented by the specimens. As only 112 species are known from the entire country, the collection represents one-fourth of the described species and must also be considered the most intensive ever taken in the United States. The value of such a collection can hardly be overemphasized.

Taxonomically the discovery of 9 new species, 1 described by Muma, 1962, and 8 described below, and the collection of hundreds of new records greatly increase our knowledge of the occurrence, distribution and variation of these rare animals. Biologically, the collection provides for the first time, information on the life cycle, longevity, sex ratio and ecological association of solpugids in this country.

Recorded Species and Specimens

The following list of species is systematically arranged in the order used in Muma, 1951. The total number of adult males and females collected during the study are cited for each species.

Family Eremobatidae Roewer, 1934.

Genus Eremorhax Roewer, 1934.

1. *Eremorhax pulcher* new species—6♂s, 21♀s
2. *Eremorhax titania* Muma, 1951—1♂, 1♀

Genus *Eremobates* Banks, 1900.

3. *Eremobates zinni* Muma, 1951—11♀s
4. *Eremobates similis* Muma, 1951—1♂
5. *Eremobates ctenidiellus* Muma, 1951—3♀s
6. *Eremobates scopulatus* Muma, 1951—3♂s, 11♀s
7. *Eremobates mormonus* (Roewer), 1934—17♂s, 7♀s
8. *Eremobates vicinus* new species—1♂

Genus *Horribates* Muma, 1962.

9. *Horribates* sp.—1 juvenile and 1 young ♀

Genus *Therobates* Muma, 1951.

10. *Therobates branchi* Muma, 1951—1♂
11. *Therobates cameronensis* Muma, 1951—15♂s, 53♀s
12. *Therobates plicatus* Muma, 1962—5♂s, 11♀s
13. *Therobates flexacus* new species—2♂s
14. *Therobates bidepressus* (Muma), 1951—4♂s, 8♀s
15. *Therobates nudus* new species—1♂
16. *Therobates attritus* new species—2♀s
17. *Therobates arcus* Muma, 1962—1♂

Genus *Chanbria* Muma, 1951.

18. *Chanbria* sp.—3 juveniles

Genus *Hemerotrecha* Banks, 1903.

19. *Hemerotrecha denticulata* Muma, 1951—5♂s, 7♀s
20. *Hemerotrecha proxima* new species—3♂s, 6♀s

[1]This study is part of the faunal ecological study at the Nevada Test Site, sponsored jointly by the Brigham Young University Department of Zoology and Entomology and the United States Atomic Energy Commission, under AEC Research Grant AT(11-1)786.

[2]Florida Agricultural Experiment Stations Journal Series No. 1680

21. *Hemerotrecha fruitana* Muma, 1951—1♂
22. *Hemerotrecha californica* (Banks), 1899—82♂s, 50♀s
23. *Hemerotrecha serrata* Muma, 1951—15♂s, 13♀s
24. *Hemerotrecha branchi* Muma, 1951—1♂

Family Ammotrechidae Roewer, 1934.

Genus *Ammotrechula* Roewer, 1934.

25. *Ammotrechula dolabra* new species—2♂s
26. *Ammotrechula lacuna* new species—1♂, 1♀
27. *Ammotrechula pilosa* Muma, 1951—2♀s

Genus *Branchia* Muma, 1951.

28. *Branchia potens* Muma, 1951—9♂s, 12♀s

New Species

The following new species were described from specimens preserved in 70 to 95 per cent ethyl alcohol. Total length measurements include the chelicerae and were gross, made without the use of magnification, under 95 per cent alcohol, over a plastic millimeter rule and adjusted to the nearest half-millimeter. Leg and palpal measurements exclude the coxae and were made in the same manner. Cheliceral and propeltidial measurements, coloration evaluations and morphological descriptions were made at 6X to 30X magnification. Measurements, comparisons, proportions and ratios were established with the same procedures as used by Muma (1951).

All primary types are deposited in the American Museum of Natural History, New York City, New York.

Eremorhax pulcher new species

Figures 1 to 3

Diagnosis: This species is most easily distinguished from *Eremorhax magnus* Hancock by its smaller size and purplish coloration of the terminal segments of the palpi, medial segments of legs 3 and 4, and anterior margin of the propeltidium. Males have a distinctive cheliceral profile and females have specifically different opercula.

Males: Total length 20.0 to 26.0 mm.

	Length	Width
Chelicerae	5.6-6.6 mm.	2.5-2.9 mm.
Propeltidium	2.6-3.1	4.2-4.4
Palpi	17.0-21.0	
First legs	14.0-16.0	
Fourth legs	23.0-28.0	

Holotype larger measurements.

Color pale to straw yellow with purplish markings as follows: eye tubercle dark; anterior half of propeltidium, excluding the exterior lobes, faintly dusky; mesopeltidium and metapeltidium unmarked; abdominal tergites, dusky; tarsus, metatarsus, tibia and apical half of femur of palpus dusky with metatarsus somewhat darker than other segments; legs 1 and 2 dusky at the union of the femora and tibiae; legs 3 and 4 dusky on femora and all but the apical fourth of the tibiae. Malleoli pale.

Dentition of chelicerae somewhat variable but maintaining general pattern of Figures 1 and 2. Movable finger with principal tooth large, intermediate tooth tiny or missing, anterior tooth aborted to a small spur on a low ridge and mesal tooth large and visible behind principal tooth. Fixed finger essentially straight but distinctly narrowed in apical third and lightly curved downward. Fondal teeth graded in size I, III, II, IV. Fondal notch U-shaped, narrower than the base of the fixed finger and containing 1 to 3 denticules.

Mesal groove of fixed finger an indistinct hollow that extends along the lower margin of the finger to the area below the tip of the flagellar setal articulation area. Flagellum essentially composed of simple tubular bristles. Mesal setae of movable finger simple on apical half of articulation area, plumose on basal half of area.

Eye tubercle, eyes, propeltidial ratio and palpal setation as in *E. magnus*.

There are no ctenidia on the posterior margin of the first post-spiracular abdominal sternite.

Females: Total length 20.5 to 31.0 mm.

	Length	Width
Chelicerae	5.6-6.9 mm.	2.5-3.1 mm.
Propeltidium	2.2-2.8	4.0-4.7
Palpi	10.5-10.0	
First legs	9.0-11.0	
Fourth legs	19.0-20.0	

Allotype larger measurements.

Coloration similar to that of male.

Dentition and other structure as in *E. magnus.* Specific differences are found in the opercula of the genital segment of the abdomen, Figure 3.

Type Locality: Male holotype from 11 miles N of Mercury, Nevada, 2/10 mile E of Mercury Highway, S of well 5B road on June 10, 1961 (5AL10C).[1] Male paratype from 35 miles N of Mercury, Nevada, 3/10 mile W of Groom Lake road on June 25, 1962 (10SH11C). Male paratype from same locality as holotype on June 6, 1961 (5AL4C). Female allotype from 28 miles N of Mercury, Nevada, 3 miles W of Mercury Highway on July 12, 1961 (1BF15C). Female paratype from same locality as female allotype on July 17, 1961 (1FA9C). Female paratype from near Mercury, Nevada (specific location unknown), on July 24, 1961. Holotype and allotype are deposited in the American Museum of Natural History, New York City, New York. Paratypes are in the author's collection and the collection at Brigham Young University, Provo, Utah.

Eremobates vicinus new species

Figures 4 to 6

Diagnosis: This species is closely related to *Eremobates scopulatus* Muma, *E. purpusi* Roewer and *E. tuberculatus* (Kraepelin). It differs from *scopulatus* in cheliceral profile, number of palpal papillae and number of abdominal ctenidia. The cheliceral profile and number of palpal papillae distinguish it from *purpusi.* The coloration, cheliceral profile and palpal papillae are the same as on *tuberculatus* but it has 8 (and one spurious) instead of 6 abdominal ctenidia.

Male Holotype: Total length 25.0 mm.

	Length	Width
Chelicerae	5.4 mm.	2.1 mm.
Propeltidium	2.2	3.9
Palpi	21.0	
First legs	17.0	
Fourth legs	28.0	

Coloration and markings identical with those of *E. tuberculatus* (Kraepelin).

Cheliceral structure nearly identical with *tuberculatus.* The palpal scopula has about 60 distinct papillae and there are 9 linear ctenidia on the first post-spiracular abdominal sternite, one ctenidium appears to be spurious. The cheliceral profile is shown in Figure 4, the palpal scopula in Figure 5 and the abdominal ctenidia in Figure 6.

Propeltidium wider than long by a ratio of 1 to 1.8. Metatarsus of palpus 3.9 times as long as tarsus.

Type Locality: Male holotype from 11 miles N of Mercury, Nevada, 2/10 mile E of Mercury Highway, S of Well 5B road on May 19, 1961 (5AA5C), in the American Museum of Natural History, New York City, New York.

Therobates flexacus new species

Figures 7 to 9

Diagnosis: This species is readily distinguished from other species of the *arcus* group by the presence of a scopula of fine papillae on the tibia as well as the metatarsus. Other diagnostic characters include the slender, tubular, S-shaped fixed finger of the chelicerae, the narrow slot-like mesoventral groove of the fixed finger and the single pair of linear abdominal ctenidia.

Males: Total length 20.0 to 21.0 mm.

	Length	Width
Chelicerae	4.8-4.8 mm	2.0-2.0 mm.
Propeltidium	2.4-2.4	3.4-3.4
Palpi	18.0-18.0	
First legs	14.0-15.0	
Fourth legs	25.0-25.0	

Holotype smaller specimen.

Coloration and markings almost identical to those of *T. arcus* Muma except the dusky area on the leg femora covers the apical two-thirds of the segment.

Dentition of the same general type as that of *arcus* except the fixed finger is slender, needle-like and strongly S-shaped: the movable finger is provided with a strong principal tooth, two tiny intermediate teeth and an aborted anterior tooth but no mesal tooth: the fondal notch is shallow, bears no denticules and is three times the width of the fixed finger at the base (Figure 7).

The mesoventral groove of the fixed finger is a narrow slot that extends nearly to the base of the finger where it expands into a cup-like hollow. Flagellum complex with basal, dorsal tubular bristles arched, apical, dorsal tubular bristles slightly S-shaped and plumose bristles strongly S-shaped covering basal half of mesoventral groove.

[1]This is a typical code number for all specimens collected as part of the AEC-BYU faunistic studies at the Nevada Test Site. A complete list of codification letters and numbers is given in the publication "Nevada Test Site Study Areas and Specimen Depositories" (Allred *et al*., 1963a). Use of the code enables the location of a collection within a few feet of the place of capture.

Structure similar to that of *T. arcus*, except that the propeltidium is wider than long by a ratio of 1 to 1.4, the palpal scopula is composed of about 50 papillae on the tibia and 15 on the metatarsus (Figure 9), and there are only two slender ctenidia on the first post-spiracular abdominal sternite (Figure 8).

Type Locality: Male holotype from 10 miles N of Mercury, Nevada, 1 mile E of Mercury Highway on March 2, 1961 (5EL4C). Male paratype from Cane Springs 12 miles NNW of Mercury, Nevada on February 26, 1962 (CBA8C). Both types are in the American Museum of Natural History, New York City, New York.

Therobates nudus new species

Figure 10

Diagnosis: The cheliceral profile and fondal tooth formula indicate a close relationship with *Therobates arcus*. It differs in its smaller size and in the lack of a palpal scopula and abdominal ctenidia.

Male Holotype: Total length 13.5 mm.

	Length	Width
Chelicerae	3.7 mm.	1.7 mm.
Propeltidium	1.7	2.7
Palpi	14.0	
First legs	10.0	
Fourth legs	17.0	

Coloration, dentition and structure of this species are very similar to that of *T. arcus*. The dentition of this species differs in a more massive fixed finger, a fondal notch that is deeper than it is wide but narrower than the base of the fixed finger and a minute intermediate tooth in addition to one at the base of the principal tooth (Figure 10). Differences in structure include the lack of a palpal scopula and the lack of abdominal ctenidia.

Type Locality: Male holotype from 28 miles N of Mercury, Nevada, 3 miles W of Mercury Highway on April 20, 1961 (1BH20C), in the American Museum of Natural History, New York City, New York.

Therobates attritus new species

Figures 11 and 12

Diagnosis: Only the female of this species is known. The posterior lobes of the distinctive opercula are hooked laterally and truncate. This exact condition is not found in any other solpugid of this genus although it is approximated in the opercula of *T. arcus*. Because of this similarity this species is placed in the *arcus* group.

Females: Total length 19.5 to 20.0 mm.

	Length	Width
Chelicerae	3.7-4.1 mm.	1.6-1.7 mm.
Propeltidium	2.0-2.1	3.1-3.2
Palpi	12.0-12.0	
First legs	9.0-9.0	
Fourth legs	16.0-17.0	

Holotype larger measurements.

Coloration somewhat faded by preservation but color and markings very similar, if not identical, to that of *T. arcus*.

Dentition worn as shown in Figure 11; similar to that of *T. arcus* but differing by having only two intermediate teeth on the movable finger and only one intermediate tooth between the medial and anterior tooth on the fixed finger.

There are no papillae on the metatarsus of the palpus and no ctenidia on the first post-spiracular abdominal sternite.

Opercula of genital segment as shown in Figure 12.

Type Locality: Female holotype from 28 miles N of Mercury, Nevada, 3 miles W of Mercury Highway on April 27, 1961 (1BB1C), and one female paratype from same locality as holotype on May 15, 1961 (1BH25C), both in the American Museum of Natural History, New York City, New York.

Hemerotrecha proxima new species

Figures 13 to 17

Diagnosis: Males are distinguished from *H. denticulata* Muma by their much smaller size, line-like palpal scopula of 5 to 15 papillae, and the presence of only two elongate ctenidia on the first post-spiracular abdominal sternite. Females have opercula that are distinctive in having knife-like, straight-edged posterior lobes.

Males: Total length 9.5 to 12.0 mm.

	Length	Width
Chelicerae	2.0-2.3 mm.	0.7-0.9 mm.
Propeltidium	0.9-1.2	1.2-1.6
Palpi	11.5-14.5	
First legs	8.5-11.0	
Fourth legs	15.5-18.5	

Holotype larger measurements.

Color and markings almost identical with those of *H. denticulata,* the 4 dusky abdominal stripes are faint on the 3 males seen.

Dentition as shown in Figure 13, very similar to that of *H. denticulata* except the fingers are more slender and elongate and the anterior and intermediate teeth of the movable finger are greatly reduced.

Flagellum complex and other cheliceral setae identical with those of *H. denticulata.* Propeltidial length to width ratio 1 to 1.3. Metatarsal scopula of palpus narrow and line-like, composed of only 5 to 15 small papillae, Figure 16. First post-spiracular abdominal sternite with 2 elongate ctenidia, Figure 14.

Females: Total length 13.5 to 17.0 mm.

	Length	Width
Chelicerae	3.4-4.1 mm.	1.2-1.6 mm.
Propeltidium	1.6-1.8	2.4-2.6
Palpi	13.5-14.5	
First legs	10.0-11.0	
Fourth legs	18.5-19.0	

Allotype smaller measurements.

Color and markings same as on male except the posterior abdominal tergites are pale.

Dentition of chelicerae as shown in Figure 17, nearly identical with that of *H. denticulata.* Supernumerary teeth and loss of teeth are common.

Structure similar to that of male except there is no palpal scopula and no or only 2 trace ctenidia on the first post-spiracular abdominal sternite.

Opercula of genital segment of abdomen as shown in Figure 15.

Type Locality: Male holotype from 28 miles N of Mercury, Nevada, 3 miles W of Mercury Highway on October 10, 1961 (1BH30C). Male paratype from 30 miles N of Mercury, Nevada, 1 mile W of Rainier Mesa road on October 10, 1960 (4AL4C). Male paratype same locality as holotype on October 10, 1961 (1BH11C). Female allotype from 19 miles N of Mercury, Nevada, 3.4 miles W of Mercury Highway on November 20, 1961 (6FJC). Female paratype from same locality as holotype on October 26, 1961 (1BH15C). Holotype, allotype and male paratype in American Museum of Natural History, New York City, New York. Male and female paratype in collection at Brigham Young University, Provo, Utah.

Ammotrechula dolabra new species

Figures 18 and 19

Diagnosis: This species is distinguished by the robust untoothed fixed finger of the chelicerae and the lack of serially arranged spines on the tibia and metatarsus of the palpus.

Males: Total length 10.5 to 11.0 mm. Chelicerae 0.7 to 0.8 mm. wide and 2.3 to 2.7 mm. long. Propeltidium 1.9 to 2.0 mm. wide and 1.7 to 1.7 mm. long. Holotype larger measurement.

Color light yellow with purplish-brown markings as follows: chelicerae with one dorsal and one ectal diffuse dusky stripe; propeltidum dark except for a narrow median stripe and the bases of the spines; mesopeltidium, metapeltidium and abdominal tergites pale on anterior third and dusky for the remainder of their length, palpi and legs dusky except on coxae, trochanters, and distal portion of tarsi; venter pale; eye tubercle dark; malleoli pale.

Dentition as shown in Figures 18 and 19. Fixed finger and fond with only an indication of the normal teeth. Dental group of movable finger occupies less than one-third of the length of the finger, principal tooth slightly larger than anterior tooth, single intermediate tooth closer to anterior tooth. Flagellum as on *A. mulaiki* Muma except the lower curled margin is fringed, attachment disc over area normally occupied by the first fondal tooth of the mesal row.

Palpi with usual clothing of long hairs, short hairs and cylinder bristles but no distinguishable series of spines on femora, tibiae or metatarsi.

Chelicerae slightly more than 3 times as long as wide. Propeltidium wider than long by a ratio of 1 to 1.1 Eyes separated by less than a diameter.

Type Locality: Male holotype from Cane Springs, 12 miles NNW of Mercury, Nevada on June 8, 1961 (CBA10C) and male paratype from 9.3 miles W of Mercury, Nevada on May 18, 1962 (JAA1C) in the American Museum of Natural History, New York City, New York.

Ammotrechula lacuna new species

Figures 20 to 23

Diagnosis: This species resembles *A. wasbaueri* Muma in the male cheliceral profile but has the metatarsus and tarsus of the female palpus pale and lacks serially arranged spines on the palpal tibia and metatarsus.

Male Holotype: Total length 9.0 mm. Chelicerae 0.7 mm. wide and 2.3 mm. long. Propeltidium 0.9 mm. wide and 0.7 mm. long.

Color pale yellow with dusky purplish-brown markings as follows: chelicerae with two distinct dorsal and one diffuse lateral stripes that are united behind flagellum and fond; propeltidium dark except for a narrow median stripe that is surrounded by a diffuse ovate area and the bases of the spines; mesopeltidium, metapeltidium, and abdominal tergites faintly dusky on lateral margins; palpi missing; legs dusky on lateral surfaces on the femora, tibiae and metatarsi; eye tubercle dark; malleoli pale.

Dentition of chelicerae very similar to that of *A. wasbaueri* Muma except the fixed finger is slightly sinuate as shown in Figures 20 and 21. Flagellum spatulate with mesal curling of lateral margins covering much of mesal surface, lower margin fringed and anterior half with abrupt slope to tip.

Palpi missing, clothing unknown, but males and females usually have similar clothing so male palpi probably lack serially arranged spines.

Chelicerae 3.3 times longer than wide. Propeltidium wider than long by a ratio of 1 to 1.3.

Female Allotype: Total length 10.0 mm. Chelicerae 0.7 mm. wide and 2.5 mm. long. Propeltidium 1.8 mm. wide and 1.6 mm. long.

Color and markings same as on male except more extensive on legs extending onto dorsal surfaces of marked segments, palpi dusky on femora, tibiae and basal margin of metatarsi and abdominal markings are more distinct.

Dentition typical of Ammotrechinae as shown in Figure 22, with dorsal carina attaining a peak over first fondal tooth of ectal row.

Palpi with the usual clothing of long and short hairs, but with few cylinder bristles and no series of paired tubular spines on the femora, tibiae or metatarsi.

Chelicerae 3.5 times longer than wide. Propeltidium wider than long by a ratio of 1 to 1.1. Genital plate wider than long by a ratio of 1 to 1.3, Figure 23.

Type Locality: Male holotype from 34.5 miles N of Mercury, Nevada, 1/2 mile E of Groom Lake road on June 26, 1961 (10DL4C), and female allotype from Cane Springs, 12 miles NNW of Mercury, Nevada on June 20, 1961 (CBA2C), both in American Museum of Natural History, New York City, New York.

New Synonymies

The systematic year-round trapping of solpugids at Mercury has resulted in the collection of numerous specimens of species originally described from limited material. These additional specimens have indicated errors in the association of sexes involving 3 previously described species. The valid names and synonyms are listed below.

Therobates cameronensis Muma, 1951, Bull. Amer. Mus. Nat. Hist. Vol. 97, art. 2, p. 90, Figs. 157-161 (male). Synonym: *Therobates arcellus* Muma, 1962, Amer. Mus. Novitates, No. 2092, pp. 13-14, Fig. 71 (female not male).

Therobates bidespressus (Muma), 1951, Bull. Amer. Mus. Nat. Hist. Vol. 97, art. 2, p. 105, Fig. 210 (female). Synonyms: *Hemerotrecha bidepressa* Muma, 1951, Bull. Amer. Mus. Nat. Hist. Vol. 97, art. 2, p. 105, Fig. 210 (female). *Therobates arcellus* Muma, 1962, Amer. Mus. Novitates, No. 2092, pp. 13-14, Figs. 68 to 70 (male not female).

Biological Notes

All of the solpugids collected during the study were taken in can traps in a 900 square mile area as described by Allred *et al.* (1963). It may be assumed that such a collecting method and procedure should result in an adequate sampling of a population of cursorial predatory arachnids such as solpugids. On the basis of such an assumption the number of sexually mature adults of 12 common species were arranged in Table 1 according to sex and month of collection.

From the results obtained it is possible to deduce several general facts concerning the biology of common solpugids in the Mercury area.

First, the unimodal peak abundance of adults in a two- to four-month period of time for most species indicates an annual life cycle. If development from egg to adult required less than one year or two or more years, there would be an overlapping of generations which would result in more than one peak abundance of adults during a year or the collection of adults during most months. Second, the adults of most species have a limited longevity. This is indicated by the fact that they mature, mate, lay eggs, and disappear in a 60- to 240-day period of time. Third, for most species, copulation takes place as soon as the females mature. This is indicated by the earlier appearance, peak abund-

Table 1. Seasonal distributions and sex ratios of adults of 12 common solpugids collected at Mercury, Nevada, from February 1960 through July 1962.

Species	Number of Specimens Collected																								Males/Females
	Feb.		March		April		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.				
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀			
Hemerotrecha denticulata Muma		1	1	2		2		2									2		1		1				0.7/1
Eremobates mormonus (Roewer)			1		9		7	4		3															2.4/1
Therobates bidepressus (Muma)					4	2		6																	0.5/1
Hemerotrecha californica (Banks)					1		15	3	56	34	10	9		4											1.7/1
Eremobates scopulatus Muma							3	5		4		2													0.3/1
Therobates cameronensis Muma							2	3	6	7	7	28		15											0.3/1
Therobates plicatus Muma								1		2	5	6		2											0.5/1
Eremorhax pulcher Muma									4	12	2	9													0.3/1
Branchia potens Muma									5	3	4	8		1											0.7/1
Hemerotrecha serrata Muma									1	2	8	2	6	4		5									1.2/1
Eremobates zinni Muma												5		6											....
Hemerotrecha proxima Muma																	3	3		3					0.5/1

ance and disappearance of males. Fourth, most species pass the winter as sub-adults and complete development in the spring or early summer. Adults are collected mainly in the spring and summer.

Because the calculated ratio of males per female varied widely within the 12 species, no generality can be expressed. Many factors inherent in the biology of arthropods result in differences in the ratio of the sexes. The best known of these are specifically different fertilization requirements, the production of males from unfertilized eggs, the production of females from unfertilized eggs, the overproduction of males in widely dispersed species, and the underproduction of males in colonial species. Further, it is realized that a trap and removal method of population sampling may result in the disproportionate or even exclusive collection of one sex owing to differences in the biological requirements of the two sexes. Solpugids are, however, predominately nocturnal, cursorial predators, a condition in which a sexual dispersion and equal prey searching activity of the sexes may be inferred. Males of trap building, nest building or ambush arthropods are generally more liable to trap collection than females owing to mate-searching activity. In solpugids, however, the earlier maturity of males would seem to contraindicate a special mate-searching period. All of these facts are considered in the discussions of the biological implications of the sex ratios of common Mercury solpugids.

Specific biological information may also be gleaned from Table 1. This, along with ecological data kindly furnished by Dr. Allred and Dr. Beck, is presented and discussed in the following paragraphs dealing with the 12 most common species in the Mercury area.

Solpugids were trapped in all 6 of the specific plant communities and the mixed communities recognized by Allred *et al.* (1963). They were, however, common only in the Desert Scrub Type, *Larrea-Franseria*, *Grayia-Lycium*, *Atriplex-Kochia*, *Coleogyne*, and *Salsola*, and Mixed communities.

Among the 12 species of solpugids rated as common in this paper by far the greater number of individuals and all but one species were taken in the *Grayia-Lycium* community. *Larrea-Franseria* and *Salsola* communities were second and third respectively in number of individuals and species. Within these communities a preponderant number of solpugids were trapped in association with the specific plant, *Salsola kali*. This plant, commonly known as Russian thistle, is a well-known invader of waste areas and at the Nevada Test Site is common at and around ground zero of old bomb sites. Such an association of predators with a specific plant type may be either direct or indirect. Solpugids may congregate in wastelands to prey upon the arthropods therein or they may congregate around Russian thistle for the thistle-associated animals.

Eremorhax pulcher Muma: This species matures in June and July with the peak abundance of adults occurring in June. It apparently passes the winter in a half-grown condition and completes development in the spring. The short period of adult collection suggests an adult longevity of less than 60 days. A sex-ratio of 1 male to 3 females indicates a single fertilization requirement for the species with males capable of copulation with several females or the production of males from unfertilized eggs.

Although commonly taken in *Larrea-Franseria*, *Salsola* and *Grayia-Lycium* communities, this species is most frequently associated with Russian thistle.

Eremobates zinni Muma: Although the collection of 11 females in July and August indicates late summer maturity of a parthenogenetic species, males are known, and it is probable that the females require only one fertilization or females are produced from unfertilized eggs. The species apparently overwinters as partly-grown nymphs. A short adult longevity is suggested by the two-month collection period.

This species is associated almost exclusively with Russian thistle in the *Grayia-Lycium* community.

Eremobates scopulatus Muma: The 14 collected adults of this species were taken in May, June, and July with the only males and largest number of females being trapped in May. The adults probably live less than three months with males shorter lived than females. Late spring or early summer maturity indicates that the species overwinters in a late nymphal stage. The low ratio of 1 male to 3 females suggests a single fertilization requirement or the production of males from unfertilized eggs.

This species is commonly associated with Russian thistle in *Grayia-Lycium* communities.

Eremobates mormonus (Roewer): This species matures in March, April, May, and June with the peak abundance of adults occurring in April and May. The two-month adult abundance period suggests an adult longevity of 60 days or less. The species apparently passes the winter in a late or penultimate instar. A preponderance of more than 2 males to every female may indicate a multiple copulation requirement for egg fertilization although it is possible that the females are more sedentary and less liable to being trapped.

