TULANE STUDIES IN ZOOLOGY

Volume 12, Number 4 October 11, 1965

ECOLOGICAL DISTRIBUTION AND ACTIVITY PERIODS OF BATS OF THE MOGOLLON MOUNTAINS AREA OF NEW MEXICO AND ADJACENT ARIZONA

CLYDE JONES

Department of Biology, Tulane University
New Orleans, Louisiana

ABSTRACT

Data concerning ecology and distribution are presented and summarized for 19 species of bats from southwestern New Mexico and adjacent southeastern Arizona. Time of capture and air temperature at time of capture are given for all species. Environmental factors that may influence activity and distribution of bats are discussed.

INTRODUCTION

Few observations have previously been published on bats in New Mexico, and information on general ecology has often been incidental to distributional or taxonomic studies. Bailey (1931), while presenting geographic ranges of bats known from New Mexico, made some mention of ecology and natural history. More recently, limited ecological information has been contributed by Mumford (1957, 1964), Commissaris (1959), Findley (1960), Constantine (1961a, b), Harris (1963), and others. Sheppard (1962) assembled natural history and ecological data for the species of bats occurring in Bernalillo Co., New Mexico.

The purpose of this report is to furnish information concerning distribution and general ecology and to discuss briefly the factors that may influence activity and distribution of bats of the Mogollon Mountains area of southwestern New Mexico and adjacent southeastern Arizona.

DESCRIPTION OF THE AREA

Fenneman (1931) included the northern part of the study area (north of 33° N lat) in the Datil section of the Colorado Plateau physiographic province and the southern part (south of 33° N lat) in the Mexican Highland division of the Basin and Range province. The study area is composed of a portion of the Mogollon Rim and several semi-isolated and isolated smaller mountain ranges bordered on the north by the closed basin of the San Augustin Plains and on the east and south by the Rio Grande and Gila River drainages (Fig. 1). From the lowest elevation of 3,800 ft on the Gila River at the Arizona-New Mexico border the altitude rises to 10,788 ft in elevation at the highest point, Mogollon Peak. Precipitation in the area is variable, ranging from about 10 to 16 inches annually (little or no weather data are available from montane areas), with the heaviest rainfall occurring in July and August (Hardy, 1941).

The Mogollon Mountains area has biotic communities characteristic of the southern Rocky Mountains (Lowe, 1964). For the purposes of this study, three biotic communities are recognized.

Xeric-shrub grassland.—Present and widespread below 6,000 ft except for restricted stands of evergreen and deciduous vegetation on north-facing slopes and canyon

EDITORIAL COMMITTEE FOR THIS PAPER:

ANDREW A. ARATA, Associate Professor of Zoology, Tulane University, New Orleans, Louisiana

DR. MARTIN EISENTRAUT, Museum Alexander Koenig, Bonn, West Germany

PHILIP H. KRUTZSCH, Professor and Head of Anatomy, College of Medicine, University of Arizona, Tucson, Arizona

floors. Conspicuous species of plants found in the xeric-shrub grassland are *Muhlenbergia wrightii, Bouteloua gracilis, Atriplex canescens, Chrysothamnus* spp., *Larrea tridentata, Prosopis juliflora,* and *P. pubescens* with *Populus* spp., *Tamarix gallica,* and *Eleagnus angustifolia* commonly riparian.

Evergreen-deciduous woodland.—Present throughout the study area from below 5,000 ft on north-facing slopes to above 7,000 ft on ridges and south-facing slopes. Some plants that make up the evergreen-deciduous woodland are *Juniperus monosperma, J. scopulorum, J. deppeana, Pinus edulis, Quercus grisea, Q. gambelii,* and *Cercocarpus breviflorus.*

Evergreen forest.—Widespread above 7,000 ft, present in restricted stands at lower elevations and in heads of cool, mesic canyons. Some common species of plants of the evergreen forest are *Pinus ponderosa, P. flexilis, P. edulis, Picea engelmannii, P. pungens, Abies concolor, A. lasiocarpa, A. lasiocarpa* var. *arizonica, Pseudotsuga mensiesii, Quercus gambelii,* and *Populus tremuloides* with *Salix* spp., *Alnus tenuifolia,* and *Acer* spp. often riparian.

Methods and Materials

Bats were, for the most part, captured in mist nets stretched across water tanks, over ponds and streams, or over entrances to mines and caves. Nets were maintained ordinarily for 5 to 6 hrs per night. Attempts were often made to maintain nets all night, however, nets frequently were left standing unattended all night and were checked during the early morning hours. In addition to those netted, a few bats were shot. Most data presented here were gathered in 1960, but limited field studies were conducted from 1958 through 1963.