Sixty-five percent of the collected specimens of this species were taken in the *Atriplex-Kochia* community.

Therobates cameronensis Muma: Although adults of this species were taken in May, June, July, and August, 50 of the 68 specimens were trapped in July and August, which suggests late summer maturity. For this reason the majority of individuals probably pass the winter in a half-grown condition. Adults probably do not live longer than 90 days. The ratio of 3 females per male indicates a single copulation requirement for egg fertilization or the production of males from unfertilized eggs.

The collections of this species do not indicate an association with any specific plant community or type. Over 85 percent of the specimens were taken in the flats.

Therobates plicatus Muma: Adults of this species were taken in May, June, July, and August, but 11 of 16 specimens were collected in July. This midsummer maturity indicates that the species passes the winter in a half-grown condition. The short period of peak abundance also suggests an adult longevity of less than 30 days. A sex ratio of 2 females per male infers a limited copulation requirement or the production of males from unfertilized eggs.

Collections of this species indicate a strong association with Russian thistle in *Grayia-Lycium* communities.

Therobates bidepressus (Muma): This species matures in April and May, which makes it probable that it overwinters in a late, possibly penultimate instar. A short adult longevity is suggested by the two-month maturity period. A sex-ratio of 2 females per male probably indicates a limited copulation requirement for egg fertilization.

Although 55 percent of the collections of this species were from a *Grayia-Lycium* community, there was no strong association with any specific plant type.

Hemerotrecha denticulata Muma: In the limited number of adults taken, this species exhibited no peak adult abundance. The collection of adults from October through May does, however, demonstrate that the species overwinters in the adult form, which is probably especially long-lived for solpugids. The nearly equal ratio of the sexes either indicates a multiple copulation requirement for egg fertilization or possibly is a biological buffer against winter mortality of the early maturing males.

Ninety percent of the specimens of this species were taken in association with Russian thistle in *Salsola* or *Grayia-Lycium* communities.

Hemerotrecha proxima Muma: All 9 of the collected specimens of this species were taken in October and November with the peak abundance occurring in October. It is possible that the species passes the winter as an adult, but the lack of spring-collected adults indicates a short lived adult and an overwintering egg or early instar. A 1 to 3 ratio of males to females indicates a single fertilization requirement.

Six of 9 specimens, 66 percent, of this species were taken in *Grayia-Lycium* plant communities with no specific plant association.

Hemerotrecha californica (Banks): Adults of this, the prevalent species, were taken from April through August but nearly 70 percent of the specimens were collected during June. Early summer maturity indicates that the species passes the winter in the mid to late instars. The short period of peak adult abundance indicates that adults may not live longer than 30 days. A sex ratio of nearly 2 males per female may indicate a multiple copulation requirement for egg fertilization, but the species is known to be diurnal and arboreal, which may have resulted in stratal escape of females from the can-traps used to sample cursorial populations.

Collections of this species indicate no specific plant type or community association.

Hemerotrecha serrata Muma: This species matures in June, July, August, and September with the peak adult abundance occurring in July and August. The late summer maturity indicates that the species passes the winter in the early instars. The two-month period of adult abundance infers a longevity of up to 60 days. A sex ratio of more than one male to every female suggests a multiple copulation requirement.

Collections of this species were divided among several communities and plant types.

Branchia potens Muma: Although adults of this species were collected in June, July, and August, 20 of 21 specimens were taken in June and July. This short period of adult abundance indicates a longevity of less than 60 days. Midsummer maturity probably means that the species passes the winter in a half-grown condition. The nearly equal ratio of males and females suggests a multiple copulation requirement for egg fertilization.

This species is not associated with any specific plant community or type.

SUMMARY

Study of nearly 1,000 specimens of solpugids collected in 1960, 1961, and 1962 from Mercury, Nevada, resulted in the identification and placement of 395 adults in 28 species. Eight new species are described and figured. Two new synonymies, resulting from proper association of males and females, are cited. Study of the seasonal distribution and relative abundance of the sexes of 12 common species has prompted general and specific deductions concerning the essentially unknown biology of North American solpugids. Systematic collection data furnished ecological information concerning the 12 common species.

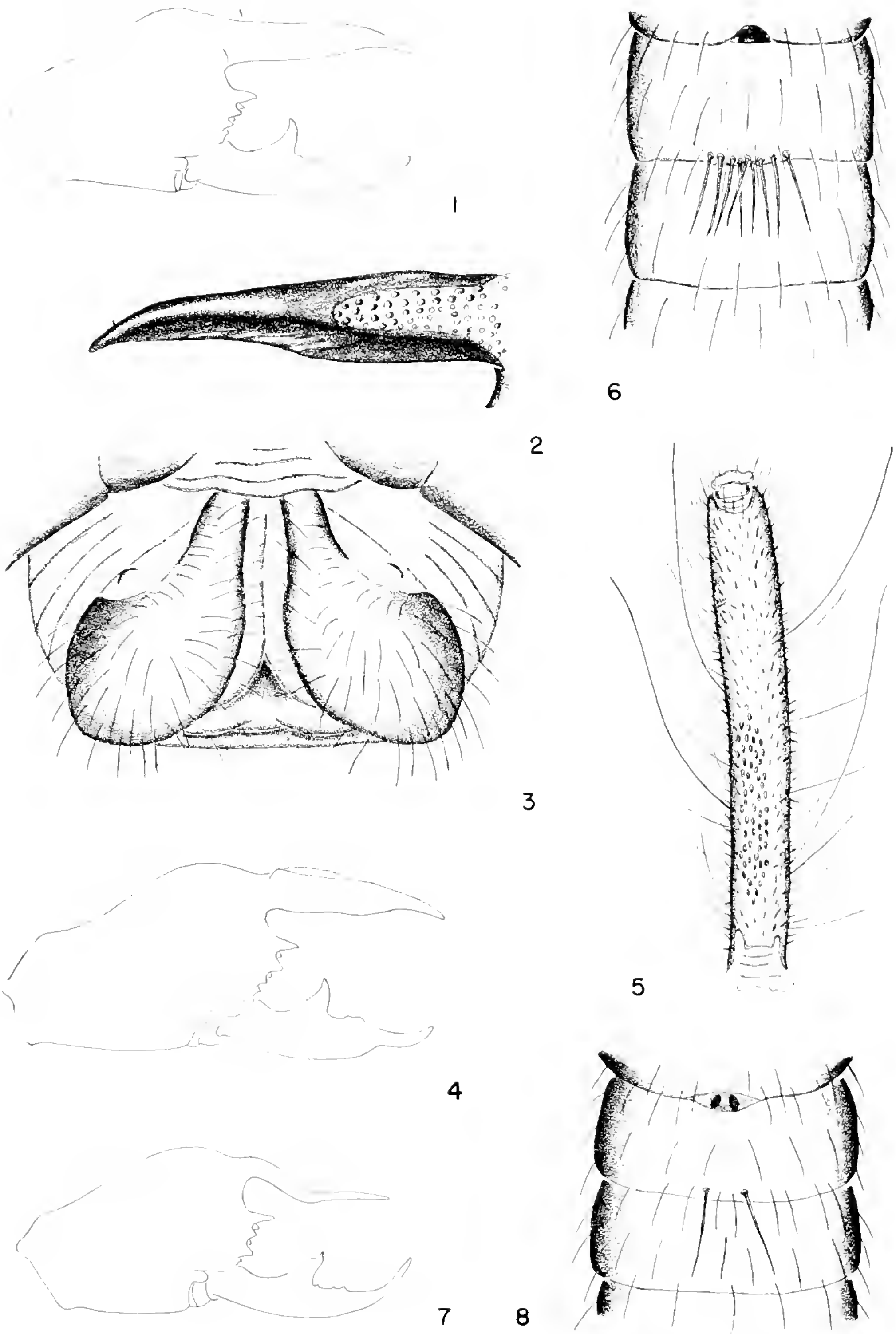
LITERATURE CITED

Allred, Dorald M., D Elden Beck and Clive D. Jorgensen. 1963. Biotic communities of the Nevada test site. Brigham Young Univ. Sci. Bull., Biol. Ser. 2(2): 1-52.

Allred, Dorald M., D Elden Beck and Clive D. Jorgensen. 1963a. Nevada test site study areas and specimen depositories. Brigham Young Univ. Sci. Bull., Biol. Ser. 2(4): 1-15.

Muma, Martin H., 1951. The arachnid order Solpugida in the United States. Bull. Amer. Mus. Nat. Hist. Vol. 97, art. 2, pp. 35-141, Figs. 1-316.

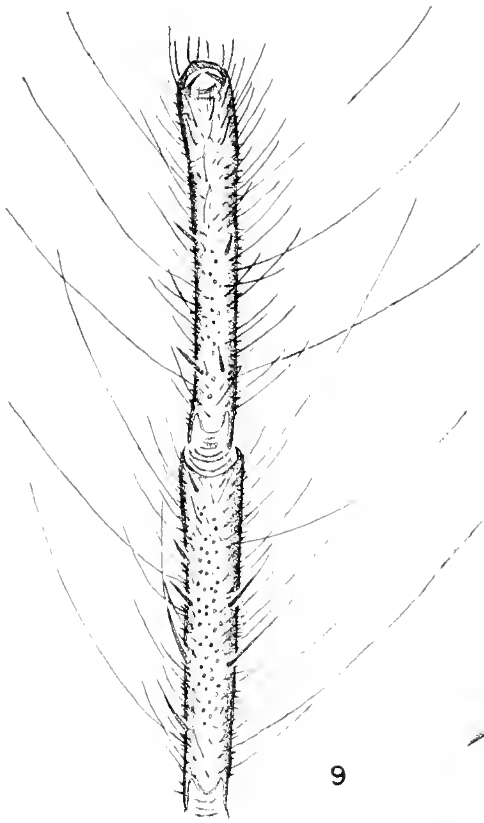
Muma, Martin H. 1962. The arachnid order Solpugida in the United States, Supplement 1. Amer. Mus. Novitates No. 2092, pp. 1-44, Figs. 1-75.



Figures 1-3. *Eremorhax pulcher*, new species 1. Ectal view right male chelicera. 2. Mesal view fixed finger right male chelicera. 3. Ventral view female genital opercula.

Figures 4-6. *Eremobates vicinus*, new species. 4. Ectal view right male chelicera. 5. Mesoventral view apical segments, male palpus. 6. Male abdominal ctenida.

Figures 7, 8. *Theobates flexacus*, new species. 7. Ectal view right male chelicera. 8 Male abdominal ctenidia.



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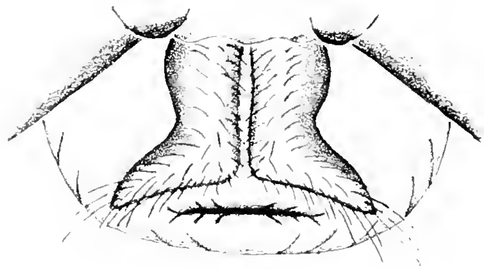

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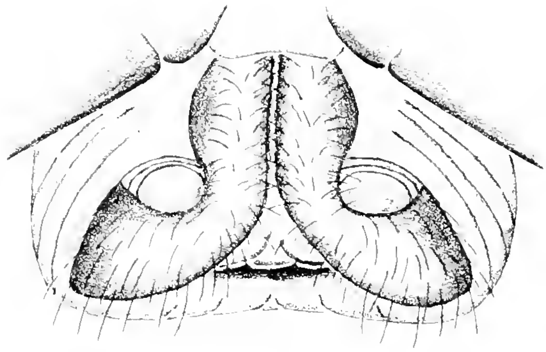

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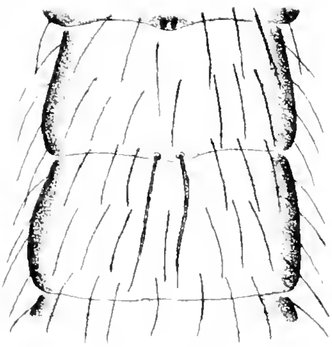

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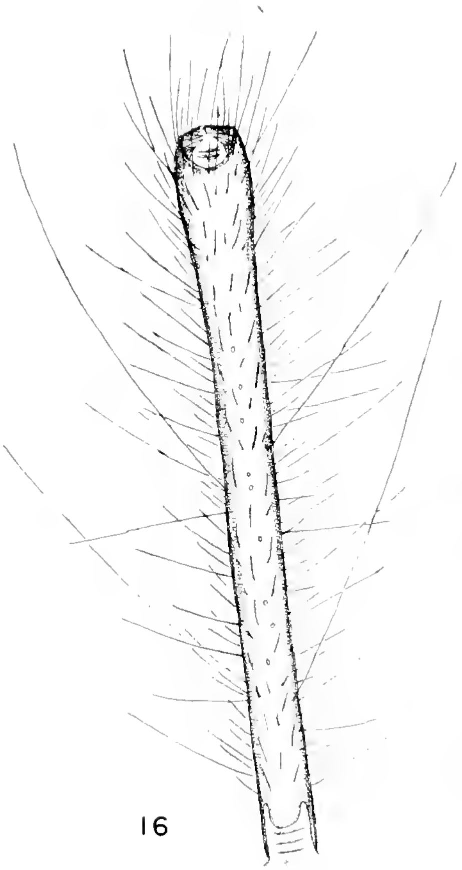
Figure 9. *Therobates flexacus,* new species, mesoventral view male palpus.

Figure 10. *Therobates nudus,* new species, ectal view right male chelicera.

Figures 11, 12. *Therobates attritus,* new species. 11. Ectal view right female chelicera. 12. Ventral view female genital opercula.

Figures 13-15. *Hemerotrecha proxima,* new species. 13. Ectal view right male chelicera. 14. Male abdominal ctenidia. 15. Ventral view female genital opercula.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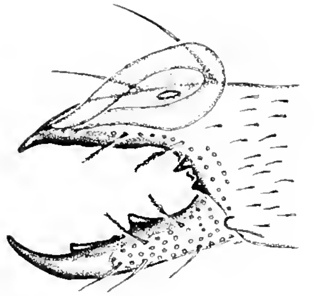
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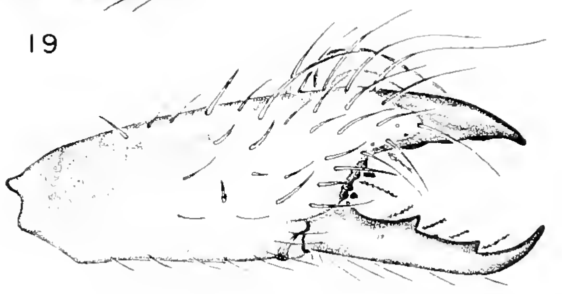
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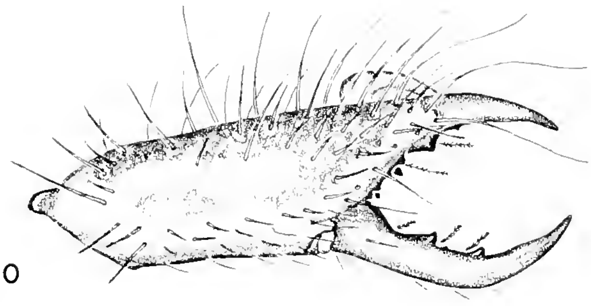
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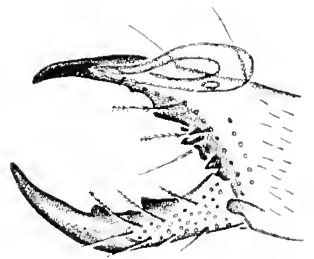
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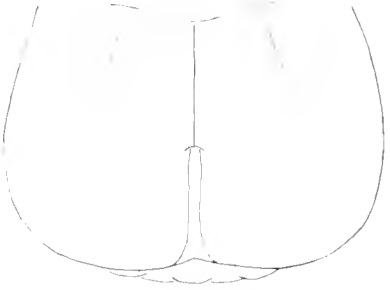
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Figures 16, 17. *Hemerotrecha proxima,* new species. 16. Mesoventral view apical segments male palpus. 17. Ectal view right female chelicera.

Figures 18, 19. *Ammotrechula dolabra,* new species. 18. Ectal view right male chelicera. 19. Mesal view same.

Figures 20-23. *Ammotrechula lacuna,* new species. 20. Ectal view right male chelicera. 21. Mesal view same. 22. Ectal view right female chelicera. 23. Ventral view female genital opercula.

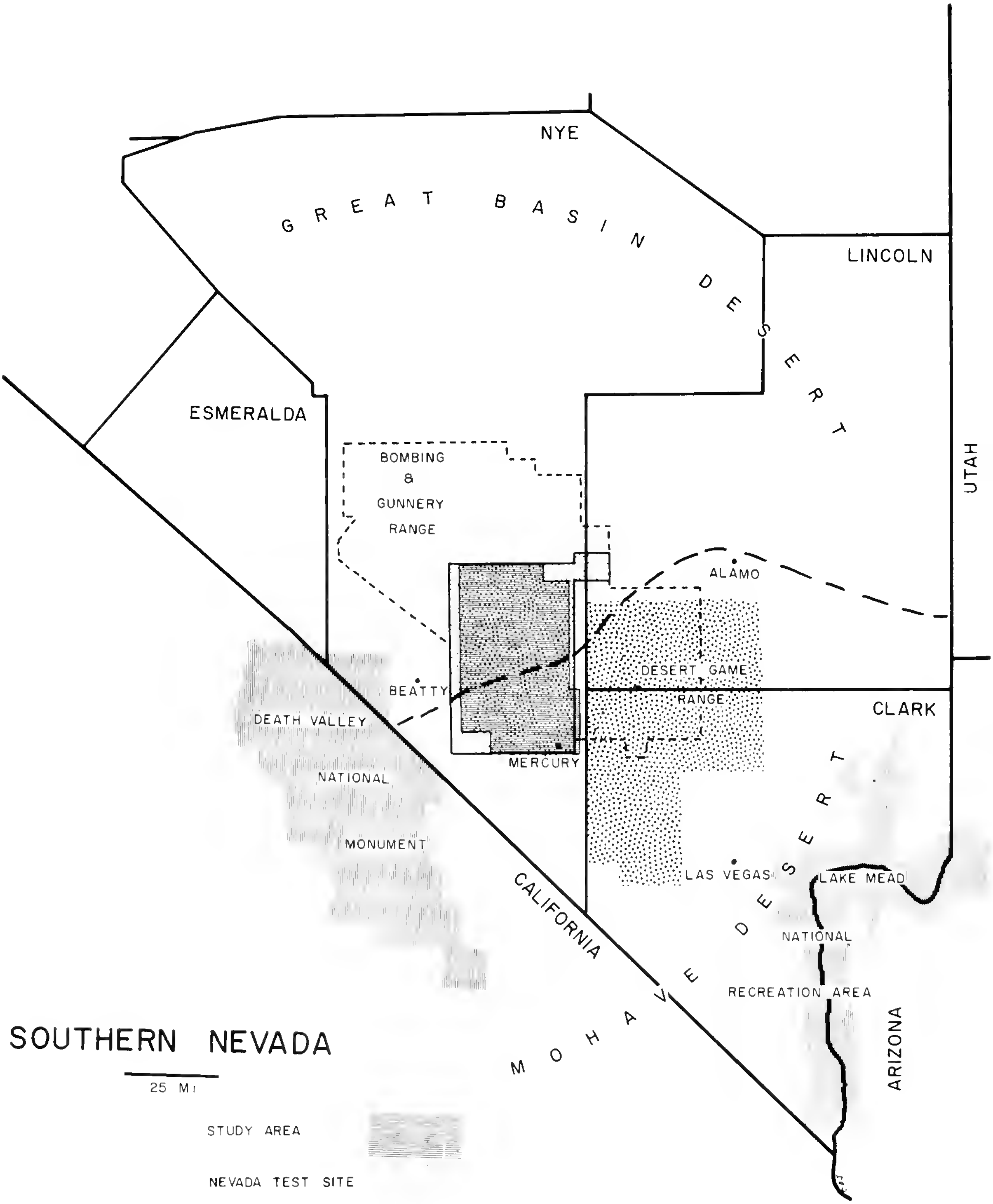

Figure 24. Map of Southern Nevada

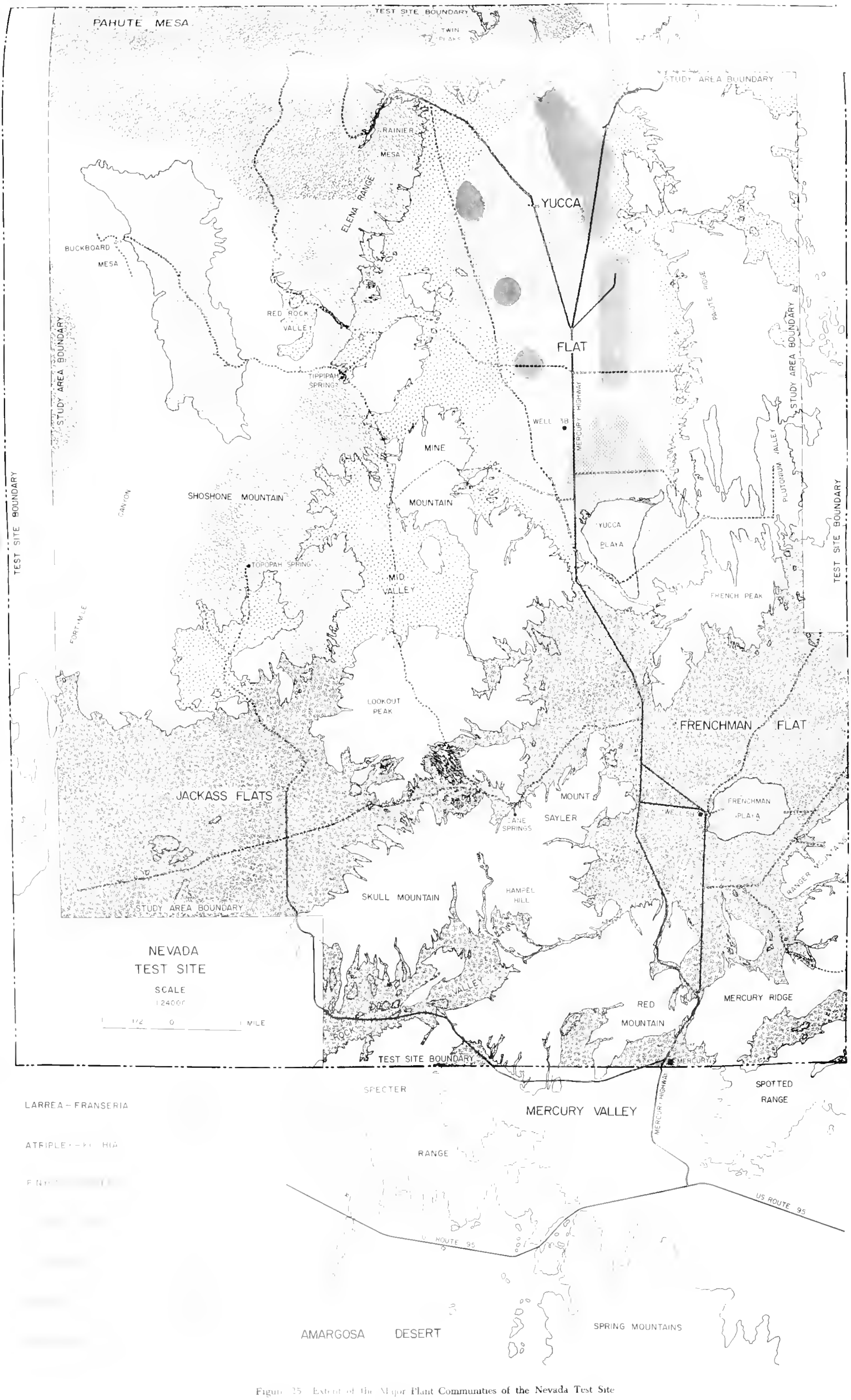

Figure 25. Extent of the Major Plant Communities of the Nevada Test Site

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SCIENCE BULLETIN

REPTILES OF THE NEVADA TEST SITE

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REPTILES OF THE NEVADA TEST SITE

INTRODUCTION

Since the Brigham Young University ecological studies at the Nevada Test Site began in 1959, twenty-nine species of reptiles have been taken. These include one tortoise, thirteen lizards, and fifteen snakes.

The data presented in this study were gathered by a number of workers while research was being done on the biotic communities of the Nevada Test Site (Allred, Beck and Jorgensen, 1963); thus, this report conforms generally with the principal objectives of the major project.*

In analyzing the available data we have been concerned primarily with a description, and where feasible, a discussion of the geographic and ecological distribution, external morphology as related to taxonomic identification, systematic position of subspecies, and seasonal occurrence for each reptile species. For some species, especially *Uta s. stansburiana* and *Cnemidophorus t. tigris*, information on certain aspects of their biology is available. This is summarized under four subheadings: Seasonal Fluctuations, Population Densities, Survival, and Growth Rate.

During the course of this study and in the preparation of this report we have taken data from the preserved collection numbering approximately 700 specimens, and from field records and observations. Unfortunately, time has not permitted a study of the biology of all the species.

The importance of the biology of desert reptiles has been indicated by Cowles and Bogert (1944), Bogert (1948), Woodbury and Hardy (1948), Fitch (1949), Tanner (1957), Tinkle (1961), and Banta (1963) to mention a few, and each has suggested different approaches to the gathering of such data.

Only a few reptiles have been taken from the Nevada Test Site prior to the present report. Insofar as is known, Linsdale (1940) provided the most complete account of Nevada reptiles and included material from and in the near vicinity of the area now occupied by the test site.

The earliest reptile collections probably were made by members of the railroad surveys conducted from about 1850 to 1859. Although these surveys crossed several parts of Nevada, there is no record that their personnel collected in the vicinity of Nye County. The geological and geographical surveys from 1867 (King survey with Robert Ridgway as zoologist) to 1878 (Wheeler survey with H. C. Yarrow and H. W. Henshaw as zoologists) returned many reptiles to the U. S. National Museum. Most of the specimens taken were from northern and central Nevada or from areas in southeastern Nevada along the trails to California. The most comprehensive reports were written or at least directed by S. F. Baird. Such reports as that of Stansbury (Report of the Expedition to the Great Salt Lake, Baird, 1852), the Wheeler Survey (Yarrow, 1875), the survey of the territory west of the 100th Meridian (Yarrow and Henshaw, 1878), and the Death Valley Expedition (prepared by L. H. Stejneger, 1893) are the most pertinent of the early field expeditions which have taken reptiles in either the Artemisian Biotic Province or the Mohavian Province, both of which occur at the Nevada Test Site. The major study by Cope (1900) lists the reptiles taken by the early expeditions which were deposited in the U. S. National Museum. Based on this report, the closest records to the Test Site were those taken in Pahranagat Valley in Lincoln County, Vegas Valley in Clark County, Ash Meadows in southern Nye County, Nevada, and Inyo County, California.

Since 1900, specimens have been reported from Current in northwestern Nye County (Bentley, 1918). Records from Vegas Valley, Pahrump Valley, Amargosa Desert and Railroad Valley were reported by Van Denburgh (1922). Actual collecting on the test site before 1959 was limited. Only a few specimens actually reached collections and only part of these have been reported. In 1921, Van Denburgh and Slevin published what appears to be the first list of amphibians and reptiles for Nevada.

The major part of the test site is in the Great Basin. A general map (prepared by the U. S. Geol. Surv. Water Resources Development U. S. Map, 1953) used by Banta (1963:254) outlines the limits of the Great Basin. We question the accuracy of the eastern boundary in Nye County which would not include Groom, Yucca and

*This research was supported by Contract AT(11-1)786 between the United States Atomic Energy Commission and Brigham Young University

Frenchman valleys in the Great Basin. Specimens used in this report were taken primarily from Yucca and Frenchman flats (our use of the term "flats" includes all of the valley draining into the playa), and areas to the west (Jackass Flats and Rainier Mesa), all of which are within the Great Basin.

The Nevada Test Site is geographically situated so as to include elements of the Mohave Desert biotic communities plus elements of the Great Basin Desert communities. Its position is briefly discussed by Allred *et al.* (1963:11, fig. 1); however, the relationships between biotic communities and the distribution of some reptiles are so clearly shown in the data that additional explanations will be helpful. A factor also not widely known and of some importance to distribution is the divided drainage of the area southeast of the test site. This area drains eastward through Indian Springs Valley to the Colorado River.

This combination of physical and biological factors is probably responsible for the southward extension of the Great Basin fauna along the higher ridges and mesas (e.g. *Eumeces skiltonianus* and *Masticophis t. taeniatus*) and the northward extension of the Mohave fauna along the low valleys (e.g. *Phyllorhynchus*, *Masticophis f. piceus*, *Chionactis* and *Coleonyx*, to list a few). This interdigitation of faunas plus the more widespread species (*Sceloporus occidentalis*, *Uta stansburiana*, *Phrynosoma platyrhinos*, etc.) has given this rather small area a most interesting reptile fauna. The Nevada Test Site reptiles are, as indicated above, basically derived from (1) Great Basin fauna, (2) Mohave Desert fauna, and (3) a group seemingly ubiquitous to both deserts.

Recent authors (Linsdale, 1940; Smith, 1946; Stebbins, 1954) have indicated the general geographic distribution of the reptiles of southern Nevada based primarily on small samples usually taken from localities to the east or west of the test site. These small and often widely separated samples have made the accurate establishment of distribution ranges speculative. It is understandable that adjustments of the boundaries for species and subspecies must be made to include the added samples. There is perhaps a much greater adherence to the geographic provinces (Great Basin or Colorado River drainage) and the biotic communities (Upper or Lower Sonoran, Artemisian or Mohavian; see Allred *et al.*, 1963) than has been previously suspected. We have not attempted to set up boundaries or limits on distribution ranges but have listed in the species account our findings and where possible, the biotic communities which serve as the basic habitat.

METHODS AND ACKNOWLEDGMENTS

The basis for ecological distribution and seasonal occurrence at the Nevada Test Site has been established by Allred *et al.* (1963), in which the plant communities are defined and the animal species when possible, associated with them. Methods used to collect and study reptiles were discussed only briefly and will therefore be clarified later in this paper.

Extensive hand collecting was done in the plant communities defined by Allred *et al.* (1963), as well as in many of the transition and mountainous areas. Sight records were also kept of those species which were readily identified in the field. These records are also accompanied by observations of the ecological conditions at each general locality.

Study plots were maintained in all of the major plant communities to obtain data on seasonal occurrence and relative reptile abundance. Lizards and some small snakes were collected in the study plots by means of sunken can traps. Each trap consists of an outer, galvanized sheet metal sleeve, seven inches in diameter and 14 inches long, and a stainless steel, flanged insert of a slightly smaller size. Records were kept in the study plots for at least 13 months, thus providing for seasonal observations during a continuous period.

The line transects radiating outward from a central point (ground zero) were used to establish the relative effects of a nuclear detonation on animal populations. Can traps were buried at stations 80.49 m (264 ft.) apart along four transects extending 2.42 km. (1.5 miles) from ground zero. The number and kinds of reptiles trapped at each station were recorded, and the results correlated with the vegetation analysis to determine the relative effect of disturbance resulting from nuclear weapons testing. Population densities, home range and other population characteristics were investigated. We were aided in this by a grid of sunken can traps (Fig. 1). This particular grid has been adequately described by Jorgensen and Tanner (1963). It was used for a capture-recapture study in which several population characteristics were investigated.

Vegetation was analyzed by the line intercept method (Jorgensen, 1963) in all cases where detailed vegetation analysis was considered important. This includes most seasonal study plots, the radiating transect study, and the grid study. The methods of analysis will be presented with the results.

We are indebted to the many students and others who have aided in securing the specimens and recording the field data. We are particularly grateful to Drs. Dorald M. Allred and D Elden Beck for the privilege of working up these data and for their many courtesies in securing the needed information; and to Mr. Arnold M. Orton, who as a former student assistant was assigned to work with the reptiles at the test site. His diligence aided greatly in providing many details. As in many such studies, certain species are often scarce and difficult to secure; we are, therefore, grateful to Mr. Joseph R. Lannom, Jr., University of California, Los Angeles, for the live specimens made available in the spring of 1963.

FIG. 1. Grid in which population parameters were determined for *Uta stansburiana* and *Cnemidophorus tigris*, showing vegetation and station locations.

ECOLOGICAL BACKGROUND

CLIMATE

The general climatic conditions at the Nevada Test Site have been summarized by Allred *et al.* (1963). Climatic factors which probably affect reptile activity most are temperature and precipitation. We will discuss these in more detail below.

Allred *et al.* (1963) stated, "The summers at the test site are long and hot and the winters short and mild. The highest temperature recorded at the test site was 112°F in July, 1958, at Jackass Flats, and a minimum of 3° in January, 1959, at Yucca Flat. The average maxima and minima vary with the location, from 64° to 77°F maximum and 39° to 52° F minimum . . . Diurnal temperature changes typical of desert regions fluctuate as much as 51° on clear days, but may not differ more than 20° on cloudy, windy days." The temperature data for 1960 (Richter, 1960) are summarized in Table 1. This is a composite table of averages, taken from the results of six sampling stations by Richter, but with larger differences usually present at the separate sampling station.

Precipitation was stated by Allred *et al.* (1963) to be primarily during the winter months (Dec., Jan., and Feb.), with 64 percent of the precipitation falling during this period. The season of least precipitation is from spring through early summer (March, April, May, and June). The composite table of precipitation (Table 2) demonstrates the seasonal distribution of precipitation at the test site.

Tables 1 and 2 give only an indication of actual conditions. Generally, annual cycles at the test site as in other deserts tend to deviate from the mean. The averages then, are not to be construed to indicate what might be expected during a single season. Averages are perhaps not ordinarily the limiting factors in distribution and activity of organisms. The limiting factors are more likely to occur at the extreme deviations from the mean.

PLANT COMMUNITIES AND ANIMAL ASSOCIATES

Since the test site is situated in the transition between major biotic provinces, there are many plant communities each with a diverse fauna and flora. Each plant community has been defined and delineated by Allred *et al.* (1963),

Table 1. Composite temperature results for six sampling stations at the Nevada Test Site for 1960 (after Richter, 1960).

	Temperature												
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Avg. Temperature	42	44	47	56	62	74	79	77	71	58	47	46	59
Maximum[a]	50	49	52	60	67	80	85	81	77	66	51	48	63
Minimum[a]	33	36	34	50	54	66	72	70	58	41	36	39	49
Avg. Range	20	19	22	25	25	27	26	25	26	24	22	23	24
Maximum	29	27	30	34	34	37	34	36	37	38	33	37	35
Minimum	13	12	17	17	18	19	18	17	18	15	13	12	16

[a]The maximum and minimum values are not the extremes for the month, but the averages of the six sampling stations included in a composite table.

Table 2. Composite precipitation of all sampling stations at the Nevada Test Site.

	Precipitation												
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1959	.59	.44	.00	.01	.00	.05	.63	.52	.57	.00	.08	1.44	4.33
1960	.49	.58	.23	.19	.04	.22	.09	.08	1.04	.86	1.85	.00	5.67
1961	.57	.06	.27	.16	.20	.15	.40	1.34	.00	.15	.90	1.27	5.47
1962	.37	1.79	.42	.02	.20	.13	.42	.00	.97	.20	.01	.31	4.84
Avg.	.51	.72	.23	.10	.11	.14	.38	.48	.65	.30	.71	.76	5.08

with the species most commonly associated with them indicated in the appendices. These same plant community designations will be followed in this paper. Where necessary, a more detailed account of plant composition and cover will be added. The analyses (Table 3) were made in the seasonal study plots which were situated in each of the major plant communities.

These analyses are intended to typify the communities, and do not indicate all of the various smaller plant associations within each community. The analyses of communities in edaphic and transition areas may alter the data considerably; however, since they appeared to be generally unimportant to the distribution of most reptiles, they are not considered in detail.

Other habitats that should be considered are the several mountainous areas. The higher ranges have a varying flora most predominant of which is the Pinyon-Juniper. The mountainous areas cannot, however, be identified as a single plant community. Scattered throughout the test site are lower mountain ranges which do not

TABLE 3. Percentage of ground cover and composition of plant communities at the Nevada Test Site.

	Plant Communities[a]					
Species	At-Ko	Co	Gr-Ly	La-Fr	Pi-Ju[b]	Sa[b]
Percentage Ground Cover	21.0	25.4	19.6	11.4	X	X
Artemisia spinescens	3.0	0.9	3.4			
Artemisia tridentata					X	
Atriplex canescens			6.4			
Atriplex confertifolia	60.7					
Bromus rubens						X
Cercocarpus ledifolius					X	
Chaenactis stevioides						X
Coleogyne ramosissima		64.2			X	
Cowania stansburiana					X	
Dalea polyadenia				3.3		
Ephedra nevadensis		2.8		6.3		
Ephedra viridis					X	
Eriogonum spp.						X
Eurotia lanata	10.6	0.1	15.1			
Franseria dumosa				20.2		
Grayia spinosa		24.3	53.7	7.9		
Hymenoclea salsola		2.0		9.5		
Juniperus osteosperma					X	
Kochia americana	25.7					
Larrea divaricata				44.9		
Lycium andersonii		2.1	15.4	7.9		
Mirabilis pudica						X
Oryzopsis hymenoides		2.4	3.7			
Pinus monophylla					X	X
Quercus gambelii					X	
Salsola kali						X
Sitanion hanseni		0.5	0.4			
Stipa comata			1.8		X	
Tetradymia axilaris		0.5				
Tetradymia glabrata		0.3				

[a]At-Ko = *Atriplex confertifolia* - *Kochia americana*, Co = *Coleogyne ramosissima*, Gr-Ly = *Grayia spinosa* - *Lycium andersonii*, La-Fr = *Larrea divaricata* - *Franseria dumosa*, Pi-Ju = *Pinus monophylla* - *Juniperus osteosperma*, Sa = *Salsola kali*.

[b]These plant communities differed so completely from the others that it was thought unnecessary to analyze the vegetation critically for the purposes of this paper.

have pinyons or junipers. These furnish habitats with diverse flora, and several reptile species are restricted to them. Some of the plants commonly found in these areas and not listed in the plant communities (Table 3) are: *Agave utahensis*, *Cercocarpus intricatus*, *Dalea fremontii*, *Ephedra torreyana*, *Fallugia paradoxa*, *Opuntia basilaris*, *Opuntia erinacea*, *Petalonyx nitidus*, *Salvia dorii*, and *Thamnosma montana*. Most of the species listed for the plant communities can also be found scattered throughout the mountainous areas.

The animal associates occurring in the various plant communities of the Test Site are listed in Appendix II of the report "Biotic Communities of the Nevada Test Site" (Allred *et al.*, 1963) and will not be discussed further here.

ACCOUNT OF THE SPECIES

TURTLES

Gopherus agassizi Cooper

Desert Tortoise

The desert tortoise occurs over wide areas of the Mohave Desert. We found it more commonly in the Larrea-Franseria community and the surrounding foothills (Fig. 2). They were most frequently observed from March to September.

Several broken carapaces were found on mountain tops which seemingly are inaccessible to an unaided tortoise. They may have been transported by either carnivores (Woodbury and Hardy, 1948) or predaceous birds. The possibility of carnivores or predaceous birds carrying the shell of a tortoise to the mountain tops seems possible. Predation was not observed by members of the project.

LIZARDS

Coleonyx variegatus utahensis Klauber

Utah Banded Gecko

A series of 31 specimens is available from Frenchman, Jackass, and Yucca flats. Based on Klauber's study (1945) the geckos in Nye County, Nevada, should belong to the typical subspecies, *variegatus*. Although three specimens have the double-barred pattern in the dorsal spots and four others might be considered color pattern intergrades, the majority of the specimens are so similar to a series from the type locality, (Washington County, Utah) that we consider them to be *utahensis*. The test site is perhaps near the western edge of the range for *utahensis* and, therefore, a greater percentage of intergradation may be expected to occur as specimens become available further to the west and south of the test site.

Scalation counts do not differ significantly from the averages stated by Klauber (1945). However, this series is perhaps on the western edge, whereas the type series is from the eastern edge and should for comparative purposes have the scalation ranges for the test site specimens presented. They are as follows: pores, (16 males) 4-8, (5.9); supralabials, 7-9 (7.8); infralabials, 7-10 (8.6); scales posterior to mental 3-8 (5.6); scales between supranasals, 1-4 (2.5).

The largest specimens have a snout-vent length of 70.4 mm. (♂) and 65.8 mm. (♀). This species was recorded only from the Larrea-Franseria community and surrounding low mountainous areas (Fig. 2). They were not particularly abundant and were collected between May and October.

Dipsosaurus dorsalis dorsalis Baird and Girard

Desert Iguana

Three specimens were taken from the Larrea-Franseria community in western Frenchman Flat. This record is approximately 50 miles further northeast of that listed by Van Denburgh (1922) for Nye County and is perhaps the most northern record for Nevada. Its occurrence at the test site is not unexpected, for it is known from areas further north in Utah. The elevation at 3,200 ft. is nearing the altitude limits for *dorsalis* in this part of its range.

There are no unusual variations in scalation. The femoral pores are 19-22, supralabials 8 or 9, infralabials 10 to 12 and there are two scales between the nasal and rostral in two specimens but only one scale in the other. The largest specimen is 122 mm. in its snout-vent length. Two have regenerated tails and in these the dorsal crest scale row is not redeveloped in the regenerated part.

This species is apparently rare at the test site and was taken only in the Larrea-Franseria plant community (Fig. 4). One was seen in the Cane Springs area in the foothills a short distance west of Frenchman Flat. They were recorded only during May and June.

Crotaphytus collaris baileyi Stejneger
Western Collared Lizard

The series consisting of 15 specimens ranges in age from recent hatchlings to adults. The largest male is 100.2 mm., the largest female 92.4 mm. in snout-vent lengths. In males, the tail length is twice or more the snout-vent length; in females it is less.

Scale counts agree with other populations of *baileyi* (Fitch and Tanner, 1951) and are as follows: ventrals (from first enlarged scales posterior to gular fold) 92-107 (98.0); femoral pores 14-20 (17.0); supralabials 12-17 (14.8); infralabials 12-16 (14.0); and interorbitals in two rows.

The color patterns are typical of *baileyi*. Some yellow and dark green are included but in general the ground color is dull and darker than in populations observed from Utah and Arizona. The head is often heavily spotted with dark brown, the body has small spots often forming irregular transverse lines of white. The paired black collars may be complete mid-dorsally or divided. Over half of the specimens have the first collar divided and the second complete. Both collars are complete from the mid-dorsal line to their lateral terminus.

In some populations of this species, the first collar is broken into two or more lateral spots. The second dark collar is unbroken and terminates before reaching the upper arm, whereas the first may extend to the ventral surface and in males produces a dark gular bar, often fusing with the dark gular spot. In females the anterior collar is always separated ventrally, and the gular and abdominal regions are white. There is considerable variation in the amount of pigment present in the population of *baileyi* from the test site. This is partially dependent on the temperature since warm active males are more decorated in shades of yellow and green colors than those which have been hiding for a time. Young and subadults always have the distinct transverse dorsal dark and light barring more distinctly than do the adults.

This species was recorded only from the mountainous and foothill areas in the vicinity of the Larrea-Franseria communities (Fig. 3). They were not recorded north of this community at the test site. They were observed from April to July.

Banta (1960) briefly discussed some of the feeding habits of this species and reviewed two accounts of their having fed on vegetable matter (Pack, 1923: Ruthven and Gaige, 1915). He found 65 and 95 percent of the stomach contents of two specimens collected in Nye County to be *Lycium andersonii* berries. No feeding observations were made at the test site.

Crotaphytus wislizeni wislizeni Baird and Girard
Leopard Lizard

A series of 35 specimens was examined and numerous observations made of live ones from various localities at the test site. Measurements and scale counts of this series agree with those of Van Denburgh (1922), Stebbens (1954,) and Smith (1946). Some are as follows: Femoral pores, 17-24 (20.5); ventrals, 74-87 (80.0); supralabials, 12-17 (15.1); infralabials, 11-16 (13.7); snout-vent length 44.7-125.0; and tail length 88-200. The largest specimen is a female with a snout-vent length of 125 mm. The color pattern consists either of scattered small to medium brown spots or one with rather large brown spots usually forming four dorsal rows with the median two extending onto the tail. In the pattern, there are usually six to eight light transverse lines which separate the spots and produce a partial checkerboard effect. The first pattern provides much more background color and thus the lizard so patterned is lighter. The ventrals are white and the gulars have six dark longitudinal stripes extending from the lower jaw to the gular fold.

This species was recorded from all the plant communities except the Pinyon-Juniper (Fig. 3). Although not in this woodland community, it is commonly found in the *Artemisia* and *Coleogyne* which are frequently distributed along the upper bajadas leading to Pinyon-Juniper. It is also found in the transition zone between the bajada and mountainous areas where it overlaps the range of *Crotaphytus collaris.* It is active from March to October, being most common during April and May.

Their habitat occurs in the more sandy or gravelly areas where holes may be dug either by rodents or perhaps by the lizards themselves. Such holes serve as their retreat. This is quite in contrast to the collared lizard and its rocky habitat.

Other authors (*op. cit.*) have referred to the habits of these lizards and most of these have been observed at the test site. A few additional notes are worthy of record. While trapping mammals, leopard lizards were frequently caught in the live traps. After several were caught, it was apparent that the lizards were actually eating the oatmeal bait. Several were killed in the field and their stomachs were found to contain only oatmeal (Jorgensen and Orton, 1962). Similar observations were made by Clyde Pritchett (1962) in Kane County, Utah. Whether this species feeds on other plant products has not been determined by us. According to Smith (1946) *wislizeni* is predominantly insectivorous, but is also cannibalistic and predaceous. While caged in the laboratory, they were observed on several occasions to feed on live adult least pocket mice (*Perognathus longimembris*). Feeding on small mammals has not to our knowledge been recorded previously (Stebbins, 1954), and it is doubtful that mammals occur frequently or normally in their diet in nature. It should be noted that *wislizeni* is active during the day and *Perognathus* at night.

In 1915, Richardson referred to the pugnaciousness of this species and mentioned one specimen that produced a "low moaning sound." Leopard lizards collected at the test site possess the ability to squeal in a high pitched voice similar to that of *Coleonyx variegatus* (Jorgensen, Orton, and Tanner, 1963). Their voice has been recorded and is available on tape. All adults and most sub-adults have a voice. They apparently were more inclined to squeal in the morning, but all would respond if sufficiently irritated. Some were moved to Provo, Utah, where it was noticed that the cooler temperatures likely reduced their squealing response even when irritated.

Sauromalus obesus obesus Baird

Chuckwalla

A series of eight specimens from the test site is uniform in scalation although below the average in most of the counts summarized by Shaw (1945).

The test site series represents the most northern records for the species in Nevada. We are, therefore, summarizing some of the data as follows: Caudals 30-38 (34.4); femoral pores 14-17 (15.5); supralabials 14-17 (16.2); infralabials 14-20 (18.2); the largest male is 217 mm. from snout to vent and 445 mm. in total length; largest female is 200 mm. from snout to vent and 380 mm. total length; tail length to total length ratio, .4737-.5251 (.4976).

In color they are essentially as described by Shaw (*op. cit.*). The pattern of dark dorsal cross bars seen in juveniles is completely obliterated in both male and female adults. This is also true for most of those seen from southern Utah. In males, the juvenile pattern is lost by an increase of black pigment, whereas in females the pattern seemingly disappears because of pigment dissolution and fading. This produces in females a dark to light gray dorsal coloration with few traces of the juvenile barred pattern.

This large species is common in the rocky mountainous areas (Fig. 2). On only two occasions were they collected elsewhere; one in Grayia-Lycium and one in the Larrea-Franseria communities. In both cases they were near their habitat in the rocky mountainous areas.

Callisaurus draconoides rhodosticus Cope

Colorado Desert Zebra-tailed Lizard

Our series consists of 37 specimens ranging in snout-vent length from 31 to 89.2 mm. The males are larger but do not, in this series, have proportionally longer tails than the females.

According to Stebbins (1954) and Smith (1946) specimens taken in central and southern Nye County should be *rhodosticus* (*gabbi*). This is undoubtedly so; however, the test site series agrees completely in only one of the key characters used by Smith (1946) in separating the subspecies *ventralis*, *rhodosticus* and *myurus*. The percentage of tail to total length ranges from 55.4 to 61.6 (57.6). Nineteen have less than 58 percent, with seven having more. If those with 58 percent or more are *rhodosticus* and those with less *myurus* in this character, then this series intergrades.

In the number of femoral pores *rhodosticus* should have 16 or less. The test site series averages 15.8 but again 12 specimens or approximately one-fourth, have 17 or more. The same percentage of specimens have the interparietal in contact with the supraorbital semi-circles by one or more scales on both sides of the interparietal, a character attributed to *ventralis*.

Only in the percentage of hind leg length to body length is there a similarity between the test site series and those reported previously for this subspecies. Since approximately 80 percent of our series have the prescribed 92 percent or more of hind leg length to body length and have the averages of other characters nearest to *rhodosticus* we have placed this series with the Colorado Desert subspecies. There are, however, strong indications of an influence of *myurus* in the percent of tail to total length and in the contact of interparietal to supraorbital semi-circles.

In many species certain interesting habits appear when individuals are observed in their habitat. This subspecies has the characteristic of holding the tail over the back while running and thus exposing the contrasting black and white tail bars. Also on several occasions it was ob-

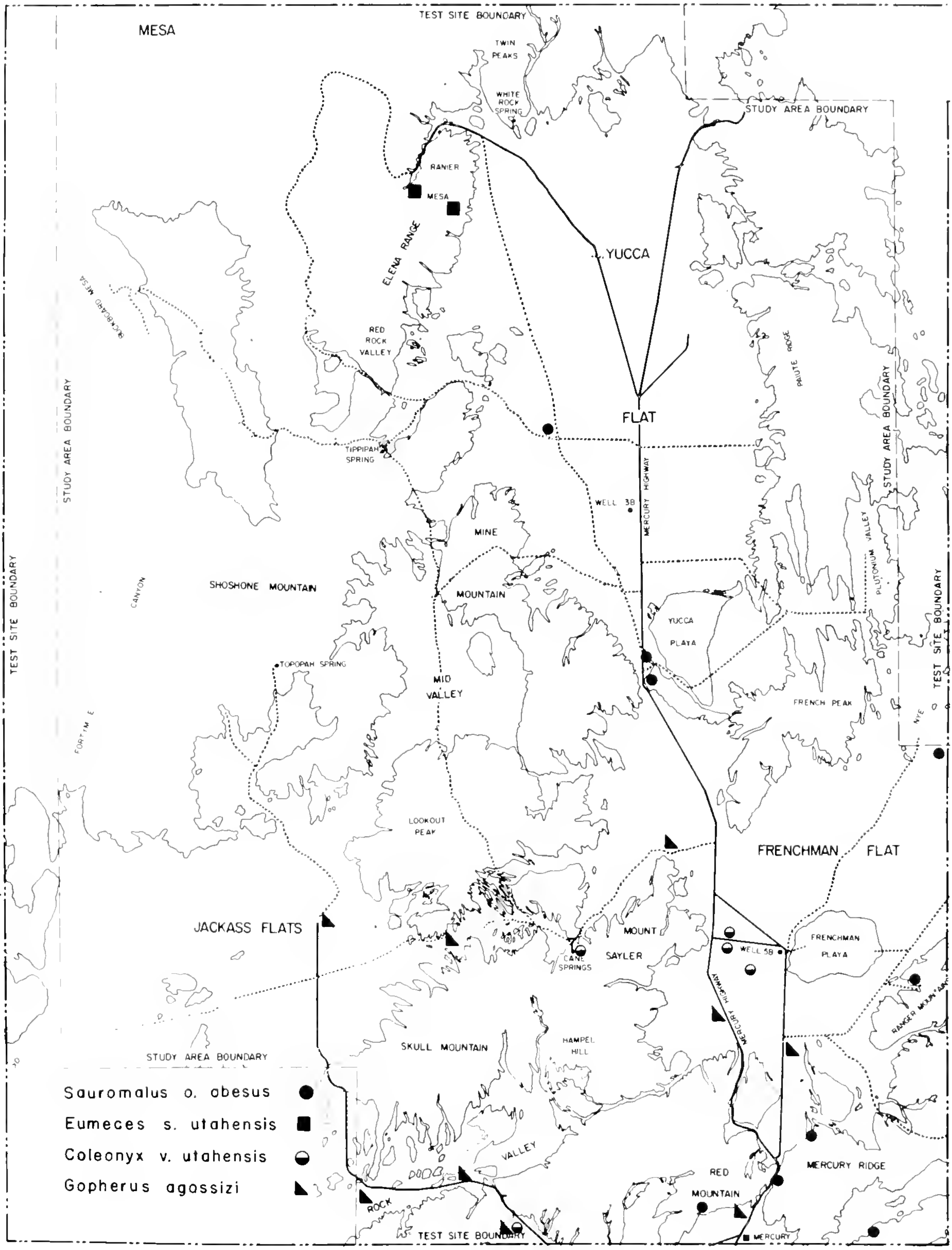

FIG. 2. Collection and observation sites of *Gopherus agassizi, Coleonyx variegatus, Sauromalus obesus,* and *Eumeces skiltonianus.*

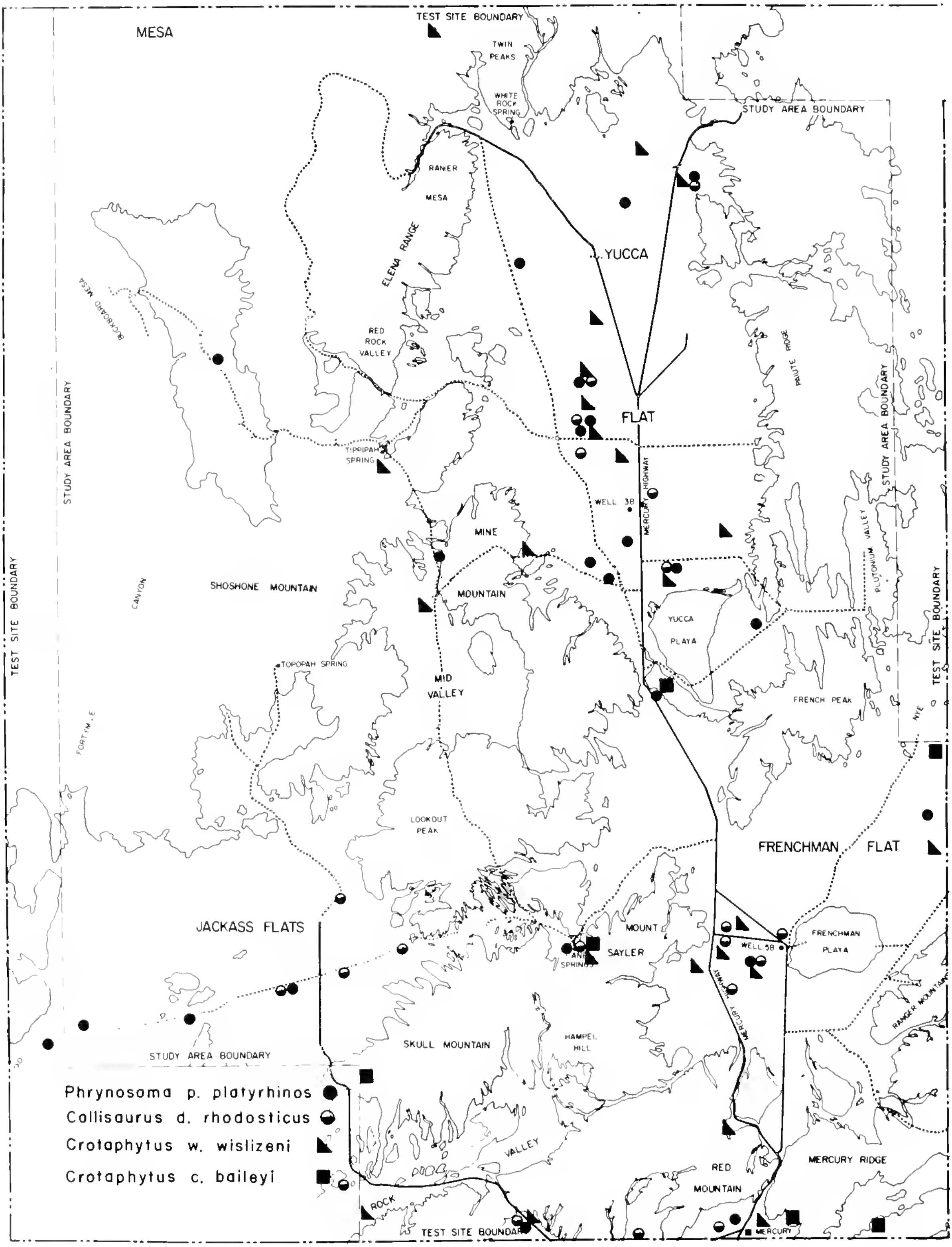

FIG. 3. Collection and observation sites of *Callisaurus draconoides*, *Crotaphytus collaris*, *Crotaphytus wislizeni*, and *Phrynosoma platyrhinos*.