Whenever possible, time of capture, air temperature at the time of capture, and sex

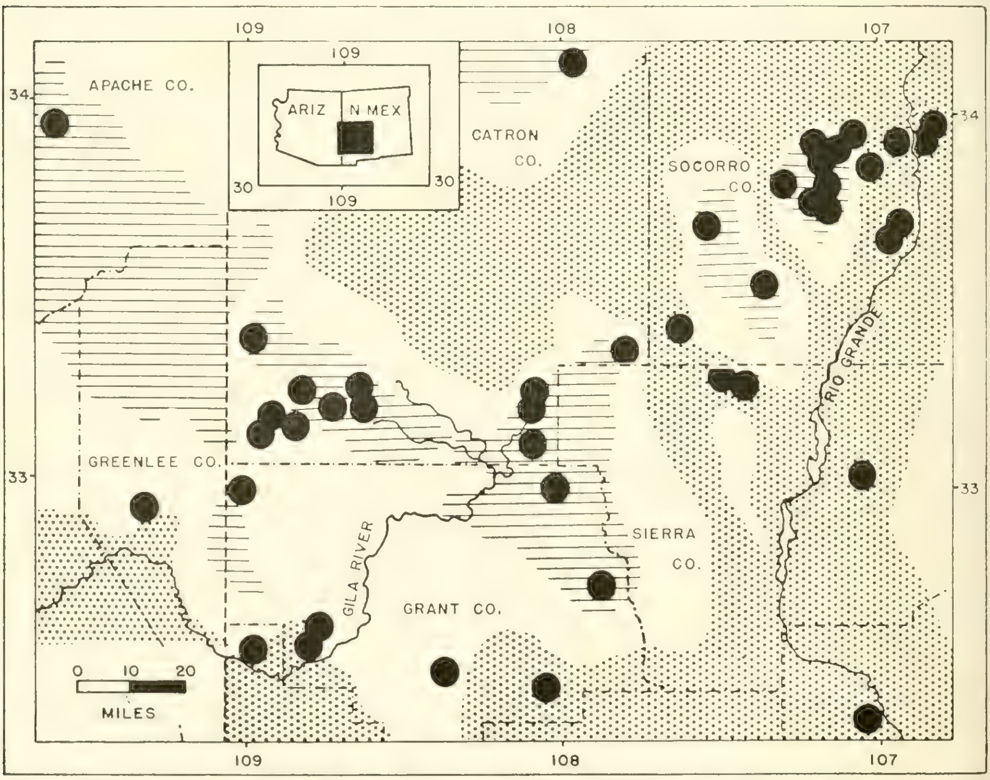

Figure 1. Map of the study area showing biotic communities and collecting stations. Evergreen forest is represented by lined areas, evergreen-deciduous woodland is represented by white areas, and xeric-shrub grassland is represented by stippled areas. The distribution of collecting stations is a reflection of the presence of permanent water over which to sample bats.

of each individual were recorded upon collection of the bat. Data on time of capture and air temperature at the time of capture were analyzed and compared by means of standard statistical methods; arithmetic mean, standard deviation, and standard error of the mean were computed. Because there were no significant differences between the two sexes in time of capture or air temperature at time of capture, data for males and females were combined. Weather conditions were noted in an attempt to determine the role of such factors as wind, rain, and moonlight in relation to activity of the animals studied.

In all, 1595 specimens were obtained from the study and were preserved in the Museum of Southwestern Biology at the University of New Mexico either as standard museum study skins and skulls with carcasses preserved in fluid or were preserved entire in fluid.

Results

The Chiropteran fauna of each of the biotic communities is summarized in Table 1. On the basis of the data presented herein, 13 species of bats are considered to be highland forms (greatest percentage of individuals collected were from localities in evergreen forest generally above 7,000 ft in elevation), and six species are regarded as lowland forms (greatest percentage of individuals collected were taken at localities in xeric-shrub grassland and evergreen-deciduous woodland mostly below 7,000 ft in elevation). *Myotis occultus* is equally

Table 1.

Percentage of each species and percentage of all bats collected in each biotic community, as well as bats collected per station (number of bats collected in a community divided by the number of collecting stations in that community) in each biotic community.

	Total number taken	Percent of total number taken in xeric-shrub grassland	Percent of total number taken in evergreen-deciduous woodland	Percent of total number taken in evergreen forest	Bats taken per station in xeric-shrub grassland	Bats taken per station in evergreen-deciduous woodland	Bats taken per station in evergreen forest
Myotis californicus	22		35.0	65.0		.77	.68
Myotis evotis	61			100.0			3.05
Myotis keenii	42		14.3	85.7		.66	1.86
Myotis occultus	66	45.5		54.5	2.0		1.80
Myotis subulatus	35	13.5	21.5	65.0	.33	.88	1.26
Myotis thysanodes	84		4.7	95.3		.44	4.31
Myotis velifer	3	33.4	66.6		.06	.22	
Myotis volans	226		2.6	97.4		.66	11.00
Myotis yumanensis	137	89.6	5.2	5.2	3.46	.33	.15
Lasionycteris noctivagans	105		25.8	74.2		3.00	4.10
Pipistrellus hesperus	43	58.1	39.5	2.4	1.66	1.42	.05
Eptesicus fuscus	277	1.5	9.0	89.5	.26	2.77	12.40
Lasiurus borealis	4		100.0			.44	
Lasiurus cinereus	191	2.2	41.3	56.5	.26	8.77	5.86
Plecotus phyllotis	31		9.7	90.3		.33	1.47
Plecotus townsendii	39	8.0	18.4	73.6	.20	.77	1.47
Euderma maculatum	7			100.0			.36
Antrozous pallidus	95	45.2	37.4	17.4	2.86	4.00	.84
Tadarida brasiliensis	126	32.8	54.4	12.8	2.73	7.55	.84
Tadarida molossa	1			100.0			.05
Total	1595	13.7	19.9	66.4	13.80	33.50	50.30