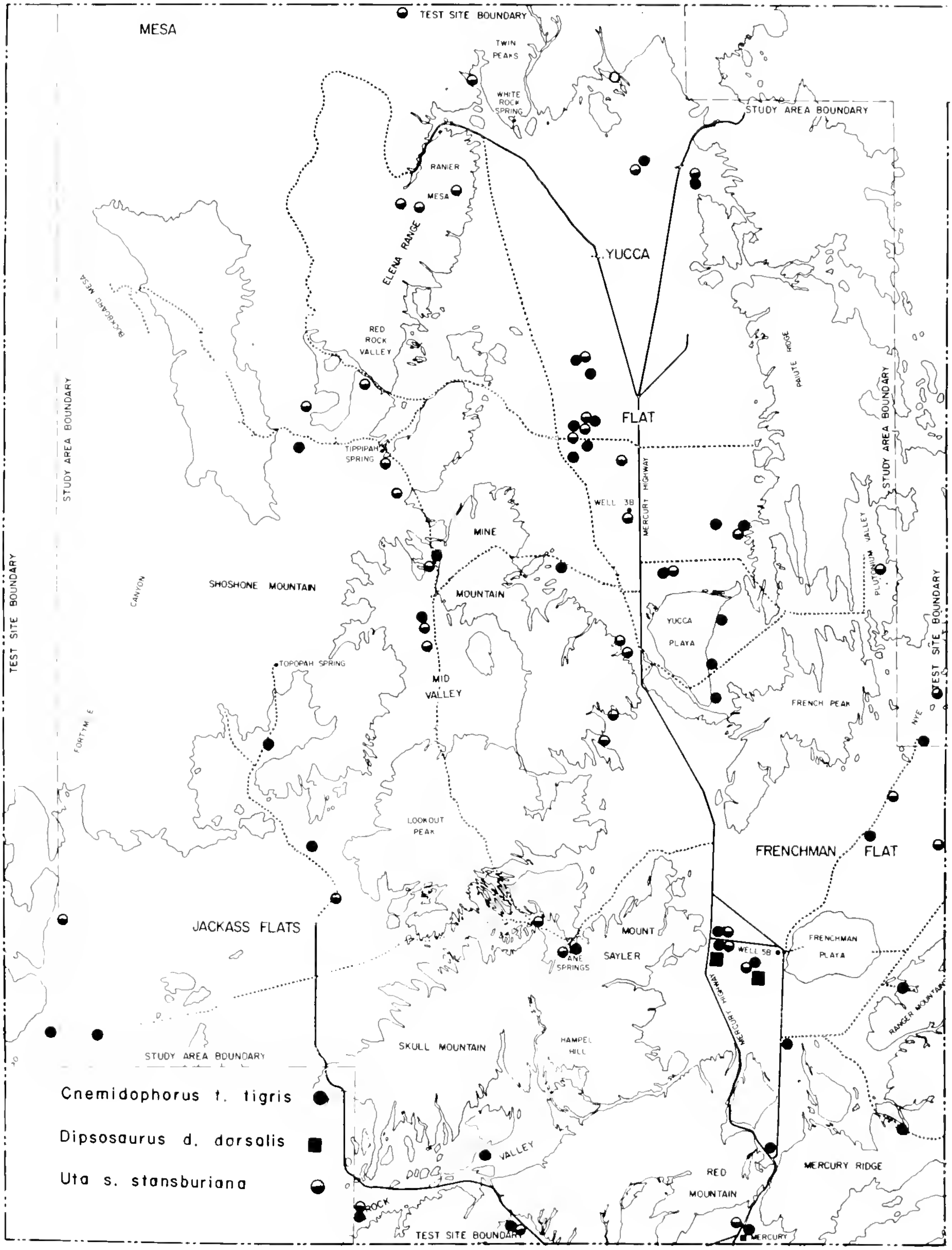

Fig. 4. Collection and observation sites of *Dipsosaurus dorsalis*, *Uta stansburiana*, and *Cnemidophorus tigris*.

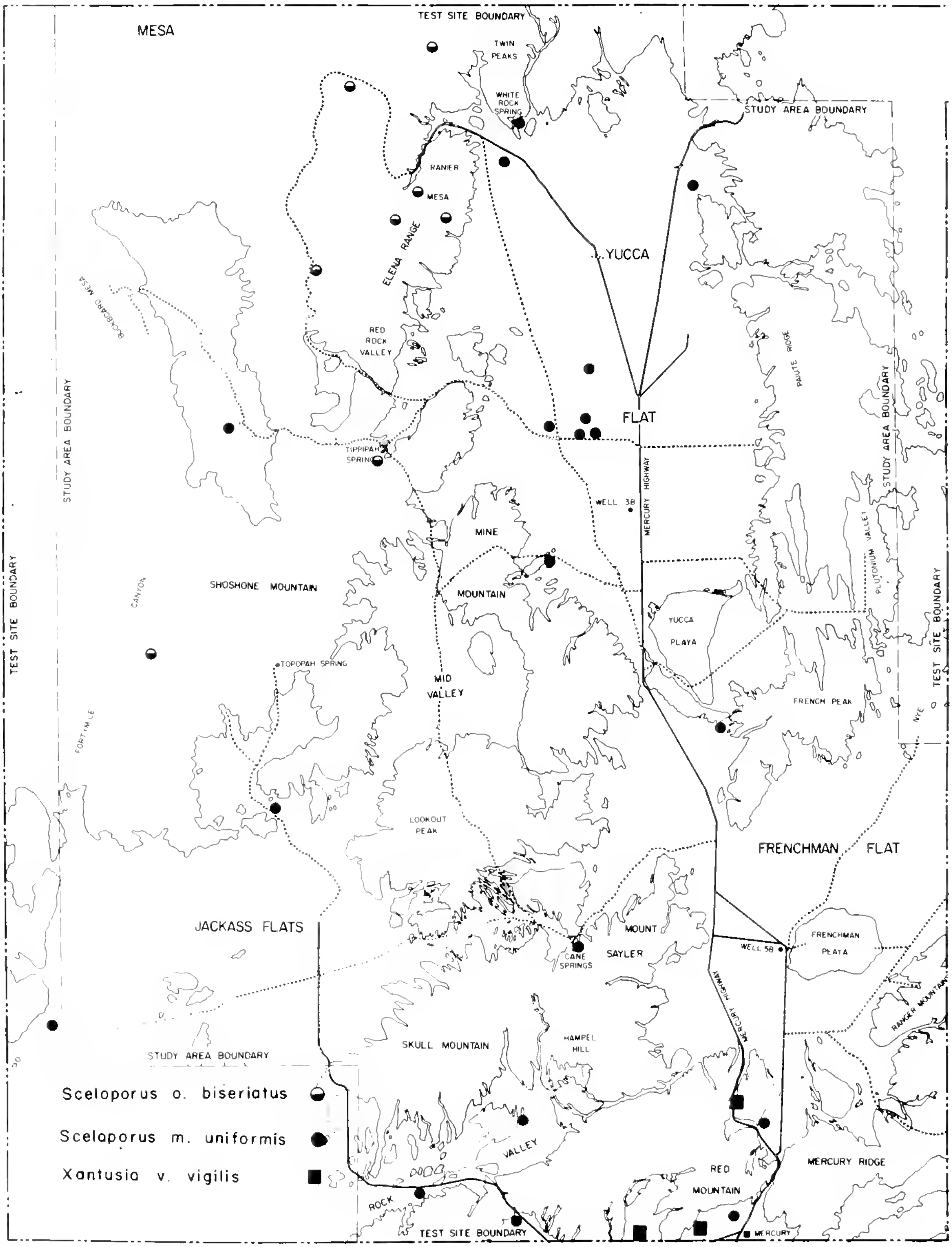

Fig. 5. Collection and observation sites of *Sceloporus magister*, *Sceloporus occidentalis*, and *Xantusia vigilis*.

served that standing lizards very often wiggle the last third of the tail. If one remembers that in this species the tail is dropped at the slightest provocation, then perhaps these habits have survival value.

Although this species was recorded from all the plant communities except Pinyon-Juniper, it was most abundant in Larrea-Franseria and Grayia-Lycium (Fig. 3). *Callisaurus d. rhodosticus* is active from March through October and most abundant during July. This common species is, according to Merriam (in Stejneger, 1893: 171), one of the most attractive and fastest lizards in western North America.

Sceloporus magister uniformis Phelan and Brattstrom

Yellow-backed Spiny Lizard

We examined 29 specimens from the test site and have determined them as *uniformis*. However, because of the geographical nearness to *transversus* the pertinent scale counts and measurements are listed. Femoral pores 11-16 (12.7); scale rows around body, 32-39 (35.8); dorsals 30-36 (33.2); ventrals 36-43 (39.6) largest male, 104.0; and largest female, 100.5 mm. in snout-vent lengths.

In adult males the dorsum is without a distinct pattern or with very faint indications of mid-dorsal spots. In the females the bars are present and usually broken; however, in one (BYU 17422) there are seven dark bars with the first forming a complete collar.

The Nevada Test Site is located directly east of the range of *transversus* which for the most part is also within the Great Basin drainage. Therefore, one might expect the *magister* populations from southcentral Nye County to show some relationships to *transversus* since, according to Phelan and Brattstrom (1955), there is intergradation in Nye County west of Beatty. In the series from Frenchman, Yucca and Jackass flats, we have found little to suggest intergradation between these two subspecies. A sampling of the populations westward to Beatty may provide a more definite indication of intergradation; however, the test site series belongs with those populations in eastern Nevada and southwestern Utah.

This species was collected in all plant communities except Coleogyne and Pinyon-Juniper, and was most common in Grayia-Lycium (Fig. 5). They were commonly observed from March through October, with one taken in December. They, too, were reported to feed on oatmeal bait by Jorgensen and Orton (1962).

Sceloporus occidentalis biseriatus Hallowell

Great Basin Fence Lizard

A series of 42 specimens has been examined from the test site. They are in all characters generally within the limits established for this subspecies by Smith (1946). This population is on the southeastern edge of the range for *biseriatus* and we are, therefore, listing the range and averages for the following scale counts. Femoral pores 13-19 (15.9); scales around body 45-51 (57.8); dorsals 40-48 (41.2); and ventrals 37-54 (47.0). In snout-vent lengths they do not exceed the maximum of 90 mm. The color and color pattern is similar to that described by Van Denburgh (1922), except that the color on the under parts of the hind legs and abdomen is more often orange than yellow.

The western fence lizard occurs from the ledges on the hills surrounding the valleys up to the high plateaus (Rainier Mesa). It is usually found in ledges and rocky habitats. Only on rare occasions are they taken in the desert flats. This is perhaps the most abundant reptile in the Pinyon-Juniper community of the test site (Fig. 5). In these areas they were can-trapped with *Eumeces*.

Uta stansburiana stansburiana Baird and Girard

Northern Side-blotched Lizard

The brown shouldered *Uta* is widely distributed at the Nevada Test Site. It ranges from the edge of the playas to the tops of the highest mountain ranges, thus occurring in most biotic communities at the test site (Fig. 4).

Recent workers (Linsdale, 1940; Smith, 1946; Stebbins, 1954) have accepted Klauber's (1932) subspecies assignment; thus, *Uta stansburiana* from south-central Nevada should, based on its geographic location, belong to the subspecies *stejnegeri*. We have seen over two hundred specimens from the test site and have checked the basic diagnostic (key) characters for the three subspecies (*stansburiana, stejnegeri,* and *hesperis*) occurring in this general area (southern Nevada and east-central California.) On the basis of specimens available to us from Arizona, California, Nevada and Utah, we have concluded that *stejnegeri* is a Chihuahua Desert form, and should be deleted from the Great Basin herpetofauna. The data available from the test site and southeastern Nevada and western Arizona has caused us to wonder if any population of *Uta stansburiana* west of the Colorado River should be referred to as *stejnegeri*.

Two characters have been used by Smith (1946) to separate *stejnegeri* from *stansburiana*: (1) the presence of distinct dark-edged light dorso-lateral stripes in the adult females (*stejnegeri*) as opposed to no stripes or interrupted ones forming a series of elongate dorsolateral spots; and (2) dorsal scales 93 or less as opposed to 94 or more in *stansburiana*. The first character is reliable only if adult or near adult females are used, since most young of both subspecies have the stripes. The adult females from the test site have the same dorsal pattern as observed in specimens from central Utah, with less than 20 percent having dorsolateral lines. The second character cannot be used in this series. A majority of the specimens (60 percent) have more than 93 dorsals. A separation based on this character for these subspecies is not realistic. A summary of the data for the test site specimens and a series from Utah near the type locality can be seen in Table 4.

The abundance of this species on the test site has permitted us to observe other important aspects of its biology. These data provide information on longevity, growth, seasonal activities and population density.

Seasonal Fluctuations

Seasonal activity is evident throughout the year although it is perhaps most intense during the spring and early summer (Allred *et al.*, 1963). At this time adults as well as the juveniles are abroad and can be trapped or observed. The analyses of data from a grid study (Fig. 1) suggest a year around activity for the adults but this does not mean that all adults are active every day. The increased numbers evident during the spring are due to the influx of hatchlings from the preceding summer (Table 5).

With the exception of the second period of October, the numbers of adult females remained relatively constant throughout the year. Adult males are most abundant during the late winter and spring months, and least apparent from June to September. Tinkle (1961) concluded that the seasonal activity differences as reflected in the sex ratios were a result of activity and biased samples. Although seasonal activity certainly may have influenced the sex ratio differences observed at the test site they are considered at least indicative. They were determined by the proportional index method of recaptures rather than on the collected samples.

Tinkle (1961) observed seasonal variations between relative numbers of adults and juveniles. He states, "The most significant point in these data is the indication that regardless of the relative percentages of adults and juveniles at any other season, almost all lizards . . . are mature in April-June, and the majority by January-March. These data demonstrate that most lizards are potentially reproductive at the age of 10-12 months." Similar observations were made at the Nevada Test Site, although adult size was less frequently observed during the first summer's growth of hatchlings.

Table 4. Scale and color variations between *Uta stansburiana* from the Nevada Test Site and a series from Central Utah near the type locality (Juab, Tooele and Utah Counties).

Characteristics	Sex	No.	*Uta* from Central Utah	No.	*Uta* from Nev. Test Site
Dorsals	♂	28	86(98.0)103	73	87(97.5)115
	♀	40	86(95.0)105	78	88(96.0)105
Ventrals	♂	28	52(59.0)64	56	53(57.1)65
	♀	38	51(60.0)65	66	51(56.9)60
Femoral Pores	♂	29	12(14.1)16	54	12(13.9)16
	♀	39	12(13.8)17	67	12(13.6)16
Supralabials	♂	29	4(5.2)6	53	4(4.1)5
	♀	40	5(5.4)7	45	4(4.0)5
Infralabial	♂	29	7(8.2)10	54	5(6.0)7
	♀	40	6(8.1)10	67	5(6.1)7
Percent of ♀ with Dorsolateral Stripes		5 of 77	6.50	10 of 80	24.39

TABLE 5. Seasonal distribution and density of *Cnemidophorus tigris* and *Uta stansburiana* expressed as estimated numbers present[1] in a grid.[2]

Month and period[3]		*Cnemidophorus tigris*				*Uta stansburiana*				Density: animals per acre	
		Males	Females	Adults	Juv.	Males	Females	Adults	Juv.	Adults	Juv.
June	2	24.1[4]	10.3	34.5	3.2	8.2	5.5	13.6	17.7	3.3	5.0
July	1	4.5	4.5	9.0	5.4	2.9	6.0	8.1	109.7	2.0	30.9
	2	2.0	2.5	4.5	2.7	1.9	3.3	5.2	71.0	1.3	20.0
August	1	.9	1.8	2.7	10.7	4.4	6.1	10.5	29.2	2.6	8.2
	2	1.3	2.3	3.6	14.4	3.7	5.1	8.8	24.2	2.1	6.8
September	1				5.3				32.4		9.1
	2				7.7				24.6		6.9
October	1	0	0	0	0	5.7	5.5	11.3	21.9	2.7	6.2
	2	0	0	0	0	9.6	9.2	18.8	26.6	4.6	7.5
November	1	0	0	0	0	6.3	6.5	12.8	33.6	3.1	9.5
	2	0	0	0	0				11.0		3.1
December	1	0	0	0	0						
	2	0	0	0	0						
January	1	0	0	0	0	9.1	5.1	14.3	7.5	3.5	2.1
	2	0	0	0	0						
February	1	0	0	0	0						
	2	0	0	0	0	9.6	3.2	12.8	5.2	3.1	1.5
March	1	0	0	0	0				6.5		1.8
	2	0	0	0	0						
April	1	0	0	0	0				1.9		.5
	2	47.9	7.8	55.7	.8	9.8	5.8	15.6	.9	3.8	.2
May	1	35.0	12.3	47.2	1.7						
	2	29.3	10.3	39.6	1.4	10.9	4.3	15.2		3.7	
June	1	36.3	15.6	51.9	4.0	6.0	4.0	10.0		2.4	

[1]Where blanks occur, insufficient numbers were captured or recaptured to make reliable estimates.
[2]Method of determination follows Hayne (1949).
[3]Each month was studied for 2 periods of 15 days each.
[4]Each value is rounded to the nearest tenth.

POPULATION DENSITIES

Densities were computed by incorporating the recapture radii which were determined by Jorgensen and Tanner (1963). The recapture radii were: juveniles, 23.1 m.; adult females, 29.5 m.; and adult, 35.2 m.; (avg. for adults, 32.4 m.). Since the recapture center could be on the border of the grid, the sampling area would have to be extended by 32.4 m. on each side for the adults and 23.1 m. for the juveniles. This would increase the area sampled from 92 ares (2.3 acres) to 165.0 ares (4.1 acres) for the adults and 142 ares (3.6 acres) for juveniles. The densities are presented in Table 5.

SURVIVAL

A survival curve could not be determined from these data, but some pertinent data are available on the rate of survival from one season to another. A summary of these data are presented in Table 6. Tinkle (1961) stated that

TABLE 6. Percentage of population survival of *Uta stansburiana* at different seasons.

Marking period	Age and sex* marked	First summer	First winter
June-July	Juvenile	36.12	14.19
	Adult	74.07	51.85
Aug.-Sept.	Juvenile	78.94	34.21
	Juvenile	80.64	22.59
	Adult	80.00	50.00
	Adult	85.71	57.14

*No differentiation of the sexes was made during the first part of the study.

there was an annual turnover of most of the population studied in western Texas. This does not appear to be the case at the test site, where 51.85 percent of the animals, which were adults in June, 1961 (near 1 year old), survived to the following June (1962); thus, they were about two years old when last observed. One male marked as an adult on July 14, 1961 was recaptured by hand on April 13, 1963. This particular animal was known to be alive in the field for 34 months.

If the above percentage is near the actual yearly survival then one would expect in this area a greater number of adults than juveniles during the first half of each year. Only 14.19 percent (*e.g.* hatching from June to August) of the juveniles survive the same interval of time. We are aware of the greater activity of hatchlings and juveniles in late summer and fall; however, these data are based on survival percentages for a complete year.

A population increase was not observed in the data (Table 6). The reasons for a lack of population increase as the juveniles attain adult size is not clear. It may result from an apparent reduction in adult females, as seen in the sex ratios. Tinkle (1961) pointed out that the egg-laying habits of females reduced their activity and thus, their numbers would appear smaller. Similar habits were observed among the females at the test site and could very likely account for some of the apparent lack of inherent population increase. Although juveniles may and apparently do attain adulthood within one year, the complete population turnover takes at least two and may overlap into three years at the test site. A failure of some adults to survive a second breeding season (which was not examined at the test site) could also account in part for the apparent lack of population increase.

Growth Rate

The rate of growth and maturation time is an intricate factor in the population structure and necessarily requires consideration in the interpretation of population characteristics. Tinkle (1961) demonstrated through an examination of the reproductive organs (gonads) that 90 percent of this species matures within one year in western Texas. The results of his observations were confirmed in southern Nevada, using size (40 mm.) as the criterion for maturity (Fig. 6).

The most rapid growth occurs during the first summer and winter, after which the rate is reduced even though some growth is evident as late as the third summer (2 years of age). The growth during the first winter and second summer are comparable, indicating a lower rate of growth after May of the first spring.

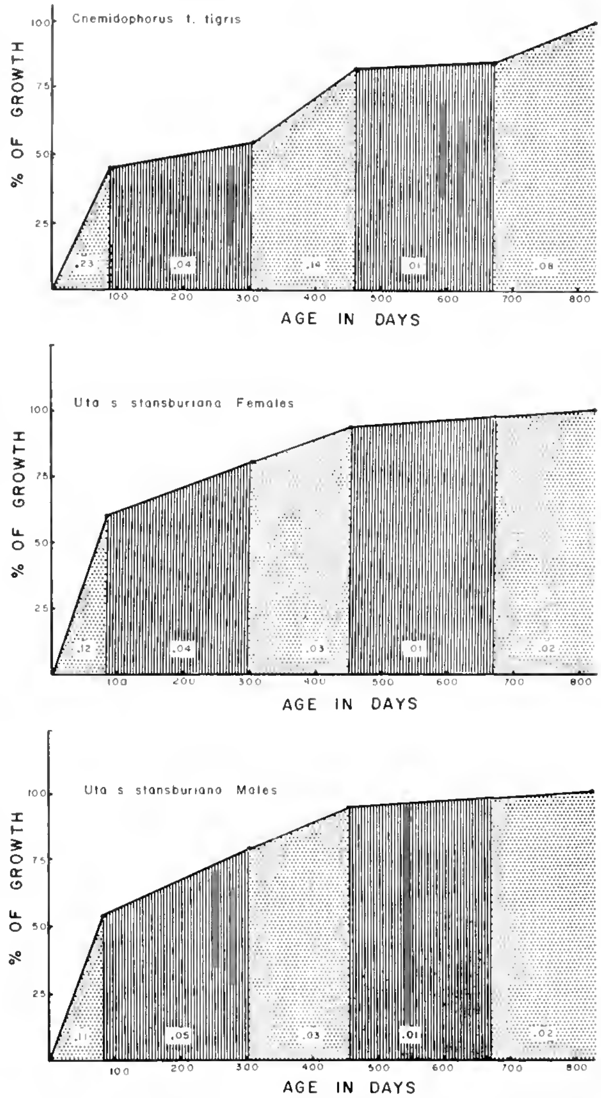

FIG. 6. Growth rates of *Cnemidophorus tigris* and *Uta stansburiana*. Stippling represents summer and lineation winter months. Actual rate for each season is inserted.

Phrynosoma platyrhinos platyrhinos Girard

Northern Desert Horned Lizard

Our considerations of this species are based on 36 specimens, all taken in the valleys and foothills of Frenchman, Jackass, and Yucca flats.

According to the most recent distribution maps (Reeve, 1952; Stebbins, 1954) the Nevada Test Site is in the range of *platyrhinos calidiarum*. Measurements and scalation counts do not support this taxonomic designation. The femoral pores range from 7-11 and thus overlap the counts of 8-8 for *calidiarum* and 11-12 for *platyrhinos* (Reeve, 1952). According to Reeve, the two rows of femoral pores are separated medially by six preanal scales. Test site specimens range from 3-6 preanal scales and are comparable to series from Tooele and Utah counties in Utah, which range from 2-6. The same range occurs for the supralabials, which range from 8 to 12. We have also been unable to confirm his ratio (45 percent or more) between the length of occipital spine and head length. Our measurements range from 23 (in hatchlings) to 45.9 percent. We are not certain as to the exact points of measurements of the spines. Reeve measured from "tip of spine to base of spine." The base is variable; a dorsal, ventral, or lateral measurement will or may provide different lengths for the same spine. To resolve this we have measured from the ventral base to the tip by firmly holding the points of a vernier caliper at the base and measuring out to the tip. By this method adults range from approximately 35 to 43 percent with only one exceeding 45 percent. A series from near the type locality of *platyrhinos* (Tooele and Utah counties) in Utah is similar in scalation to the specimens from the test site. The measurements of the occipital spine of the Utah specimens (31.52 to 39.02) overlap those of the test site (33.60 to 45.94) but average fewer 35.7, as compared to 40.03 for the adults from the test site. Nine young ones from the test site were not included in these measurements because they are much shorter (23 to 31) than in the adults. We are, therefore, assigning the Nevada Test Site horned lizards to *platyrhinos* rather than *calidiarum*.

Such a designation is not surprising or out of line with other species in south-central Nevada. As stated previously, the collecting areas are all within the Great Basin and thus represent a narrow southward extension between those populations to the southwest in Death Valley and to the east in the Colorado River drainage.

This species has been taken or observed in all of the plant communities except the Pinyon-Juniper. It is most abundant in Larrea-Franseria and Grayia-Lycium (Fig. 3). As with most lizard species occurring in the flats and on the low foothills, the horned lizard is perhaps most active during April and May but is abroad from March to September.

Xantusia vigilis vigilis Baird

DESERT NIGHT LIZARD

A series of 25 specimens came from a growth of Yucca just west of Mercury. This species appears to be limited to the Larrea-Franseria plant community where it is associated with *Yucca schidigera* (Fig. 5). In this ecological niche it may be very common, although difficult to extract from the Yucca. They are apparently active during most of the year. Although they are not associated with *Yucca brevifolia* at the test site, it is thought that with more extensive collecting this and perhaps other associations might be found.

Cnemidophorus tigris tigris Baird and Girard

GREAT BASIN WHIPTAIL

In the desert flats this is one of the most abundant lizards, exceeded only by *Uta* with which it shares a similar habitat. Its common name, Tessellated race runner, is most appropriate, and its speed and size is rivalled only by *Crotaphytus wislizeni* which also occurs sympatrically at the Nevada Test Site.

Our data are based on 113 preserved specimens and many marked lizards studied in the field. Large adults are 90 to 98 mm. in snout-vent and 300 to 332 mm. in total length. The longest specimen with a complete tail has a snout-vent length of 92.5 mm.; thus it is assumed that larger specimens (95 mm. or more) may have a total length up to 350 mm. Hatchlings have a snout-vent length of approximately 40 mm. and are mature at about 70 to 75 mm.

The scale formulae are not at variance with specimens from or near the type locality (Great Salt Lake Valley). However, our rather large series from a single population does provide a wide variation in most scale counts and particularly in the dorsals. We have summarized these as follows: scale rows around body, not including enlarged ventral rows, 70-99 (83.97); ventral rows usually eight, but with four having ten, and one nine; dorsals 137-185 (166.2) counting from parietal to first enlarged caudal row, this is a spread of 48 scale rows; ventrals 35-42 (38.2); femoral pores 17-25 (20.7) (see Fig. 7); supralabials 4-6, usually five, one with four and three with six; infralabials 4-7 (5.4); anals usually two, but four with three and seven with one.

This species was recorded from all plant communities except Pinyon-Juniper and was most abundant in Grayia-Lycium (Fig. 4).

SEASONAL FLUCTUATIONS

Allred *et al.* (1963) pointed out that the seasonal activity of *tigris* is most intense during the months of April, May and June, although it is abroad from April through October. This ob-

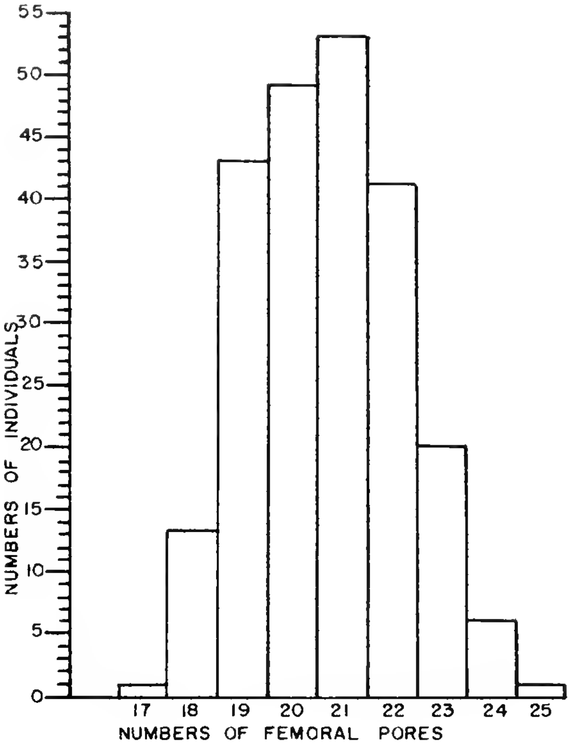

Fig. 7. A histogram showing the distribution of femoral pores in 113 *Cnemidophorus tigris* from the Nevada Test Site.

servation is in agreement with the results of the population analysis of the grid study (Table 5).

Caution must be used in the interpretation of these data since they are influenced considerably by activity. For example, animals are doubtless present during the colder months between October and April but are in a state of hibernation. Our data indicate that there is also a reduction in the number of active adults from July through August. Their presence is known from the fact that a large number of them reappear after the winter hibernation period, indicating a summer aestivation for adults.

The hatchlings first appeared near the end of July and continued to appear until the end of September, with an apparent peak during August. This agrees closely with Milstead (1957*a*) for *C. t. mormoratus* in western Texas. The juveniles present during April, May, June and most of July are hatchlings of the previous summer and will attain adult size (70 mm.) at about one year, since they are near the lower limits of adults in late spring.

Maslin (1962) found that specimens representing six species of *Cnemidophorus* (*tigris* not included) were virtually all females. This is not the case with *tigris* (Table 5). The males, although more active earlier in the spring became essentially equal in numbers with the females the latter part of June and remained so into August.

Population Densities

The problem of computing densities and an estimation of population size in this species are increased because a portion of the population is inactive at any given time. This is evident from an examination of the data presented in Table 5. The estimate for April is 55.70 adult animals, and since this is only 59 percent (see survival discussion) of those present during the preceding June, there must have been an additional 38 animals who were not active or escaped observation. If this is the case, approximately 94 animals were actually present during the first summer. This does not mean that all 94 were active at the same time, some may even have died during this first summer. It simply means that an accurate estimate of the population size from captures alone was not possible because there were always some which were not active. Although the species is active from early spring to early fall, the adults begin aestivating and/or hibernating in mid-August. From these data it is obvious that species activity is maintained by hatchlings which have appeared by this time and continue to be active until fall. The inactivity of the adults and subadults during August and September cannot be explained on the basis of average temperatures (Table 1). There appears to be adequate food, particularly during seasons when thunderstorms occur. In August 1961, 1.34 inches of precipitation occurred, producing considerable vegetative growth and an increase in insect food. This, however, did not produce an increase in adult activity. We surmise that activity is based on two physiological factors: first, the breeding season in the spring and early summer; and second, the completion of egg laying. The fact that growth in reproducing adults is greatly slowed provides for a rapid buildup of body tissues and lipids which may reduce the necessity for continued activity. This may actually be responsible for terminating the seasonal activity for adults.

The population density of active animals is obtained by dividing the values in Table 5 by the area sampled. This does not reveal the actual density, however, and consequently, the proceeding extrapolation from survival data was necessary. The computation of the area sampled is a problem which must be approached from an understanding of their home range. Jorgensen and Tanner (1963) computed the recapture radii for adult males, females, and juveniles to be 30.2, 40.4 (avg. 35.3), and 26.3 m., respectively. Since the recapture center may be on the border of the grid, the sampling area would have to be extended by 35.3 m. on each side for the adults and 26.3 m. for the juveniles. This would increase the area from 92 ares (2.3 acres) to 172.3 ares (4.3 acres) for the adults and 149.6 ares (3.7 acres) for the juveniles. Thus, the maximum population densities for the first summer were approximately .55/are (21.8/acre) for adults and juveniles combined. Densities for the second summer could not be computed because the survival rate could not be determined (approximated) for the third summer.

Survival

A survival curve could not be established because of the short duration of the study and lack of data on the mean life length, but the percentage of survival is available. Approximately 59 percent of the adults which were marked during June reappeared the next season. Only 29 percent and 17 percent of the adult females and males, respectively, that were marked during the late summer, survived to the next season. From this, it appears as though animals which aestivate early in the summer have a better chance of surviving from one season to the next. Similar observations were made for the juveniles; in this group 41 percent of the early spring juveniles survived to the next season, whereas 33 and 20 percent of the females and males, respectively, which were active during the late summer, reappeared the next season. The early spring juveniles were hatchlings from the previous summer and probably should not be compared with the late summer juveniles.

These figures for survival are difficult to explain when the data presented in Table 5 are considered. For instance, if 59 percent of the adults survive from one season to the next, one would expect fewer animals in the spring than the preceding summer. This is not borne out in the table which shows more in the spring. Several factors may contribute to this apparent discrepancy: (1) aestivation and inactivity of animals during the summer resulting in few captures and a low recapture rate, (2) hibernation during the winter months, and (3) an apparent maximum activity during the early spring months affecting an apparent increase in the population size. All of these simply alter the number of animals observed without necessarily affecting the actual number present in the area at any prescribed time.

Milstead (1957*b*) stated in his discussion of reproduction of four species of *Cnemidophorus*, in which *tigris* was included, that ". . . a population of whiptails during any given summer year are the young of the preceding year. What happens to the adults over the winter is a question that is not easily answered." The lizards at the test site behaved differently since at least 59 per cent of the adults survived to the next season.

Growth Rate

The rate of growth actually determines the time necessary to reach maturity and will to some extent affect the population structure. Milstead (1957*b*) states that maturity was reached in one year while Tinkle (1961) concluded that 2 to 3 years was necessary before reaching maturity. Although we have arbitrarily determined maturity, it was considered safe to assume that animals equal to or greater than 70 mm. were adult. Two lizards failed to grow during the year they were observed and were excluded from these data since they were both slightly below 70 mm. It is possible that young breeding adults may be less than 70 mm.

The growing rate is illustrated in Figure 6. From this it may be observed that adult size is not attained until the latter part of the second summer season. Thus, maturity would more likely take from 2 to 3 years, and reproduction would probably not occur until the second summer following the season in which they were hatched. The rate of growth is greatest during the first, second, and third summers, respectively. Virtually no growth is evident during the winter months.

Eumeces skiltonianus utahensis Tanner

Great Basin Skink

One adult female and five recent hatchlings are available. All were taken from Rainier Mesa west of Yucca Flat in a Pinyon-Juniper plant community (Fig. 2).

The hatchlings range in snout-vent length from 27.0 to 33.4 mm. and have the color pattern of *utahensis*. There is more blue in the dorsolateral stripes than observed in hatchlings from Utah. Actually the blue appears to be an extension from the tail and becomes progressively less apparent in the stripes from posterior to anterior. In the adult the dorsolateral stripes occupy more of the second row than in the young. This is normal for the subspecies as we have observed it in populations further north in both Nevada and Utah.

Scalation patterns are normal; however, the supralabials average 7.5 for the series which is lower than the average for the subspecies (Tanner, 1957). The dates of capture for the hatchlings (Aug. 11-21) are well within those dates established by Tanner (1957) for this subspecies in similar habitats in Utah.

SERPENTS

The snake populations of the Nevada Test Site consist of at least fifteen species. Some species examined by us are represented by large series while others are known by single specimens.

Although the present study is concerned with those snakes taken on the Nevada Test Site, it is seemingly necessary to discuss them in the light of their relationship to other adjoining populations. Two species (*Tantilla utahensis* and *Arizona e. candida*) represent new records for the state of Nevada; some species help in the clarification of distribution, and others provide scale and color pattern variations which contribute significantly to our understanding of the species. For these reasons certain species will receive more attention than others.

With the exception of *Chionactis occipitalis*, the snakes were too infrequently collected or observed to reliably associate them with plant communities or to establish seasonal variations. In more instances the distribution of specimens ranged over a wide variety of plant communities when several of one species were collected, thus indicating that generally they may not have a community preference as is the case with many species of other vertebrates (Fig. 8, 9, and 10).

Masticophis flagellum piceus Cope

Red Racer

A series of 14 specimens is available for study. They were collected in or along the low rocky foothills of Frenchman and Yucca flats. There are no noticeable variations in the scale patterns when compared with a series from adjoining areas in Nevada and Utah. The red phase color pattern of the test site specimens has been used locally to designate this species as the "Red Racer."

Masticophis taeniatus taeniatus Hallowell

Desert Striped Whipsnake

This is one of our most wide spread Great Basin species, occurring in large numbers throughout most of its range. In spite of its abundance, it is not seen as often as one might expect because of its speed and wariness. Three specimens from the test site are available for study. This small number should not be considered as an indicator of their scarcity in the test site but undoubtedly reflects the lack of collecting on the rocky hillside habitats. Although the ecological ranges of *flagellum* and *taeniatus* are adjacent and thus provide for some overlapping, they appear to inhabit different habitats and are not, therefore, normally competing with one another.

Salvadora hexalepis mojavensis Bogert

Mohave Patch-Nosed Snake

Ten specimens are available for study. This series, though small by most standards, is a larger series than is usually available for this species from a localized area.

The scale patterns are similar to those of a series from southwestern Utah and represent a similar if not the same general population. A comparison of the ventral and caudal averages in this series with a series of 11 from Utah (placed in bracks)is as follows: ventrals ♂ 198.6 (197.5), ♀ 200.00 (197.6); caudals ♂ 91.7 (90.3), ♀ 84.3 (81.2). Other scale and color patterns are similar in both series.

The test site is near if not at the northern limits for this species in south-central and southeastern Nevada. A specimen from Hiko (B.Y.U. 18047) about 40 miles northeast of the test site represents perhaps the most northern record for Nevada. This species occurs widely throughout the area and has been taken primarily on the upper, usually rocky edges of the valleys and bajadas.

Phyllorhynchus decurtatus perkinsi Klauber

Western Leaf-Nosed Snake

Based on the report of Klauber (1935) this is the first record of this species for Nye County and extends its range in Nevada nearly 100 miles northwest. All specimens (B.Y.U. 17924-5, 17758-9) were taken in Frenchman Flat.

The three males are uniform in scale patterns, and although the ventrals (169) are lower than the average as indicated by Klauber (1940*a*:207) for western and northern specimens, they are within the established limits of 168-182. The single female has 182 ventrals which is also lower than the average (187.7) set by Klauber.

The dorsal pattern consists of a row of large spots separated by the light area longer than

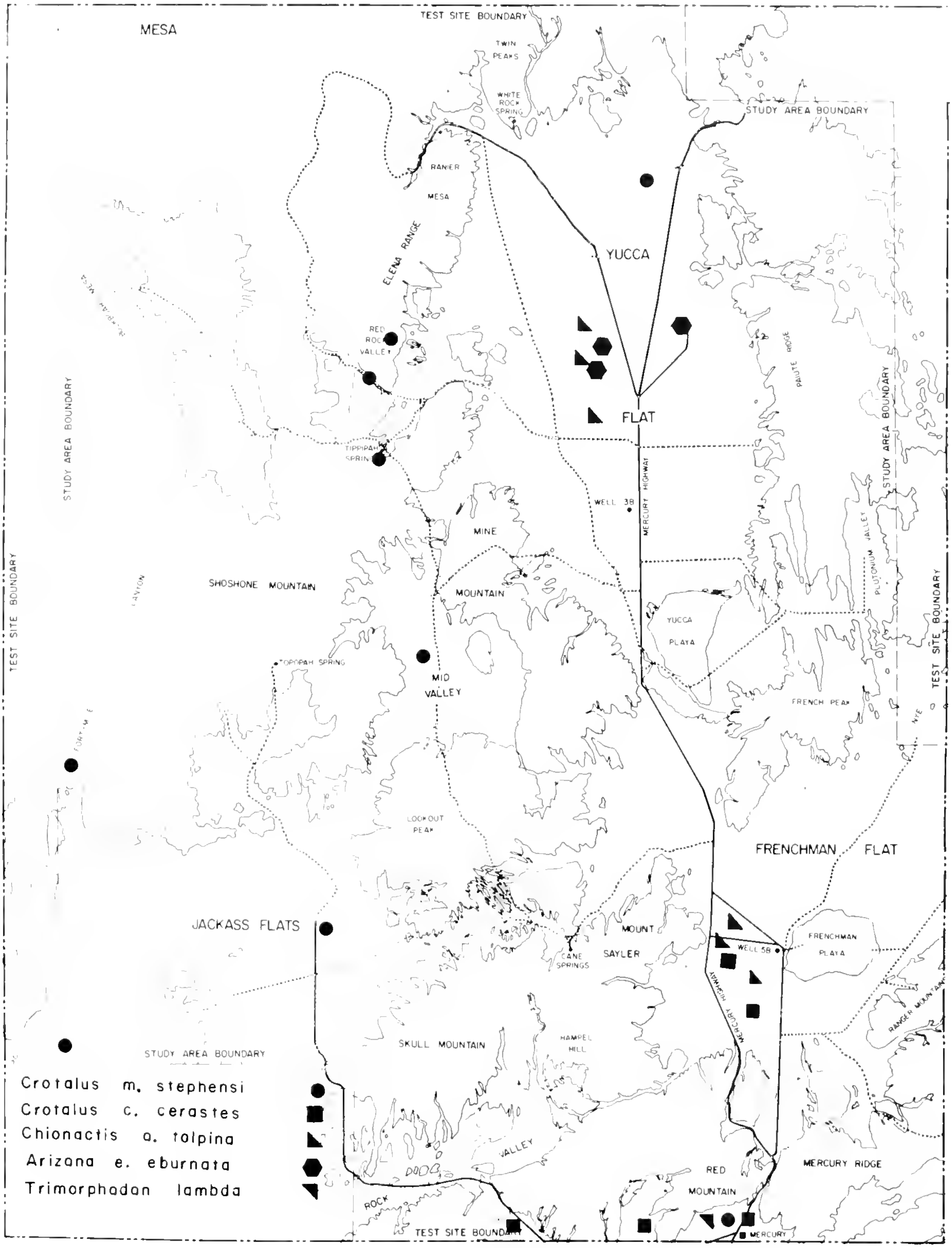

Fig. 8. Collection and observation sites of *Crotalus mitchelli, Crotalus cerastes, Chionactis occipitalis, Arizona elegans,* and *Trimorphodon lambda.*

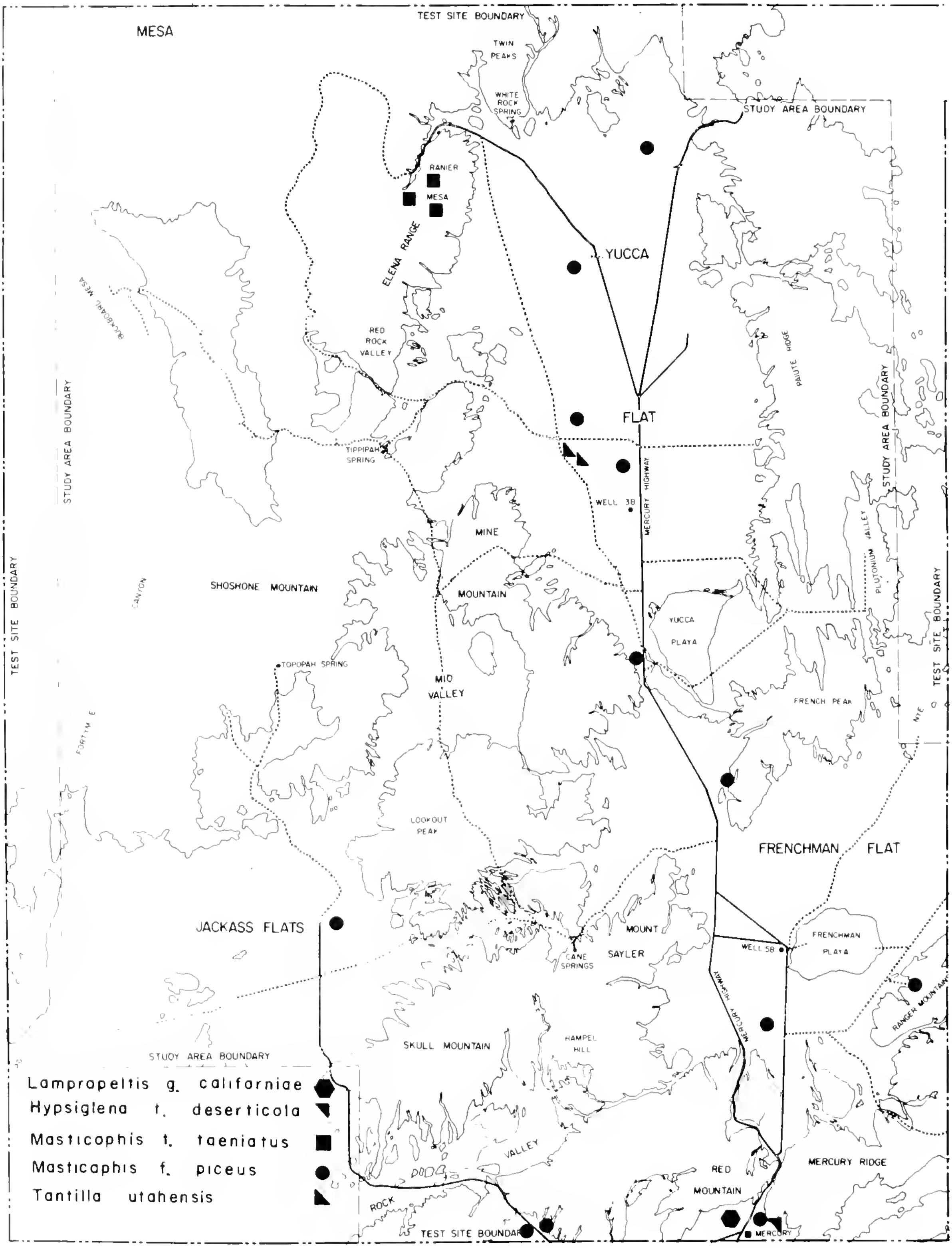

FIG. 9. Collection and observation sites of *Lampropeltis getulus*, *Hypsiglena torquata*, *Masticophis taeniatus*, *Masticophis flagellum*, and *Tantilla utahensis*.

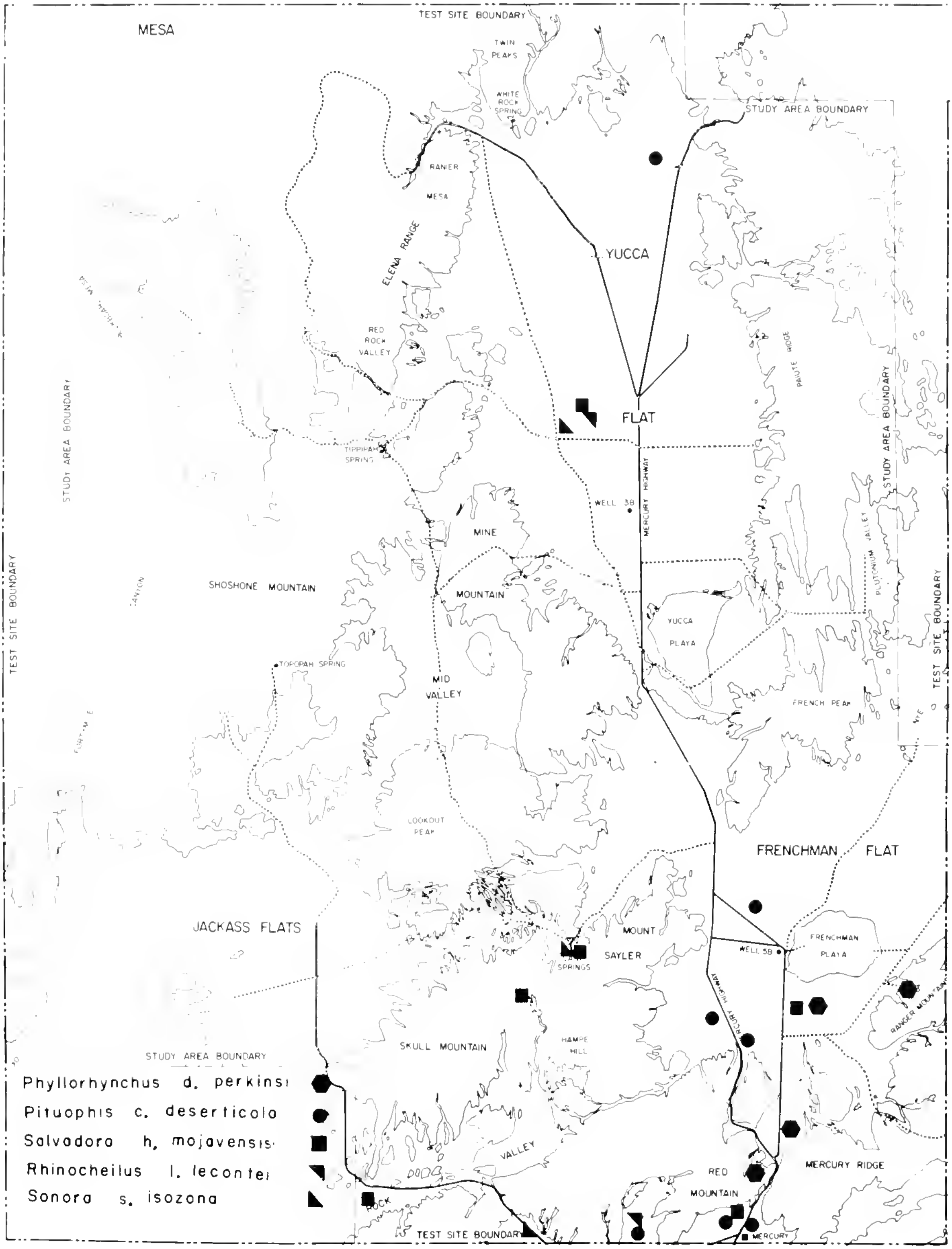

Fig. 10. Collection and observation sites of *Phyllorhynchus decurtatus, Pituophis catenifer, Salvadora hexalepis, Rhinocheilus lecontei,* and *Sonora semiannulata.*

the length of each spot. The female has 49 and the three males are 40, 44, and 45 (avg. 42.3).

With so few specimens available we can only suggest that the northern populations have fewer scales (ventrals and caudals) and a greater number of dorsal spots than most specimens seen by Klauber (1935, 1940*a*). The ventrals are near the lower limits (♂ 168, ♀ 181), with the total dorsal spots (body and tail) more than the average set by Klauber (1935) at 34.8 and 7.9, respectively. We are perhaps now seeing a cline which for lack of specimens from the northern limits was not previously possible. There is reason to suspect that these snakes, because of their burrowing habits, do not move far in a lifetime. If this is true, then many populations occurring in small desert basins such as Frenchman and Yucca flats may interbreed little with adjoining basin populations. Such reasoning would explain the lack of uniformity in the scale and color patterns of this species in southern Nevada.

Arizona elegans candida Klauber

Western Mojave Glossy Snake

According to Klauber (1946) *Arizona elegans* in south-central Nevada belongs to the subspecies *eburnata*. Few specimens have been examined in previous studies and only seven specimens are available to us from the test site. Klauber places the limits for the ventrals of *eburnata* at ♂ 208-228 and ♀ 220-241. This is well above the test site specimens which range from ♂ 206-218, and ♀ 212-222, respectively. In neither sex do the ventrals approach the averages listed by Klauber (219.5 for males; 231.2 for females) for *eburnata*. The counts for the test site specimens are nearer to those given for *candida*, (♂ 208-220, ♀ 220-232), but again are lower than the listed averages.

The dorsal spots are either larger or more widely separated (occasionally both) than in the paratypic series of *eburnata*, 58-82 (68.41) and *candida* 55-73 (62.91). The test site specimens are 56-63 (59.2). Equally significant in the color pattern is the width of the dorsal spots. Some spots are only eight or nine scale rows, but usually the dorsal spots extend for 9 to 12 scale rows across the back. The two lateral rows of spots alternate with each other and with the dorsal row. In juvenile and subadult specimens, the lateral suffusion of pigment is not present and in adults it is reduced. This produces a very distinct spotting not seen in adult *eburnata*. In adults the dorsal interspaces between the spots become light colored producing a distinct light and dark dorsal spotting. One specimen (B.Y.U. 21215) has the following colors as determined by the Ridgeway Color Standards: background an olive buff with a faint yellowish-orange along the margins of the scales becoming light orange yellow to orange buff on the skin between the scales. The dorsal and lateral spots are light yellowish-olive with darker brown spots on the margins.

Unfortunately a large series of comparative *candida* and California *eburnata* are not available, but those at hand substantiate the relationship of the test site material to *candida*. The occurrence of this subspecies in western and south-central Nevada greatly extends the range of *candida* to the northeast and suggests that the distribution of *eburnata* in Nevada be restricted to the Las Vegas and Virgin River valleys.

Pituophis catenifer deserticola Stejneger

Great Basin Gopher Snake

Ten specimens are relatively uniform in scalation. They follow the general pattern of the large series from the Great Basin at Brigham Young University (Tanner, 1939), namely that there is clinal increase in ventral and dorsal rows from north to south. In Utah except for specimens from the south (Washington County) most ventral counts are less than 240 scales, and the dorsals are usually in 29 or 31 rows. The test site specimens all have more than 240 ventrals (avg. 246.2) and 33 to 35 dorsals. In this they reflect the clinal increase from central Nevada and Utah (where there are usually less than 240 ventrals and 31 or less dorsals) to southern Utah (where ventrals are more than 240 and dorsals are 29 to 33).

Lampropeltis getulus californiae Blainville

California Kingsnake

Two female specimens of the banded phase were collected. Both are similar to others of this color phase seen from Utah and California. In scalation they are also much the same except for the ventrals which are well above average with 253 scutes in each specimen.

Rhinocheilus lecontei lecontei Baird and Girard

Western Long-Nosed Snake

Six specimens in our collection and five additional live ones from the test site have been examined. Four specimens have the color characteristics defined by Klauber (1941) for the subspecies *lecontei*, four are typical *clarus*, and three intermediate. The scalation characters are similar to a series (13 specimens) from southern and western Utah.

The principle characters used by Klauber for separating *clarus* from *lecontei* are the fewer and larger dorsal spots or bands; and the nearly if not complete absence of pigment in the light areas between the spots. Using these criteria we would have, in the 24 specimens examined from Nevada and Utah, six *clarus* (B.Y.U. 2879, 3 mi. S Bunkerville, Clark Co., Nevada; B.Y.U. 18761 and three live ones, NTS N of Mercury, Nye Co., Nevada; and U. of U. 2027, St. George, Washington Co., Utah). The first of these has 24 body spots, three have 23, and one each has 22 and 21. A specimen (B.Y.U. 2863) from White Valley, Millard Co., Utah has 25 spots, and other specimens from Utah and Nevada range up to 32 with an average of approximately 29. There is not a clear break in the numbers of spots or in the percentage of pigmentation between the spots, suggesting to us a variation within a subspecies rather than two widespread overlapping subspecies. Both specimens from St. George and Bunkerville (*clarus*) have much red associated with the spots and the interspaces; three from the test site are juveniles with only a trace of reddish-orange. Several juveniles have been noted alive from Utah, and they, too, have a reduction in the reddish color but lack the contrasting black and white bands. Concerning the diffused and stippled pigment in the light areas between the black spots we find this to vary from almost none to considerable amounts in the Bunkerville specimen and those seen from the test site.

In spite of the fact that Klauber (1941) has listed the Bunkerville specimens as *clarus*, we fail to see it or other specimens from southern Nevada with a reduced number of spots as other than a color phase in the subspecies *lecontei*. There is ample evidence that such pattern dichromism (or perhaps polychromism) occurs in other species of snakes in southwestern United States. Klauber's study (1939) of the California king snake and Stickel's (1943) work with *Sonora* establishes ample proof of such phenomena. The data available may not as yet be decisive, requiring a study of hatchlings before a final decision on the validity of *clarus* is made. In the meantime we prefer to consider *clarus* a color phase of *lecontei*, inasmuch as subspecies are not ordinarily sympatric in the same geographical area. We realize that our series of eleven specimens from the Nevada Test Site is not large but believe it to be adequate inasmuch as the material is from one population and has a complete range from the *clarus* color phase to *lecontei*. We, therefore, recognize only *lecontei* in southern Nevada and Utah. Specimens were taken in Yucca Flat in the Grayia-Lycium plant community, and in Jackass Flats in a mixed community.

Sonora semiannulata isozona Cope

Great Basin Ground Snake

Six specimens are available from the test site. In scalation this series is similar to those available from Idaho, Nevada, and Utah. One male from the test site has 61 caudals, a count higher than previously reported for this species.

The color pattern in five is the usual bicolored phase, but the other specimen is a modification of the striped phase and is described as follows: four middorsal rows reddish-orange with flecks of gray, the gray becoming more predominant laterally; first three lateral rows and ventrals gray with the centers of the lateral scales a darker gray; head and nape gray. In life, this specimen had a reddish dorsal stripe extending from the nape onto the tail; laterally the red is replaced by the gray over a space of two or three scale rows. The replacement is uniform producing a blending between the dorsal and lateral colors.

A departure from the more standard bicolor phase to a modified striped phase or to plain gray or orange phases has been observed by us in specimens from Idaho, Nevada, California and from Chihuahua, Mexico. Although the color phase phenomenon is discussed elsewhere, it should be indicated that in this species we are not concerned with pattern dichromism but with pattern polychromism.

Chionactis occipitalis talpina Klauber

Nevada Shovel-Nosed Snake

By employing can traps in several of the valleys, we have secured 32 specimens from the test site. This is the largest series of a snake available to us from the Nevada Test Site.

The type locality for *talpina* is 50 miles south of Goldfield on the highway to Beatty, Nye County, Nevada. This locality is really closer to Beatty than Goldfield, being only approximately 15 miles north and is in the southeastern part of Sarcobatus Flat. In relationship to the test site the type locality is about 50 miles directly west of Yucca Flat.

Klauber (1951) based his description of *talpina* on three specimens (two males and one female) and used as his primary key character the presence of secondary bands (or pigmentation) in the interspaces between the primary bands. As secondary characters the primary bands were brown (rather than black) and the ventrals were increased (152 or more in males and 160 or more in females). The availability of the present large series may add to our understanding of this northern subspecies.

With only three specimens available, averages and pattern ranges were not possible at the time of its description. It is therefore, considered desirable to present these data now, based on the present series (32) and the three types. Comparative material used is taken from Klauber (1951) and from seven specimens in the B.Y.U. collection from California. These data are best set forth in Table 7.

In all characters except the pigmentation in the light interspaces, these two subspecies are essentially the same and do not vary sufficiently to warrant separation. However, the secondary banding is distinct enough to provide a key character useful in separating approximately 72 percent of the individuals of these subspecies. This is assuming that *occipitalis* has no pigmentation between the spots and that *talpina* does. On this basis 25 specimens of *talpina* have at least distinct lateral if not dorsal pigmentation in the interspaces, six have faint lateral spotting and four have none.

It is also possible that specimens taken in the type locality, Amargosa Desert, and west into California may show a greater differentiation, but based on the Nevada Test Site material, with the three types included, *talpina* must be considered to be strictly a color phase of *occipitalis.* We are permitting it to stand because the material from the Las Vegas area is *occipitalis* and may have an intergrading effect on the test site population, thus, limiting typical *talpina* to the areas of western Nye County, Esmeralda County, and immediate eastern California. This conforms to a recent study by Elvin (1963) which includes material from Western Nye County and Saline Valley, California.

This species was abundant in Grayia-Lycium and Larrea-Franseria plant communities from May through August.

Hypsiglena torquata deserticola Tanner

Desert Night Snake

A single specimen taken just east of Mercury is available from the test site. It is a typical specimen in both scalation and color pattern. This is to be expected inasmuch as this area is near the center of the geographical range of *deserticola.*

Trimorphodon lambda Cope

Sonora Lyre Snake

A single specimen was taken from near Mercury, Nye County. In all characters, except the ventrais, it is within the limits set up by Klauber (1940*b*). There are only 221 ventrals which is one less than observed previously for males. In this and other characters it is similar to southwestern Utah material. Klauber (1940*b*) refers to two Nevada specimens which have a contact on one side between the preocular and frontal; this characteristic is also true for our specimen.

This record extends the range for approximately 75 miles to the northwest and is a new record for Nye County.

Tantilla utahensis Blanchard

Utah Black-Headed Snake

Two specimens (B.Y.U. 17922-3) were collected in can traps on the western edge of Yucca Flat. Both are females and are within the scalation limits established for this species (Tanner and Banta, 1963). This record is important not only because it is the first reported for Nevada but also because it indicates a continuous range for *utahensis* from southwestern Utah across Nevada to the populations in California.

Table 7. Comparison of ventral and caudal scales and body spots in *Chionactis o. occipitalis* and *Chionactis o. talpina.*

	Subspecies			
	occipitalis		*talpina*	
	Male (3)	Female (4)	Male (19)	Female (15)
Ventrals	146(155.9)165	153(165.9)176	148(151.3)155*	157(160.6)164
Caudals	38(44.7)50	37(41.9)48	41(45.3)49	43(44.8)48
Body spots	25(31.2)40		24(31.2)39	

*Not including male paratype which is reported to have 162 ventrals.

Crotalus mitchelli stephensi Klauber

Panamint Rattlesnake

This moderate to medium-sized rattlesnake is widely distributed over the test site and ranges from the desert flats to the higher Pinyon-Juniper community. Fourteen specimens are available for study.

Perhaps this species provides a greater diversification in color and color patterns than any other snake discussed. *Crotalus m. stephensi* has a range in ground color from dark gray to a pinkish-tan. The spots also participate in the color variations, thus providing color and patterns which marks each adult specimen differently. The dorsal spots range in number from 32 to 40 on the body and from 3 to 7 on the tail. Each spot is edged with either a darker shade of grayish-black or reddish-tan, depending on the basic ground color, and has a lighter color in the center. There is a general trend for the dorsal series of spots to be longer anteriorly and wider posterity, with dark flecking between the spots, or it may be a uniform light gray or tan. Based on color patterns, this species shows greater variation than any other snake on the test site, except perhaps *Rhinocheilus*.

In scalation the variation is within the range limits established by Klauber (1930). The ranges for the test site series are as follows: ventrals, males 168-181, females 171-178; caudals, males 26-27, females 17-20; supralabials 13-16, and infralabials 12-16. In all specimens the supraoculars are sutured, indentated, and roughened as is characteristic for this subspecies. The largest male and female are 881 and 728 mm. total length, respectively.

Crotalus cerastes cerastes Hallowell

Mojave Desert Sidewinder

Specimens taken on or to the west of the test site seemingly represent the most northern population of *cerastes* in Nevada. A specimen (B.Y.U. 18786) taken 40 miles north of Beatty is the most northern; however, collecting has not been attempted or is restricted by security in the more northern valleys of the test site (Groom and Penoyer Valleys). Ten specimens are available from Frenchman Flat, Jackass Flats, and Mercury Valley. Only one female is represented in this series, thus providing variation data only for the males.

Several have more than 21 dorsal rows just behind the head, only one has as many as 24 rows at mid-body. The ventrals range from 138 to 142 (avg. 139.7) in the males and 146 in the single female. Caudals range from 22 to 25 (avg. 23.1) in males and the female has 18. In other scale formulae there is nearly complete uniformity.

A comparison of the males to those listed by Klauber (1944) for the Mojave Desert series suggests that the Nevada populations have on the average a higher ventral count. Seventy-eight specimens averaged 136.9, approximately three scales less than the test site series. In the caudals there is also an average increase of one scale. In neither ventrals nor caudals are the range limits exceeded. This is a reflection of the small area covered and perhaps of the uniformity among the snakes of this local population.

PROBABLE SPECIES

At least three other reptile species may occur at the test site: the Great Basin Sagebrush Lizard (*Sceloporus graciosus*), the worm snake (*Leptotyphlops humilis*), and the Great Basin rattlesnake (*Crotalus viridis*). The worm-snake has been collected in Clark County (Boulder Dam environs, Klauber, 1940*c*; Indian Springs, La Rivers, 1942) to the southeast and at Ash Meadows, Nye County (Banta, 1953), to the southwest. The two specimens from Indian Springs were determined by Klauber to be *L. h. utahensis*. This species is difficult to locate, but if present would probably be in the rocky foothill areas surrounding the lower valleys.

Although not as yet collected at the test site, the Great Basin rattlesnake (*Crotalus viridis lutosus* Klauber) is probably present on the higher mesas. This species is frequently collected from similar plant communities (Pinyon-Juniper) in the Great Basin Desert. It has been taken from several locations in Nye County north of the test site in much the same habitat as occurs at Rainier Mesa, west of Yucca Flat.

The distribution maps presented by Smith (1946) and Stebbins (1954) include the test site within the range of *Sceloporus g. graciosus*.

From a review of the known distribution and habitat occurrences, it is presumed that the three doubtful species are present at the test site but have been missed by our limited collecting in their more specific habitats. The habitat of *Crotalus viridis lutosus* is essentially the same as for *graciosus*, and it is expected that both would occur in the same plant communities.

During three years of study (1960-62) not a single amphibian has been recorded. One might have expected to find the Great Basin spadefoot; however, it has not been seen at the few permanent springs or after the infrequent thunderstorms.

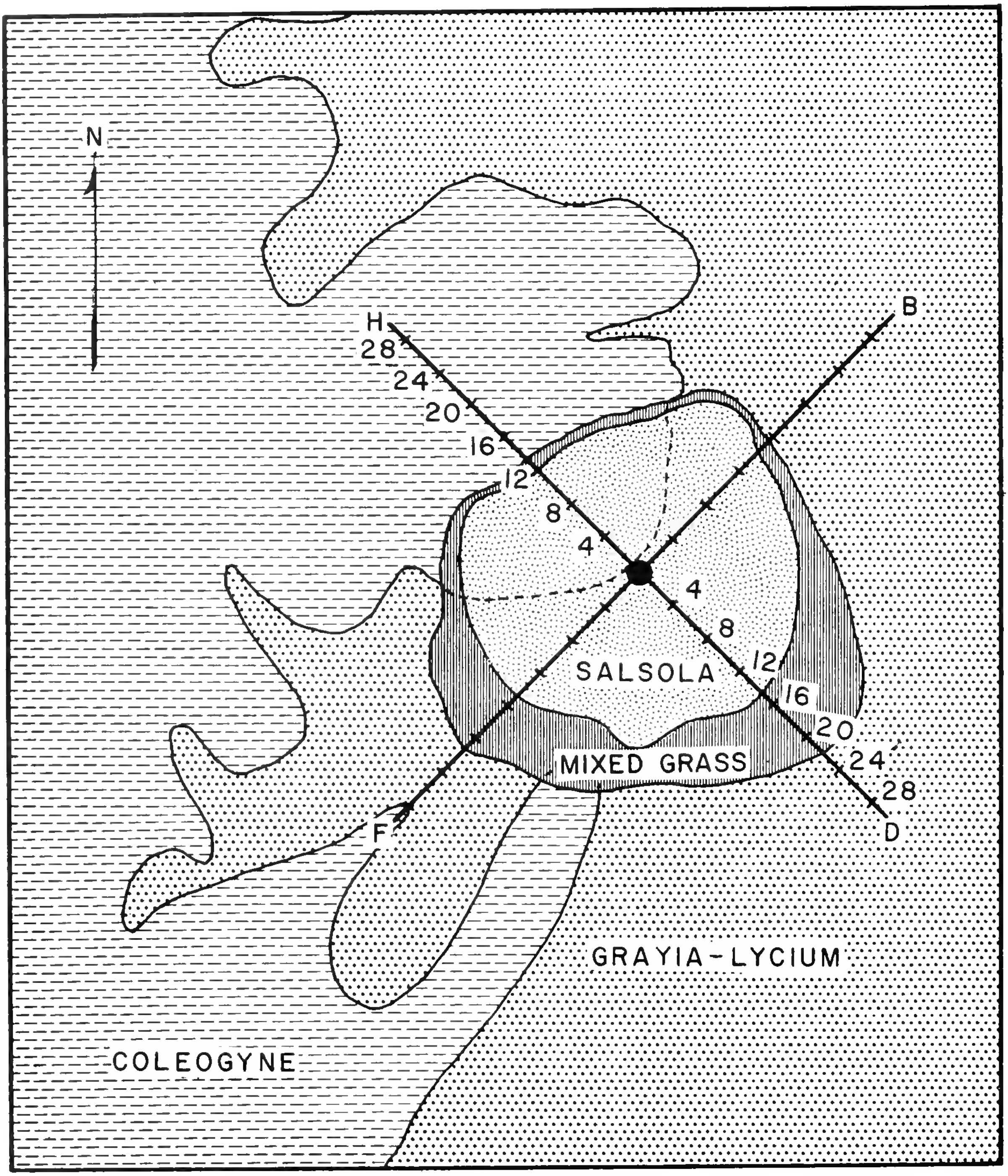

FIG. 11 Vegetation zones around a disturbed ground zero, trapping design indicated by four transects B, D, F, and H. Mixed grass is composed primarily of *Stipa speciosa*, *Oryzopsis hymenoides*, *Sitanion hanseni*, and *Hilaria jamesi;* composition of other communities was discussed previously.

EFFECTS OF A NUCLEAR DETONATION

An objective of the ecological studies at the Nevada Test Site is to determine how animal populations are affected by nuclear weapons tests. Ground zeros (center points of nuclear detonations) scattered throughout the test site have resulted in varying types of disturbance to the native biota. Generally, the area immediately surrounding each ground zero has been denuded of its original vegetation and probably was initially stripped of most animals. The degree of disturbance naturally decreases as the radius extends from ground zero outward and the size of nuclear devices decreases.

The effects of this type of disturbance are apparent on reptiles near ground zero, but the effects at greater distances are not nearly as evident. These are generally in areas where disturbance resulted in scattered fires, seismism, and damaged but not killed vegetation, and radioactive fallout. Also, an important factor in evaluating the total effects of disturbance is the rate and extent to which endogenous species reinvade the disturbed area after being forced out. Subsequent to the original disturbance and after many years, the biota will re-establish itself through a series of successional stages. Although primary plant invaders quickly establish themselves (Shields and Wells, 1962), it will require many years in this desert area before the endemic shrubby vegetation is again established. When pioneer plant invaders and subsequent developmental stages occupy the area, they provide cover and food for certain associated animals which invade the disturbed area at the same time.

One representative ground zero was selected for study, and the effects of a nuclear detonation on reptiles are inferred from this single example. Four detonations have occurred at this particular site. The last was in September 1957, two years before the Brigham Young University study began. The trapping design, as described by White and Allred (1961, Fig. 1), consisted of sunken can traps at 264 ft. distances along each of the four transects radiating outward 7,920 ft. from ground zero. This design resulted in 30 stations along each transect (Fig. 11). These traps were serviced periodically (usually 3 times per week) and the kinds and numbers of lizards collected at each station recorded. From these data relative numbers were determined which were used to evaluate the total effect which nuclear detonations had on the distribution of lizards.

The distribution of lizards within the various disturbance zones is considered only for *Uta stansburiana* and *Cnemidophorus tigris* which were collected in sufficient numbers to evaluate their response to nuclear disturbance.

Cnemidophorus tigris was distributed throughout the disturbed area, except for the immediate vicinity of ground zero. This area was characterized by an asphalt pad around ground zero extending out to station three (Fig. 11), followed by an area out to about station four which was excessively disturbed by grading after the detonation. *Uta stansburiana* was distributed essentially evenly from station 10 outward. The reason for its apparent absence closer to ground zero is unknown inasmuch as it was abundant within the limits of the initial denuding that resulted from the test (Fig. 11). The distributions of these two species apparently were affected by the detonation. Factors that may have influenced this are lack of food and suitable habitat. Perhaps appropriate food has not followed the pioneer plants into the disturbed area or the vegetation did not offer a suitable cover. It was not possible to evaluate the effects of the initial or residual radiation, inasmuch as the time lapse of three years since detonation has permitted the original intensity to decay to low levels.

LITERATURE CITED

Allred, Dorald M., D Elden Beck, and Clive D. Jorgensen. 1963. Biotic communities of the Nevada Test Site. Brigham Young Univ. Sci. Bull. 2(2):1-53.

Baird, S. F. and Charles Girard. 1852. Reptiles. Appendix C. in: Stansbury, Howard. An expedition to the valley of the Great Salt Lake of Utah: including a description of its geography, natural history, and minerals, and an analysis of its waters, with an authentic account of the Mormon settlement. Philadelphia: Lippincott, Grambo, and Co., pp. 336-353, 6 pls.

Banta, Benjamin H. 1953. Some herpetological notes from southern Nevada. Herpetologica 9:75-76.

——— 1960. Notes on the feeding of the western collared lizard, *Crotaphytus collaris baileyi* Stejneger. Wasmann Jour. Biol. 18(2):309-311.

———. 1963. Preliminary remarks upon the zoogeography of the lizards inhabiting the Great Basin of the western United States. Wasmann Jour. of Biology, 20(2):253-287.

BENTLEY, GEORGIA H. 1919. Reptiles collected in the vicinity of Currant, Nye County, Nevada. Copeia, 75:87-91.

BOGERT, CHARLES M. 1948. Thermoregulation in reptiles, a factor in evolution. Evolution, 3(3):195-211.

COPE, E. D. 1900. The corcodiliams, lizards and snakes of North America. Rept. U. S. National Museum for 1898, pp. 153-1270.

COWLES, RAYMOND B., AND CHARLES M. BOGERT. 1944. A preliminary study of the thermal requirements of desert reptiles. Bull. Amer. Mus. Nat. Hist., 82:265-296.

ELVIN, DAVID W. 1963. Variation and distribution of the shovel-nosed snake (*Chionactis occipitalis*) in the Northern Mojave Desert, California and Nevada. Herpetologica 19:73-76.

FITCH, HENRY S. 1949. Outline for ecological life history studies of reptiles. Ecology, 30(4):520-532.

——— AND WILMER W. TANNER. 1951. Remarks concerning the systematics of the Collared Lizard, *Crotaphytus collaris*, with a description of a new subspecies. Trans. Kans. Acad. Sci. 54(4):548-559.

HAYNE, DON W. 1949. Two methods for estimating population from trapping records. Jour. Mammal. 30(4):399-411.

JORGENSEN, CLIVE D. 1963. Spacial and time distribution of *Dipodomys microps occidentalis* Hall and Dale within distinct plant communities. Ecology 44:183-187.

JORGENSEN, CLIVE D. AND ARNOLD M. ORTON. 1962. Note of lizards feeding on oatmeal bait. Herpetologica 17(4):278.

JORGENSEN, CLIVE D. AND WILMER W. TANNER. 1963. The application of density probability function to determine the home range of *Uta stansburiana stansburiana* and *Cnemidophorus tigris tigris*. Herpetologica 19(2):105-15.

JORGENSEN, CLIVE D., ARNOLD M. ORTON, AND WILMER W. TANNER. 1963. Voice of the leopard lizard *Crotaphytus wislizeni* Baird and Girard, Proc. Utah Acad. Sci., Arts, and Letters. 40(1): 115-16.

KLAUBER, LAURENCE M. 1930. New and renamed subspecies of *Crotalus confluentus* Say, with remarks on related species. San Diego Soc. of Nat. Hist., 6(3):95-144.

———. 1932. Amphibians and reptiles observed enroute of Hoover Dam. Copeia, 1932:118-128.

———. 1935. *Phylorhynchus*, the leaf-nosed snake. Bull. of the Zool. Soc. of San Diego, No. 12:5-31.

———. 1939. A further study of pattern dimorphism in the California King Snake. San Diego Zool. Soc. No. 15:3-23.

———. 1940*a*. Two new subspecies of *Phyllorhynchus*, the leaf-nosed snake, with notes on the genus. Trans. San Diego So. of Nat. Hist., 9(20): 195-214.

———. 1940*b*. The Lyre snakes (Genus *Trimorphodon*) of the United States. Trans. of the San Diego Soc. of Nat. Hist., 9(19):163-164.

———. 1940*c*. The worm snakes of the genus *Leptothyhlops* in the United States and northern Mexico. Trans. San Diego Soc. of Nat. Hist., 9(18): 87-162.

———. 1941. The long-nosed snakes of the genus *Rhinocheilus*. Trans., San Diego Soc., of Nat Hist., 9(29):163-194, pl. 7.

———. 1944. The sidewinder, *Crotalus cerastes*, with description of a new subspecies. Trans. San Diego Soc. of Nat. Hist. 19(8):91-126, 2 pls.

———. 1945. The geckos of the genus *Coleonyx* with description of a new subspecies. Trans. San Diego Soc. of Nat. Hist., 10(11):133-216.

———. 1946. The glossy snake, *Arizona*, with descriptions of new subspecies. Trans. San Diego Soc. of Nat. Hist., 10(17):311-398, pls. 7-8.

———. 1951. The shovel-nosed snake, *Chionactis*, with descriptions of two new subspecies. Trans. San Diego Soc. of Nat. Hist. 11(9):141-204, pls. 9-10.

LA RIVERS, IRA. 1942. Some new amphibian and reptile records for Nevada. Jour. Entomol. and Zool., 34(3):53-68.

LINSDALE, J. M. 1940. Amphibians and reptiles in Nevada. Proc. Amer. Acad. of Arts and Sci. 73:197-257.

MASLIN, T. PAUL. 1962. All-female species of the lizard genus *Cnemidophorus*, Teiidae. Sci. 135:212-213.

MERRIAM, CLINTON HART. 1895. The geographic distribution of life in North America with special reference to the Mammalia. Biol. Soc. of Washington, 7:1-64.

MILSTEAD, WILLIAM W. 1957*a*. Some aspects of competition in natural populations of whiptail lizards (genus *Cnemidophorus*). Texas Jour. Sci. 9(4): 410-447.

———. 1957*b*. Observations on the natural history of four species of whiptail lizards, *Cnemidophorus* (Sauria, Teiidae) in Trans-Pecos Texas. Southwestern Nat. 2(2-3):105-121.

PACK, HERBERT J. 1923. Food habits of *Crotaphytus collaris baileyi* (Stejneger). Proc. Biol. Soc. Wash. 36:83-84.

PHELAN, ROBERT L. AND BAYARD H. BRATTSTROM. 1955. Geographic Variation in *Sceloporus magister*. Herpetologica. 11(1):1-14.

PRITCHETT, CLYDE L. 1962. Vertebrate distribution in relation to certain habitats in Central Kane County, Utah. Unpublished Master's thesis, Brigham Young University, Provo, Utah.

REEVE, WAYNE L. 1952. Taxonomy and Distribution of the horned lizards genus *Phrynosoma*. Univ. Kansas Sci. Bull. 34(14):817-960.

RICHARDSON, CHARLES H. JR. 1915. Reptiles of northwestern Nevada and adjacent territory. Proc., United States Nat. Mus., 48:403-435.

RICHTER, ALDEN P. 1960. The climatology of the Nevada Test Site. U. S. Weather Bureau report submitted to the U. S. Atomic Energy Commission, Las Vegas, Nevada. 37 pp.

RUTHVEN, ALEXANDER, AND HELEN GAIGE. 1915. The reptiles and amphibians collected in northeastern Nevada by the Walker-Newcomb expedition of the Univ. of Michigan. Occas. Papers, Mus. Zool. Univ. Mich., No. 8:1-33.

Shaw, C. E. 1945. The chuckwallas, genus *Sauromalus*. Trans., San Diego Soc. of Nat. Hist. 10(15): 269-306.

Shields, Lora M. and Philip V. Wells. 1962. Effects of nuclear testing on desert vegetation. Science 135 (3497):38-40.

Smith, Hobart Muir. 1946. Handbook of lizards. Lizards of the United States and of Canada. Ithaca, New York: Comstock Publish. Co., Inc., xxi+557 pp.

Stebbins, Robert C. 1954. Amphibians and reptiles of western North America. McGraw Hill Book Co., Inc., New York. 537 pp.

Stejneger, Leonard H. 1893. Annotated list of the reptiles and batrachians collected by the Death Valley Expedition in 1891, with description of new species. No. Amer. Fauna, 7:159-229.

Stickel, W. H. 1943. The Mexican snakes of the genera *Sonora* and *Chionactis* with notes on the status of other colubrid genera. Proc. Biol. Soc. of Wash., 56:199-128.

Tanner, Wilmer W. 1939. The status of the Utah gopher snake. Proc. Utah Acad. Sci. Arts and Letters. 16:107.

———. 1957. A taxonomic and ecological study of the western skink (*Eumeces skiltonianus*). The Great Basin Nat. 17(3-4):59-94.

——— and Benjamin H. Banta. 1963. The distribution *Tantilla utahensis* Blanchard. Great Basin Nat. 22:116-18.

Tinkle, Donald W. 1961. Population structure and reproduction in the lizard *Uta stansburiana stejnegeri*. Amer. Midland Nat. 66(1):206-234.

Van Denburgh, J. 1922. The reptiles of western North America. 2 vols. Occasional Papers, California Academy of Sciences, No. 10, 1-1028 pp.

——— and Joseph R. Slevin. 1921. A list of the amphibians and reptiles of Nevada, with notes on the species in the collection of the Academy. Proc., Calif. Acad. Sci., series 4, 11(2):27-83.

White, Leland D. and Dorald M. Allred. 1961. Range of kangaroo rats in areas affected by atomic detonations. Proc. Utah Acad. Sci., Arts., and Letters. 38:101-110.

Woodbury, Angus M. and Ross Hardy. 1948. Studies of the desert tortoise, *Gopherus agassizii*. Ecol. Monographs 18(2):145-200.

Yarrow, Harry C. 1875. Report upon the collections of batrachians and reptiles made in portions of Nevada, Utah, California, Colorado, New Mexico, and Arizona, during the years 1871, 1872, 1873, and 1874. Report, Geographical and Geological Explorations and Surveys west of 100th Meridian (Wheeler Survey), Zoology, 5:509-584, ch. 4.

——— and Henry W. Henshaw. 1878. Report upon the reptiles and batrachians collected during the years 1875, 1876, and 1877, in California, Arizona, and Nevada. Appendix NN, Annual Report, Chief of Engineers for 1878. Geographical Survey of the Territory of the United States West of the 100th Meridian. Washington, D. C., pp. 206-226.

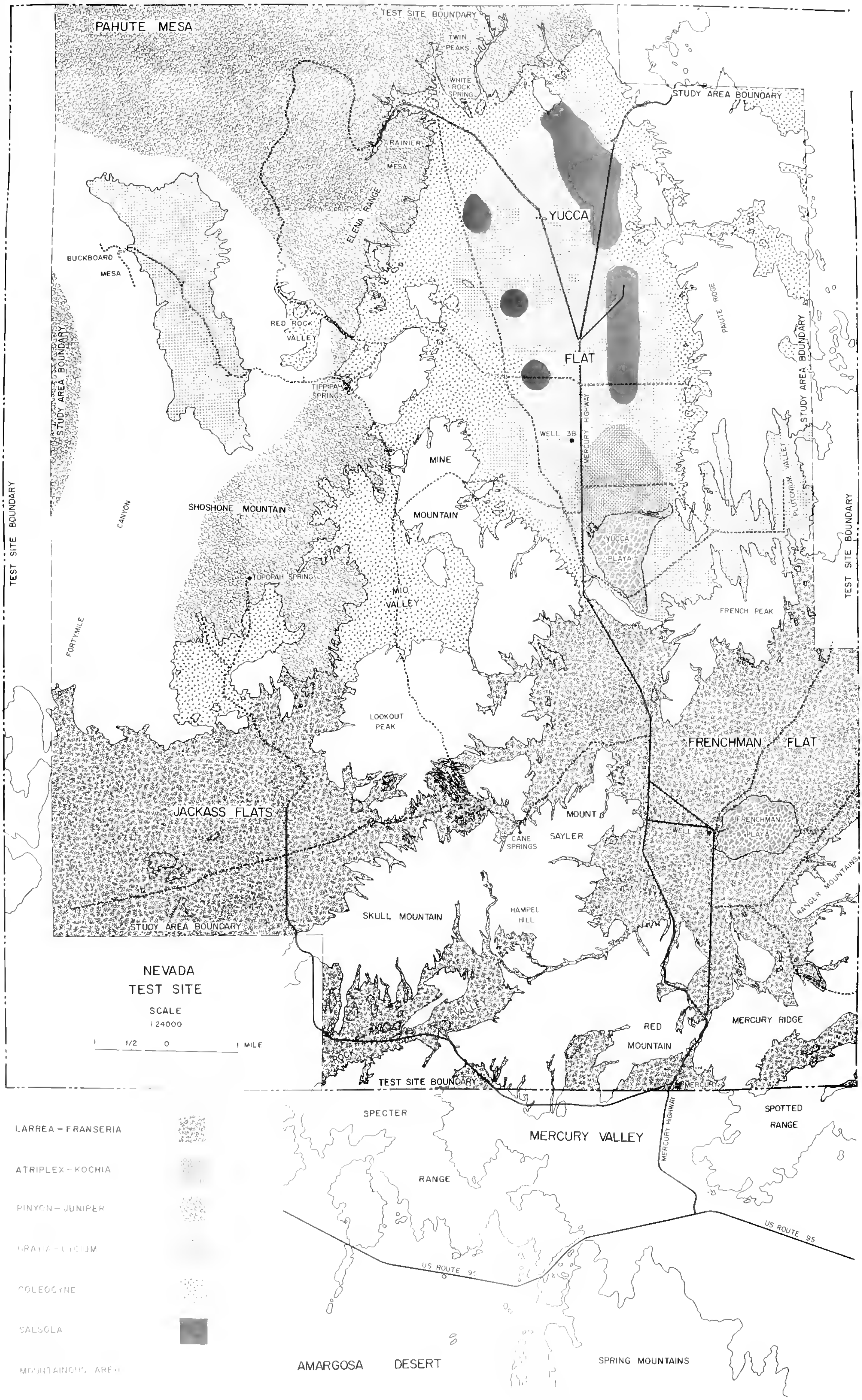

FIG. 12. Extent of the major plant communities of the Nevada Test Site

BRIGHAM YOUNG UNIVERSITY
SCIENCE BULLETIN

MITES ON KANGAROO RATS AT THE NEVADA TEST SITE

by

Morris A. Goates

Biological Series - Volume III, Number 4

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INTRODUCTION

In August 1959 Brigham Young University began an ecological survey of the native animals at the Nevada Test Site near Mercury, Nye County, Nevada. The objective was a comparative study to determine the reaction of the animals to exposure of nuclear effects. The phase of the project reported herein covered the period from August 1959 to December 1961. The intent was to determine the kinds of mites found on kangaroo rats of two species, *Dipodomys merriami merriami* Mearns and *Dipodomys microps occidentalis* Hall and Dale, (1) where both hosts occupied the same habitat in about equal numbers, (2) where one host was predominantly more abundant than the other, (3) living in nuclear disturbed areas and contiguous undisturbed areas, (4) from the standpoint of seasonal occurrence, and (5) to determine the microhabitat of the mites.

As far as is known, this was the first systematic study of its kind dealing with parasitic mites of kangaroo rats. A seasonal study of the ectoparasites of *D. ordii* ssp., and *D. microps bonnevillei* Goldman was made by personnel of the University of Utah Institute of Environmental Biological Research at Dugway, Utah, but their data on mites have not been published. Brennan and Beck (1955) listed five species of chigger mites from *D. ordii* and *D. merriami* in Utah as part of a study of the ectoparasites of Utah. Gould (1956) listed eight species of chiggers found on kangaroo rats in California, and Loomis (1956) reported nine species of chiggers on kangaroo rats in Kansas. Other published records of mites from kangaroo rats are very few and are from collections incidental to other studies.

Acknowledgment is made of United States Atomic Energy Commission Research Grant AT (11-1)786 to Brigham Young University which assisted this research. I express gratitude to Drs. Donald M. Allred and D Elden Beck, principal and associate investigators, for permission to use the data in this study, and for suggestions for analysis. To my associates at the Nevada Test Site and Brigham Young University who helped in the collection and preparation of specimens, I extend thanks. Acknowledgment is made especially for the help of Carole McLain and Reed Preston, technicians associated with this project, in mounting many of the mites on microslides.

Identification and verification of some of the mites were kindly made by Dr. James M. Brennan, Rocky Mountain Laboratory, Hamilton, Montana; Dr. Russell W. Strandtmann, Texas Technological College, Lubbock; and Dr. Donald A. Chant, Canada Department of Agriculture Research Laboratory, St. Catharines, Ontario.

STUDY AREAS AND PROCEDURES

The Nevada Test Site is situated in southeastern Nye County, adjacent to the western boundaries of Clark and Lincoln counties. Study areas were established in the three major valleys of Jackass, Yucca, and Frenchman flats, although most collections were made in the latter two areas. Frenchman and Yucca flats each has a large playa supporting little or no vegetation, whereas Jackass Flats has an open drainage system and lacks a playa. The valleys lie at elevations between 940 and 1,125 meters. The test site presents an interesting ecological situation in having communities typical of both the Mojave and Great Basin influences. Allred, Beck and Jorgensen (1963) discussed the geographic and vegetative features of the test site and study areas.

The plant communities from which animals were trapped were designated on the basis of the predominant plant species present. These were (1) *Artemisia tridentata* Nutt., (2) *Atriplex confertifolia* (Torr. and Frem.) Wats. and *Kochia americana* Wats., (3) *Coleogyne ramosissima* Torr., (4) *Grayia spinosa* (Hook.) Moq. and *Lycium andersonii* A. Gray, (5) *Larrea divaricata* Cov. and *Franseria dumosa* Gray,

(6) *Lycium pallidum* Miers., (7) *Salsola kali* L., and (8) Mixed.[1] The Mixed designation consists of complexes of both northern and southern desert shrubs. These do not fit clearly into the other plant community types, and it is difficult to designate a predominant plant type because of the relative numbers of the numerous species present. In designating the major plant communities at the Nevada Test Site, Allred, Beck and Jorgensen (1963) listed *Artemisia tridentata* as part of the *Coleogyne* community, and *Lycium pallidum* as part of the *Larrea-Franseria* community. These two plant species occur in relatively pure stands but cover only small areas. Because each may have its own species of animals, each is considered as a separate community in this paper.

The vegetation in all the areas studied shows no physical disturbance from the effects of nuclear detonations except at one study site in the *Grayia-Lycium* community where plants were damaged by wind and thermal forces. This site was designated as "*Grayia-Lycium* disturbed" as contrasted to the *Grayia-Lycium* (undisturbed). In several areas where nuclear detonations occurred, the native vegetation was eliminated and *Salsola* was the predominant invasive plant.

Many rats were collected during mammal population and home range studies. Young-type, live-catch traps and Museum Special, break-back traps baited with oatmeal were used for trapping rats. Trapping designs with live-catch traps consisted of eight transects radiating from a central point in Grayia-Lycium, four similarly arranged transects in Atriplex-Kochia, and four in Larrea-Franseria. Traps were spaced at 30 ft. intervals with 10 traps per transect. Trapping designs with break-back traps were arranged as single transects or two parallel transects with traps spaced at 30 ft. intervals. Single transects had 100 traps per transect; parallel transects had 50 traps each.

Traps were operated once each month for a sufficient number of nights to catch a minimum of five rats in each community. Captured rats were placed in white paper bags as soon as they were removed from the traps, and rats still alive were immediately killed. The bags were tightly closed to prevent escape of ectoparasites. The bags containing rats were placed in a refrigerator for several hours to chill the body of the host. The rats were then removed from the refrigerator, allowed to warm to room temperature, and the detached mites were brushed from the fur into a large, white enamelware pan. Examination for attached mites was made by parting the hairs of the hosts.

Mites were preserved in 70 percent ethyl alcohol until they were mounted on glass slides in polyvinyl alcohol medium. They were identified with the use of a phase-contrast microscope.

RESULTS

General Infestation of Rats

Dipodomys merriami

Totals of 252 males, 259 females, and 17 rats not identified to sex were examined. From 28 to 94 rats were examined each month except in March and May when only 13 and 11, respectively, were examined (Table 1).

About equal numbers of male and female rats from each plant community were examined. More rats from the Mixed and disturbed Grayia-Lycium communities were examined than from other communities (Table 2). Relatively few from Coleogyne and none from Atriplex-Kochia were examined inasmuch as this species is not common in these communities.

Twenty-six percent of the rats from all areas together were infested with mites. Rates of infestation of rats by all species of mites in each of the plant types were: Larrea-Franseria, 54%; Grayia-Lycium, 33%; Salsola, 32%; Artemisia, 30%; Grayia-Lycium (disturbed), 28%; Lycium, 20%; and Mixed, 18%.

In January only one species of mite was found on this host. In February and May three species were found, and in the remaining months the number varied from five to seven.

In Grayia-Lycium the average number of mites on male rats was double the number found on females, whereas in Salsola the situation was reversed. In other communities males and females were about equally infested. Mite numbers were highest in February, July, August and October, and lowest in January, May, and September. The greatest number of mites on a host was 174 on a male in Grayia-Lycium in August. In all but Lycium and Salsola the greatest number was found on males.

[1] In the presentation that follows these communities are referred to by their generic and common names only

TABLE 1

NUMBER OF KANGAROO RATS EXAMINED EACH MONTH

Host	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
D. merriami	40	35	13	31	11	63	61	94	58	28	55	39	528
D. microps	40	29	27	65	16	131	59	52	87	106	81	35	728

Dipodomys microps

Totals of 378 males, 301 females and 49 rats not identified to sex were examined. From 27 to 131 rats were examined each month except in May when only 16 were examined (Table 1).

About equal numbers of male and female rats from each plant community were examined. Relatively fewer rats from Artemisia, Larrea-Franseria, Lycium, and Salsola were examined than from other communities because of their infrequent occurrence in these areas (Table 2).

Thirty-four percent of the rats from all areas together were infested with mites. Rates of infestation by all species of mites in each of the plant types were: Grayia-Lycium, 55%; Grayia-Lycium (disturbed), 36%; Lycium, 33%; Coleogyne, 32%; Atriplex-Kochia, 31%; Mixed, 28%; and Salsola, 20%.

In March only two species of mites were found on this host. Nine species were found in June, and eight in July, September and December. During the remaining months the number varied from five to six.

In Atriplex-Kochia male rats possessed four times as many mites as females, although in other communities males and females were about equally infested. There was no significant difference between the degree of infestation of the two rat species where both occurred in the same plant community. Highest mite numbers were observed in February and July, and lowest in January and May. The greatest number of mites on a host was 156 on a female in Grayia-Lycium in July. In all but Grayia-Lycium (disturbed) the greatest number was found on females.

TABLE 2

NUMBER OF KANGAROO RATS EXAMINED IN THE PLANT COMMUNITIES

Plant Community	*D. merriami*	*D. microps*
Artemisia	10	*
Atriplex-Kochia	*	65
Coleogyne	*	115
Grayia-Lycium	48	127
Grayia-Lycium (disturbed)	102	85
Larrea-Franseria	37	*
Lycium	15	15
Salsola	57	25
Mixed	238	253
Unknown	18	40

*Rats did not occur in sufficient numbers in this plant community to yield an adequate sample.

Mite Associates

As a result of this study 6,208 mites representing 16 species were collected. Greatest numbers were 4,919 chigger mites of which 2,169 were *Odontacarus linsdalei*, 1,604 *Trombicula arenicola*, 320 *Euschöngastia decipiens*, 233 *Euschöngastia radfordi*, 52 *Euschöngastia lacerta*, 42 *Trombicula jessiemae*, and 499 belonging to a species tentatively referred to as *Sasacarus* sp. "W."

Of the remaining mites 394 were *Ischyropoda armatus*, 372 *Haemolaelaps glasgowi*, 76 *Hirstionyssus triacanthus*, 31 *Listrophorus dipodomius*, 12 *Androlaelaps leviculus*, and 373 *Kleemannia* spp. Specimens of the genus *Kleemannia* were sent to Dr. Donald A. Chant, Canada Department of Agriculture, who stated (personal correspondence) that the material included at least four undescribed species. These have been retained by him for description. In this paper these will be discussed as one group designated as *Kleemannia* spp.

Twelve species of mites were found on both male and female rats. These were *H. glasgowi*, *H. triacanthus*, *I. armatus*, *Kleemannia* spp., *O. linsdalei*, *T. arenicola*, *E. radfordi*, *E. decipiens*, and *Sasacarus* sp. "W." Two species, *A. leviculus* and *E. lacerta*, were not found on *merriami*. *Listrophorus dipodomius* was not found on male rats of either species, and *T. jessiemae* was not found on male *microps*.

Twice as many *merriami* were infested with chigger mites than with mesostigmatid mites, and twice as many rats of this species were infested with one species of chigger, *O. linsdalei*, than with any other mite. Considerably more *microps* were infested with chigger mites than with mesostigmatid mites, but the difference in degree of infestation was not so great as with *merriami*. Twice as many rats of *microps* were infested with *O. linsdalei*, *T. arenicola* and *Kleemannia* spp. than with any other mites.

In the discussions that follow, ecological data (when available) will be presented for each species of mite in the following sequence: general comments on previously known host relationships, frequency and degree of infestation, acarine symbioses[1], microhabitat, plant community and seasonal realtionships as they relate to mite populations and rates of infestation.

Haemolaelaps glasgowi (Ewing) 1925

Mites have been reported from numerous birds and mammals including *D. microps* (Strandtmann, 1949; Strandtmann and Wharton, 1958). They have not been reported heretofore from *D. merriami*.

In my study 333 females, two males and 37 deutonymphs were collected. There was no significant difference between the number of male rats infested when compared with the number of females. However, the average and largest numbers of mites were greater on female rats. Over twice as many mites were found on female as on male *merriami*, whereas only 50% more mites were found on female as on male *microps*. In both rat species the largest number of mites on a rat was six times greater on females.

This mite was the only species found on its host 57% of the time that it was collected (Table 3). It occurred 22% of the time in combination with chiggers and mesostigmatids. Its most frequent associates were *Kleemannia* spp.

Numbers of mites on *merriami* were three times higher in the Mixed community than in Grayia-Lycium (disturbed) and Salsola, and six times higher than in Lycium and Larrea-Franseria. Numbers on *microps* were 60% higher in Coleogyne and Grayia-Lycium (disturbed) than in the Mixed and Grayia-Lycium, and 80% higher than in Salsola.

More *merriami* were infested in Lycium, and more *microps* were infested in Salsola than in any other community. In areas where both rat species were infested with this mite there were some significant differences. Nearly five times as many *merriami* were infested in Lycium than were *microps*, twice as many *microps* were infested in Salsola, and 40% more microps were infested in Grayia-Lycium (disturbed) than were *merriami*.

Twice as many *merriami* were infested in December than any other month, although the numbers of mites on *merriami* were eight times greater during June. More *microps* were infested in January than in any other month, but numbers on *microps* were highest in February and March.

Androlaelaps leviculus Eads 1951

Mites are known from *Perognathus hispidus, Onychomys leucogaster*, and *Sigmodon hispidus* (Eads, 1951), but have not previously been reported from kangaroo rats.

The 12 female mites collected in my study were found on four *microps*. The average number of mites per infested host was five on males and one on females. The greatest number of mites on one host was six on a male and one on a female.

One of the four times that it was found *A. leviculus* was the only mite found on its host. It occurred in combination with chigger mites twice, and with chiggers and mesostigmatid mites once.

These mites were found only in the Grayia-Lycium and Mixed communities during the months of June, July, and August.

Hirstionyssus triacanthus Jameson 1950

Mites have previously been reported only from *D. merriami* (Strandtmann and Wharton, 1958).

Totals of 73 female and three male mites were collected in my study. There was no significant difference between the number of male rats infested when compared with the number of females. The average number of mites per infested rat varied from one to two, and the largest number of mites on a host was five on a female *merriami* and four on a male *microps*.

This mite was the only species found on its host 29% of the time (Table 3). It occurred 33% of the time in combination with other mesostigmatid mites, 33% with chigger mites, and 5% with combinations of chiggers and mesostigmatids. Its most frequent associates were *Kleemannia* spp.

The number of mites on *merriami* in Grayia-Lycium was nearly two times higher than in the Mixed community, and five times higher than in Grayia-Lycium (disturbed), Larrea-Franseria, and Salsola. The number on *microps*

[1]In this paper this term is used in the broad sense of association between two or more species of mites

TABLE 3

SYMBIOTIC FREQUENCIES OF MESOSTIGMATID AND SARCOPTIFORM MITES ON KANGAROO RATS[1]

	Percentage of times associated[2]					
	H. glasgowi	*A. leviculus*	*H. triacanthus*	*I. armatus*	*Kleemannia* spp.	*L. dipodomius*
H. glasgowi	57		7	10	16	33
A. leviculus		25				
H. triacanthus			29	13	12	
I. armatus	8	25	19	54	10	
Kleemannia spp.	19		24	11	45	33
O. linsdalei	8	25	12	8	10	
T. arenicola	7	25	19	16	20	
E. radfordi	7		5			
E. decipiens		25	12			
L. dipodomius						33

[1]Only those associations which occurred more than 5 percent of the time were included.
[2]Based on the total times these species were collected.

in the Mixed community was twice as high as in any of the other communities.

More *merriami* and *microps* were infested in the Salsola than in any other community. In areas where both rat species were infested with this mite there were some significant differences. Six times as many *microps* in Grayia-Lycium (disturbed) and twice as many in Grayia-Lycium and Salsola were infested than were *merriami*, whereas in the Mixed community 50% more *merriami* were infested than were *microps*.

Nearly five times as many *merriami* were infested in March than any other month, although the number of mites on *merriami* was more than twice as high during June. Twice as many *microps* were infested in May than in any other month, and the numbers of mites on *microps* were highest in April and May.

Ischyropoda armatus Keegan 1951

Mites of this species have been reported from mammals of several species including *D. merriami* (Strandtmann and Wharton, 1958). They have not been reported heretofore from *D. microps*.

During this study 367 females, 10 males, and 17 nymphs were collected. There was no significant difference between the number of male rats infested when compared with the number of females. However, the average and largest numbers of mites on a host were three times greater on female than on male *merriami*, and 50% greater on male than on female *microps*.

This mite was the only species found on its host 54% of the time that it was collected (Table 3). It occurred 19% of the time with other mesostigmatid mites, 16% with chigger mites, and 11% with chiggers and mesostigmatids. Its most frequent associate was *T. arenicola*.

The number of mites on *merriami* in Salsola was seven times higher than in the Mixed community, and 14 times higher than in Lycium and Grayia-Lycium (disturbed). The number on *microps* in Salsola and Grayia-Lycium was 50% higher than in Coleogyne, and four times higher than in the Mixed, Lycium, and Grayia-Lycium (disturbed) communities.

More *merriami* were infested with mites in Salsola, and more *microps* infested in Lycium than in any other community. In areas where both rat species were infested with this mite there were some significant differences. Fifty percent more *merriami* were infested in Salsola than were *microps*, and twice as many *microps* were infested in the Lycium and Mixed communities than were *merriami*.

Twice as many *merriami* were infested in May as any other month, although the number of mites on *merriami* was twenty times greater during July and October. More *microps* were infested in May and June than in any other month, and the numbers on *microps* were highest during June, August, and September.

Kleemannia spp.

Specimens of this genus represent at least four undescribed species. In this paper these are discussed as one group.

During this study 373 mites were collected. There was no significant difference between the number of male rats infested when compared with the number of females. There was also no significant difference between the average number of mites per infested male rat when compared with the average number of mites per infested female rat. The largest number of mites on a host was three times greater on male than on female *merriami*, and two times greater on female than on male *microps*.

Kleemannia spp. were the only mites found on their host 35% of the time they were collected (Table 3). They occurred 26% of the time with other mesostigmatid mites, 20% with chigger mites, and 9% with chiggers and mesostigmatids. Their most frequent associate was *T. arenicola*.

The number of mites on *merriami* in the Mixed community was twice as high as in Grayia-Lycium and Larrea-Franseria. The number of mites on *microps* in Coleogyne was 50% higher than in Grayia-Lycium, two times higher than in Lycium and Mixed, and four times higher than in Atriplex-Kochia and Grayia-Lycium (disturbed).

More *merriami* were infested with *Kleemannia* spp. in Larrea-Franseria, and more *microps* infested in Lycium than any other community. In the Mixed community four times as many *microps* were infested as *merriami*, whereas in Grayia-Lycium there was no difference in rate of infestation.

Three times as many *merriami* were infested in May and October than in any other month, although the number of *Kleemannia* spp. on *merriami* was nine times greater during June. Four times as many *microps* were infested in May than in any other month, but the number on *microps* was highest during June, with high numbers also found during May, August, October and November.

Odontacarus linsdalei (Brennan and Jones) 1954

Mites of this species are known from mammals of several species including *D. microps* (Brennan and Beck, 1955) They have not been reported heretofore from *D. merriami*.

During this study 2,169 larval mites of this species were collected. There was no significant difference between the numbers of male rats infested when compared with the number of females. The average number of mites was twice as high on male as on female *merriami*, and 13% higher on female than on male *microps*. The largest number of mites on a host was found on males of both rat species.

This mite was the only species found on its host 52% of the times that it was collected (Table 4). It occurred 34% of the time with other chigger mites, 7% with mesostigmatid mites, and 9% with chiggers and mesostigmatids. Its most frequent associate was *T. arenicola*. Mites were found in the ears of their hosts 89% of the time. The remainder of the time they were found on the underparts of the hind legs and near the genitalia.

The number of mites on *merriami* in the Mixed community was 40% higher than in Grayia-

TABLE 4

SYMBIOTIC FREQUENCIES OF TROMBICULID MITES ON KANGAROO RATS[1]

Symbiont	Percentage of times associated[2]						
	O. linsdalei	*T. arenicola*	*T. jessiemae*	*E. lacerta*	*E. radfordi*	*E. decipiens*	*Sasacarus* sp. "W"
H. glasgowi					10		
H. triacanthus		6				6	
I. armatus	5	8					
Kleemannia spp.	5	13				5	
O. linsdalei	52	48				10	51
T. arenicola	34	29		20			49
T. jessiemae			75				
E. lacerta				20			
E. radfordi					54	5	
E. decipiens					8	44	
Sasacarus sp. "W"	11	15					36

[1]Only those associations which occurred more than 5 percent of the time were included.
[2]Based on the total times these species were colleted.

Lycium (disturbed), 57% higher than in Grayia-Lycium, 66% higher than in Salsola, and 14 times higher than in Larrea-Franseria and Artemisia. The number on *microps* in Coleogyne was 81% higher than in Grayia-Lycium, over twice as high as in Grayia-Lycium (disturbed), Mixed, and Atriplex-Kochia, and five times as high as in Lycium.

More rats of both species were infested with *O. linsdalei* in the Grayia-Lycium than in any other community. In areas where both rat species were infested with this mite there were some significant differences. Fifty percent more *merriami* were infested in Grayia-Lycium (disturbed) than were *microps*, whereas 50% more *microps* than *merriami* were infested in Grayia-Lycium.

Twice as many *merriami* were infested in April and November than any other month. The number of mites on *merriami* was twice as high during April, May, October and November. More *microps* were infested in May and July than in any other months, but the number was highest in July.

Trombicula arenicola Loomis 1954

Mites of this species have been reported from reptiles of two species and numerous mammals including *D. microps* (Brennan and Beck, 1955). They have not been heretofore reported from *D. merriami*.

In this study 1,604 larval mites of this species were collected. There was no significant difference between the number of male rats infested when compared with the number of females. The average number of mites was slightly higher on male rats, but the largest number of mites was twice as high on female *merriami*, and 30% higher on female *microps*.

This mite was the only species found on its host 29% of the times that it was collected (Table 4). It occurred 45% of the time with other chigger mites, 17% with mesostigmatid mites, and 9% with chiggers and mesostigmatids. Its most frequent associate was *O. linsdalei*. Ninety-two percent of the time they were found, mites were attached to the underparts of the hind legs. The remainder of the time they were found on the ears.

The number of mites on *merriami* in Larrea-Franseria was three times higher than in Grayia-Lycium and four times higher than in the Mixed and Grayia-Lycium (disturbed) communities. The number on *microps* in Atriplex-Kochia was two times higher than in Grayia-Lycium, three times higher than in Grayia-Lycium (disturbed), four times higher than in the Mixed community, and six times higher than in Coleogyne.

More *merriami* were infested with *T. arenicola* in Grayia-Lycium and Larrea-Franseria, and more *microps* were infested in the Grayia-Lycium than in any other community. In areas where both rat species were infested with this mite, *microps* was more heavily infested. Seven times as many *microps* were infested in Grayia-Lycium (disturbed), three times as many in Mixed, and 50% more *microps* were infested in Grayia-Lycium than were *merriami*.

Over twice as many *merriami* were infested in June than in any other month, although the number on *merriami* was 20% higher in September. Sixty percent more *microps* were infested in July than in any other month, and the number on *D. microps* was over twice as high in July.

Trombicula jessiemae Gould 1956

Mites of this species are known from *Sigmodon hispidus* and *Neotoma* sp. (Gould, 1956).

Forty-two larval mites were collected in my study from six male and one female *merriami* and one female *microps*. The average number of mites was the same on both male and female *merriami* but was three times higher on the *microps* than on *merriami*. The largest number of mites on a rat was the same for male *merriami* and female *microps* but only one-half as high for female *merriami*.

In six of its eight collections, *T. jessiemae* was the only species found on its hosts (Table 4). They were taken from *merriami* in the Larrea-Franseria and Mixed communities in July, August, September, and October and from *microps* in the Mixed community in July.

Euschöngastia lacerta Brennan 1948

Mites have been collected from mammals of several species and one species of lizard (Loomis, 1956). They have not been reported heretofore from kangaroo rats.

During my study 59 larval mites were collected from three male and two female *microps*. Twice as many mites were found on male as on female *microps*, and the largest number of mites on a host was five times greater on male than on female *microps*.

This mite was the only species found on its host 20% of the times that it was collected (Table 4). The rest of the time it was collected in combination with other chigger mites. Its most frequent associate was *T. arenicola*. It was collected in the Atriplex-Kochia and Mixed communities during June, July, and August. Twice as many rats were infested during July and the number of mites was three times higher also during July.

Euschöngastia radfordi Brennan and Jones 1954

These mites have been reported from numerous birds and mammals including *Dipodomys* spp. (Brennan and Beck, 1955; Gould, 1956). They have not been reported heretofore from *D. merriami* or *D. microps*.

A total of 233 larval mites was collected during my study. There was no significant difference between the number of male rats infested when compared with the number of females. However, the average and largest numbers of mites were greatest on female *merriami* and on male *microps*. Fifty percent more mites of this species were found on female as on male *merriami*, whereas three times as many mites were found on male as on female *microps*. The largest number of mites on a host was twice as high on female as on male *merriami*, and six times higher on male than on female *microps*.

This mite was the only species found on its host 54% of the times that it was collected (Table 4). It ocurred 13% of the time with other chigger mites, 17% with mesostigmatids, and 13% with chiggers and mesostigmatids.

The number of mites on *merriami* in Grayia-Lycium (disturbed) was three times higher than in the Mixed community, and six times higher than in Salsola. These mites were found on *microps* only in Grayia-Lycium (disturbed) where the number was twice as high as that found on *merriami* in the same community. In Grayia-Lycium (disturbed) were both species of rats were infested, 50% more *microps* were infested than *merriami*. The infestation of *merriami* was three times higher in Grayia-Lycium (disturbed) than in Salsola and 14 times higher than in the Mixed community.

Sixty percent more *merriami* were infested in December than in any other month, although the population of *E. radfordi* on *merriami* was five times greater during March. Twice as many *microps* were infested with twice as many mites of *E. radfordi* in February as in December, the only other month they were found on *microps*.

Euschöngastia decipiens Gould 1956

Mites of this species have been reported from several mammals including *D. merriami* (Brennan and Beck, 1955; Gould, 1956). They have not been reported heretofore from *D. microps*.

A total of 320 larval mites was collected during this study. There was no significant difference between the number of male rats infested when compared with the number of females. However, the average and largest numbers of mites were greatest on male rats. Twice as many *E. decipiens* were found on male as on female *merriami*, whereas eight times as many mites were found on male as on female *microps*. The largest number of mites on a rat was twice as great on male as on female *merriami*, and nine times as great on male as on female *microps*.

This mite was the only species found on its host 44% of the times that it was collected (Table 4). It occurred 25% of the time with chigger mites, 19% with mesostigmatid mites and 12% with chiggers and mesostigmatids.

The number of mites on *merriami* in Artemisia was four times higher than in the Mixed community and nine times higher than in Grayia-Lycium (disturbed). The number on *microps* in Coleogyne and Grayia-Lycium (disturbed) was twice as high as in Grayia-Lycium and 14 times as high as in the Mixed community.

Ten times as many *merriami* were infested in Artemisia, and 50% more *microps* in Coleogyne than in any other community. In areas where both rat species were infested with this mite, twice as many *microps* were infested as were *merriami*.

Over three times as many *merriami* were infested in March than any other month, although the population on *merriami* was three times greater during February. Three times as many *microps* were infested in February and May as in any other month, but the number on *microps* was six times greater during February.

Sasacarus sp. "W"

This represents a species whose taxonomic placement is debateable (Brennan, personal correspondence). It is tentatively assigned to this genus.

During this study 499 larval mites were collected. There was no significant difference between the number of male rats infested when compared with the number of females. Three times as many mites were found on male as on female *merriami*, but there was no difference between male and female *microps*. The largest number of mites on a rat was six times greater on male than on female *merriami*, and two times greater on female than on male *microps*.

This mite was the only species found on its host 36% of the times that it was collected (Table 4). It occurred 51% of the time with other chigger mites, and 13% with chigger and mesostigmatid mites. Its most frequent associates were *O. lins-*

dalei and *T. arenicola.* Mites were found only in the ears of their hosts.

The number of mites on *merriami* in Grayia-Lycium was three times higher than in Larrea-Franseria and Salsola. The number on *microps* in the Mixed community was four times higher than in Grayia-Lycium and Atriplex-Kochia.

More *merriami* were infested in Larrea- Franseria and more *microps* in Grayia-Lycium than in any other community. In areas where both rat species were infested with this mite, there was no difference in percentage of animals infested.

Fifty percent more *merriami* were infested in September than in July or August, although the number of *Sasacarus* sp. "W" on *merriami* was three times greater during August. Twice as many *microps* were infested during August as in July or September, but the number on *microps* was 30% higher during July.

Listrophorus dipodomius Radford 1953

Mites have been reported from *Dipodomys spectabilis* (Radford, 1953). They have not been reported heretofore from *D. merriami* or *D. microps.*

During this study 18 females and 13 males were collected from one female *merriami* and two female *microps.* Three mites were found on the single *merriami,* 27 on one *microps,* and one mite on the other. In one collection, this mite occurred as the only species on its host, once in combination with *H. glasgowi,* and once with *Kleemannia* spp. The infested *merriami* was collected in Salsola in August, and the *microps* were collected in December in Grayia-Lycium (disturbed).

Other Mites

Three specimens of fur mites of the family Myobiidae were found on the kangaroo rats. These mites commonly occur on rodents and other mammals. Six specimens of the family Cheyletidae and ten of the family Glycyphagidae were collected. These mites are not commonly found on mammals.

DISCUSSION

According to Allred and Beck (1963) species and numbers of kangaroo rats at the Nevada Test Site vary with the plant community. Specifically, *merriami* was not abundant in Atriplex-Kochia and Coleogyne, whereas *microps* was rarely found in Larrea-Franseria. Consequently, in my study fewer rats were collected and examined from certain communities than from others.

Frequency of infestation of hosts. In areas where one of the two species of rats was greatly predominant in number, a greater percentage of the rats of the predominant species was infested with mites. Where both species of rats were found as associates in somewhat equal numbers, relatively more *microps* were infested than *merriami.* The rate of infestation of *merriami* was highest in Larrea-Franseria, and of *microps* in Grayia-Lycium. This phenomenon on *merriami* was due to a high rate of infestation by two species of chiggers, *T. arenicola* and *Sasacarus* sp. "W," which occurred abundantly in Larrea-Franseria. In this community these two chiggers were never found together on the same individual rat, thereby potentially increasing the rate of rat infestation. With reference to *microps* in Grayia-Lycium, these two species of mites with a third abundant species, *O. linsdalei,* were usually found as symbionts on the same rat.

The average number of mites per infested host ranged as high as 18. The highest average on both rat species occurred in Grayia-Lycium and the lowest in Lycium. There was no significant difference between the average number of mites per infested *merriami* when compared with the average number of mites per infested *microps* in any community. In areas where the rates of infestation of rats with chiggers were low, the average number of mites per infested host also was low. Although there was no significant difference between the number of males infested when compared with the number of females infested with all mites, the average number of mites for infested males as compared with females was significantly different in some instances. In each case, however, the higher average was due to an infestation by chiggers. In all but one case where relatively high numbers of mites infested one host, chiggers were the principal mites involved. The single exception was a female *merriami* infested with 68 *I. armatus.*

The greatest number of mites found on a single rat was 174 on a *merriami* and 156 on a *microps,* both in Gravia-Lyceum. Fewest numbers of mites on both species of rats were found on animals in Lycium. Male *merriami* were generally more heavily infested than females, whereas female *microps* were generally more heavily infested than males.

Frequency of infestation by particular mite species. All species of mites collected were found on both rats except *A. leviculus* and *E. lacerta* which were found only on *microps*. All species of mites were found on both sexes of host in about equal numbers, except *L. dipodomius* which was found only on females of both hosts and *T. jessiemae* which was not found on male *microps*.

Odontacarus linsdalei and *T. arenicola* infested relatively more rats than other species of mites. The next highest rate of infestation was with *Kleemannia* spp. which was one-half the rate of infestation of *O. linsdalei*. Twice as many *merriami* were infested with *O. linsdalei* than with any other mite species. Only one *merriami* was infested with *L. dipodomius*. *Odontacarus linsdalei* and *T. arenicola* infested relatively more *microps* than did any other species of chiggers, and *Kleemannia* spp. and *H. glasgowi* infested twice as many *microps* as any other mesostigmatid.

The average number of each species of mite was generally the same on both host species except for *Sasacarus* sp. "W" which was predominantly greater on *merriami* than on *microps*. There were few differences between the average number of mites on the different sexes of hosts except for mites of *E. decipiens* which were eight times as abundant on male as on female *microps*. Almost three times as many *E. radfordi* were found on male as on female *microps*, and almost three times as many *Sasacarus* sp. "W" were found on male as on female *merriami*. Over three times as many *I. armatus* were found on female as on male *merriami*.

A significant difference between the greatest numbers of mites found on *merriami* and *microps* was noted with *Sasacarus* sp. "W" where the number was over six times greater on *merriami*. The number of *I. armatus* was three times greater on *merriami* than on *microps*, and *L. dipodomius* was nine times greater on *microps* than on *merriami*. A significant difference was also noted between the greatest numbers of mites on a single rat when males were compared with females. The numbers of *O. linsdalei* and *Sasacarus* sp. "W" were greater on female *merriami*, whereas the number of *T. arenicola* was greater on female than on male *microps*. The numbers of *E. lacerta*, *E. radfordi* and *E. decipiens* were greater on male than on female *microps*.

Acarine symbiosis. Each species of mite that was collected occurred as the only species on its host in at least 20% of its collections. Three species of chiggers and two mesostigmatids occurred alone 50% or more of the time. One of the chiggers, *T. jessiemae*, was found as the only mite species on its host 67% of the time. The remaining species occurred alone up to 45% of the time. Some mites occurred as symbionts in certain combinations more frequently than did others. *Trombicula arenicola* was found with *O. linsdalei* nearly twice as often as it was alone. *Sasacarus* sp. "W" was associated with *T. arenicola* and *O. linsdalei* nearly 50% of the time. *Kleemannia* spp. occurred with the chigger *T. arenicola*, and *I. armatus* with *Kleemannia* spp. one-fourth of the time. Other combinations were found, but not in significantly large numbers.

Microhabitat. Inasmuch as the mesostigmatid mites were never found attached to their hosts, no data as to a preferred site of location on the animal were obtained. The chigger mites, which remain attached for prolonged periods, were found to prefer particular sites for attachment. *Sasacarus* sp. "W" was found only on the ears of its hosts, *O. linsdalei* was found predominantly on the ears and occasionally on the underparts of the hind legs, and *T. arenicola* was found predominantly on the underparts of the hind legs and only occasionally on the ears. No data are available on the site of attachment of other species found.

Plant community relationships. In communities where numbers of kangaroo rats were high, the numbers of mite species on the rats were also high. For example, in Grayia-Lycium (disturbed) and Mixed communities where rat numbers were high, 10 to 12 species of mites were collected. In Artemisia where rat numbers were low only two species of mites were collected.

Total mites collected varied from one community to another. Slightly higher numbers were observed in Artemisia, Atriplex-Kochia, Coleogyne, Grayia-Lycium, and Larrea-Franseria plant types than in the others.

In Atriplex-Kochia, *I. armatus*, *Kleemannia* spp., and *Sasacarus* sp. "W" were least common, whereas *T. arenicola* and *E. lacerta* were most common. *Odontacarus linsdalei* was least common in Artemisia, whereas *E. decipiens* was most abundant there. No species was particularly abundant in Lycium. In Larrea-Franseria *T. jessiemae* was least abundant, whereas *T. arenicola* was very common. *Euschöngastia radfordi* was least abundant there. Most species were found in abundance only in one or two communities, whereas *O. linsdalei* and *T. arenicola* were abundant in several communities.

Seasonal occurrence. Seasonally there were three main peaks of mite activity with respect to those species which were active most of the year. These peaks occurred in February-March, July, and October-November when mite numbers were about equal. Numbers during these periods were about six times greater than the numbers which occurred in January and April. These differences likely resulted from high numbers of chiggers. Numbers of the mesostigmatid *I. armatus* reached a high peak in October. Mites which were not active most of the year were found principally during the period from June through September.

New host records. The new host records that were established are *A. leviculus*, *T. jessiemae*, *E. radfordi* and *L. dipodomius* on *merriami* and *microps; H. glasgowi*, *O. linsdalei* and *T. arenicola* on *merriami;* and *H. triacanthus*, *I. armatus*, *E. lacerta* and *E. decipiens* on *microps.*

Effects of nuclear disturbance. Forty percent more animals in the undisturbed Grayia-Lycium were infested than in the nuclear disturbed Grayia-Lycium. Infested animals in the undisturbed areas had an average of three times as many mites as in disturbed areas. The maximum number of mites on any one host in the undisturbed was double the number in the disturbed. No significant difference in the number of species of mites was found between the two areas. About half of the species occurred in both areas in about equal numbers. *Ischyropoda armatus* and *Sasacarus* sp. "W" were considerably more abundant in undisturbed areas, whereas *E. radfordi* was most abundant in disturbed areas. *Odontacarus linsdalei*, *T. arenicola*, and *Sasacarus* sp. "W" infested more rats in undisturbed than in disturbed areas. *Haemolaelaps glasgowi*, *E. decipiens*, and *E. radfordi* infested more rats in disturbed than in undisturbed areas.

Morphological anomalies of chiggers. An occasional *T. arenicola* was found to have two anteromedial setae or an extra scutal seta. In many specimens the dorsal pattern of setae varied considerably. Dr. James M. Brennan stated (personal correspondence) that this variation was common for these chigger mites. An occasional *O. linsdalei* was found with three anteromedial setae instead of the common two. In each specimen other characteristics indicated it to be *O. linsdalei.*

One-hundred and nine *T. arenicola* possessed a stylostome which remained attached to the chigger when it was removed from its host's tissue. Several stylostomes were much longer than the chigger itself.

SUMMARY

A systematic study of parasitic mites on kangaroo rats of two species at the Nevada Test Site was conducted from August 1959 to December 1961. The intent was to determine the kinds, numbers, seasonal occurrences and ecological relationships of mites in nuclear disturbed and contiguous undisturbed areas. A total of 1,256 rats from nine plant communities was examined.

The 6,208 mites collected represented 16 species including four undescribed. Fourteen were found on both kinds of rats. Considerably more rats were infested with chiggers than with mesostigmatids. Each species of mite occurred alone on its host at least 20% of the time, and one species was found alone as much as 67% of the time. Chiggers of two species occurred predominantly on the ears of their hosts, whereas mites of another species were found principally on the underparts of the hind legs. Although most mite species were found in all plant communities, they occurred in abundance in only one or two. However, two species were abundant in several communities. Seasonal peaks in numbers of mites occurred during the three periods of February-March, July, and October-November. Forty percent fewer rats in the nuclear disturbed areas were infested than in undisturbed areas, and only one-third as many mites were found on rats in the disturbed as in the undisturbed areas.

LITERATURE CITED

Allred, D. M., and D E. Beck. 1963. Ecological distribution of some rodents at the Nevada atomic test site. Ecology, 44(1):211-214.

Allred, D. M., D E. Beck, and C. D. Jorgensen. 1963. Biotic Communities of the Nevada Test Site. Brigham Young University Science Bulletin, Biological Series, Vol. 2, No. 2.

Brennan, J. M., and D E. Beck. 1955. The Chiggers of Utah (Acarina: Trombiculidae). Great Basin Nat., 15(1-4):1-26.

Eads, R. B. 1951. New mites of the genus *Androlaelaps* Berlese. J. Parasitol., 37(2): 212-216.

Gould, D. J. 1956. The Larval Trombiculid Mites of California (Acarina: Trombiculidae). University of California Publications in Entomology, 11(1):1-115.

Loomis, R. B. 1956. The Chigger Mites of Kansas (Acarina, Trombiculidae). University of Kansas Science Bulletin, 37(19):1195-1443.

Radford, C. D. 1953. Four new species of "Harvest Mite" or "Chigger" and a new furmite (Acarina: Trombiculidae and Listrophoridae). Parasitol., 43(3 and 4):210-214.

Strandtmann, R. W. 1949. The blood-sucking mites of the genus *Haemolaelaps* (Acarina: Laelaptidae) in the United States. J. Parasitol., 35(3):325-352.

Strandtmann, R. W., and G. W. Wharton. 1958. A Manual of Mesostigmatid Mites Parasitic on Vertebrates. Institute of Acarology, University of Maryland, College Park, Contrib. No. 4.

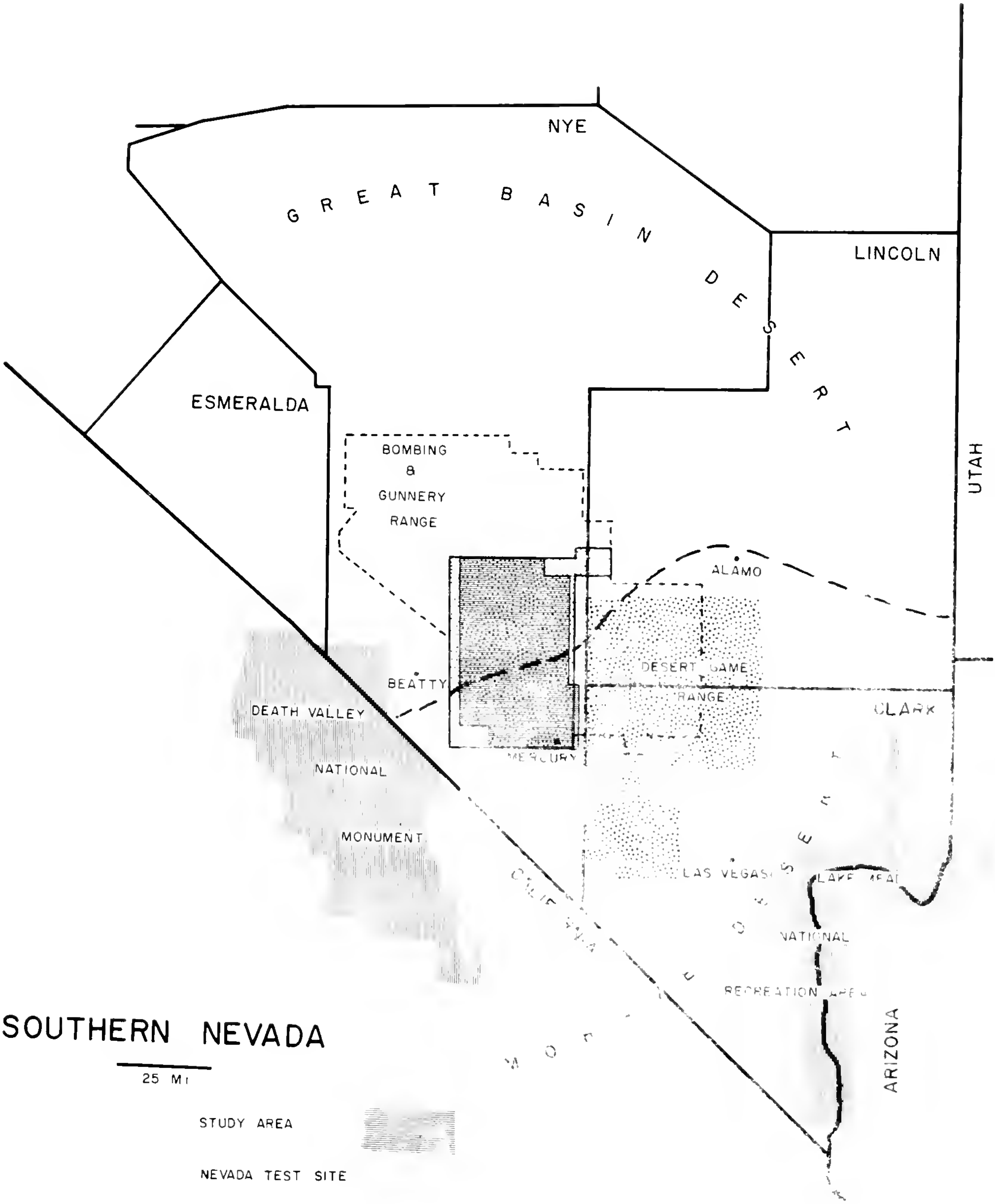

Fig. 1. Location of the Nevada Test Site

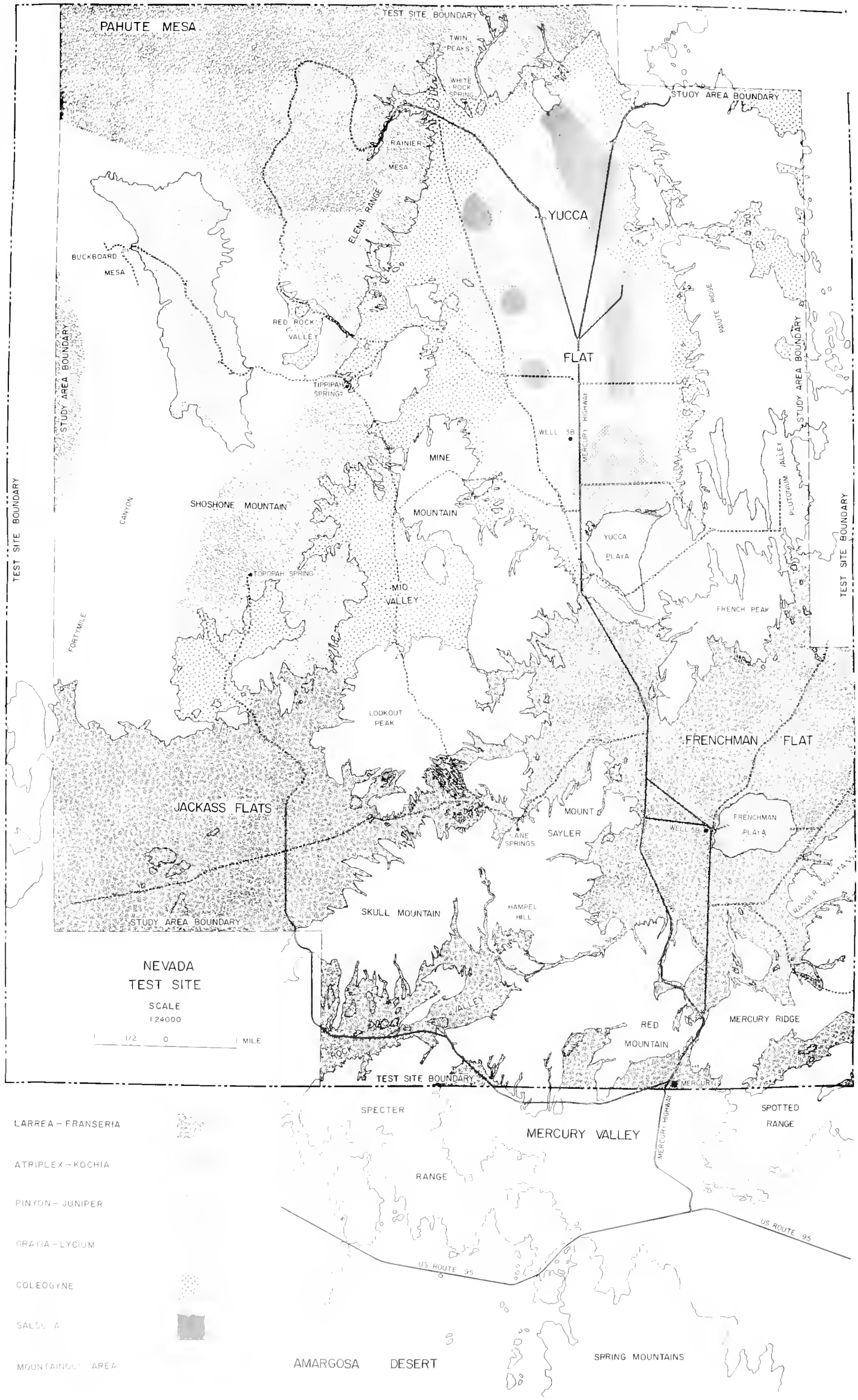

Fig. 2. Major plant communities at the Nevada Test Site.

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