distributed in the xeric-shrub grassland and in evergreen forest, whereas *Myotis evotis* is restricted to the evergreen-forest community. *Myotis velifer, Lasiurus borealis, Euderma maculatum,* and *Tadarida molossa* were taken on too few occasions to determine the true habitats of the species. *Lasionycteris noctivagans* and *Lasiurus cinereus,* considered here as highland species, were taken at lower elevations during April, May, and June, but were more abundant at higher elevations in July and August. Vaughan and Krutzsch (1954) suggest a similar distribution for *L. cinereus* in southern California.

The seasonal distributions of each species of bats is summarized in Table 2. Four species (*Myotis velifer, Lasiurus borealis, Euderma maculatum,* and *Tadarida molossa*) perhaps are represented by insufficient numbers to give a valid indication of seasonal distributions of the species. Bats were most abundant in the study area during June and July (Table 2) and were least abundant during August. Females were more abundant than males in April and May, but males were slightly more abundant than females during the remainder of the season of study.

The range of time, expressed in minutes after sunset, in which each species was active is presented in Fig. 2. Three species (*Myotis californicus, M. occultus,* and *Pipistrellus hesperus*) were active mostly during the first 1 hr and 40 min after sundown. Mumford (1964) and Cockrum and Cross (1964) present similar data for *P. hesperus.* Other species (*Myotis evotis, M. subulatus, M. velifer, M. yumanensis, Lasiurus cinereus, Plecotus townsendii, Euderma maculatum, Antrozous pallidus,* and *Tadarida brasiliensis*) seemingly have a later period of activity, mostly after the first 1 hr and 40 min after sundown. The seven remaining species seem to be active during a period intermediate to the two aforementioned groups. The data indicate peaks in the activity of the animals during the first 2 hrs after sunset (Fig. 2). In only one case was predawn collecting successful.

Air temperature at capture is given for each species in Fig. 3. For those species where ten or more individuals are represented, a few general trends are suggested: *Plecotus phyllotis* was taken in a narrow range of temperature from 9 to 17° C, whereas *Lasionycteris noctivagans* (minus 2 to 20° C), *Lasiurus cinereus* (0 to 22° C), and *Tadarida brasiliensis* (7 to 27 °C) were active through a wide range. A high temperature preference, mostly above 20° C, was shown by *Myotis velifer, Lasiurus bore-*

TABLE 2.

Numbers of bats of each species taken per night each month (number of bats collected each month divided by the number of nights bats were collected in each month). The total number of times bats were collected each month is given in parentheses with the name of each month.

	Total taken	April (9)	May (7)	June (36)	July (27)	Aug. (12)	Sept. (9)	Oct. (1)
Myotis velifer	3			.08				
Tadarida molossa	1				.03			
Lasiurus borealis	4		.14	.08				
Myotis occultus	66			1.08	.85	.33		
Plecotus phyllotis	31	.22		.36	.59			
Myotis californicus	22		.29	.36	.18		.22	
Myotis subulatus	35	.66		.44	.37	.25		
Myotis evotis	61		.14	.36	1.18	.41	1.11	
Myotis keenii	42	.44		.50	.28	.75	.44	
Pipistrellus hesperus	43	.22	.57	.69	.29	.33		
Antrozous pallidus	95	1.22	.29	2.09	.22		.11	
Myotis thysanodes	84	1.33	.14	1.16	.77	.16	.66	
Myotis volans	226	.77	.14	2.47	3.25	1.08	3.11	
Myotis yumanensis	137	.44	.14	.33	.77	.16	10.77	
Plecotus townsendii	39	.11	.29	.33	.11	.41	1.77	
Tadarida brasiliensis	126	.33	.29	1.55	.96	1.25	2.66	
Lasiurus cinereus	191	.44	7.85	3.02	.70		.22	1.00
Lasionycteris noctivagans	105	1.00	1.42	2.03	.29	.08	.33	1.00
Eptesicus fuscus	277	.44	.71	4.30	2.03	.91	4.77	4.00
Total	1595	7.66	12.57	21.47	12.92	6.16	26.22	6.00

alis, and *Euderma maculatum*; however, these data represent less than ten observations each, and thus may not be meaningful.

Discussion

The data presented in Table 1 provide an indication of the habitat of the various species of bats found within the study area. Inasmuch as the number of times collections were made within each plant community and the number of localities from which collections were made varied, bats collected per station may be the least biased means of comparing habitats.

The great abundance of bats in the early part of the collecting season is due to the presence of relatively large numbers of fe-

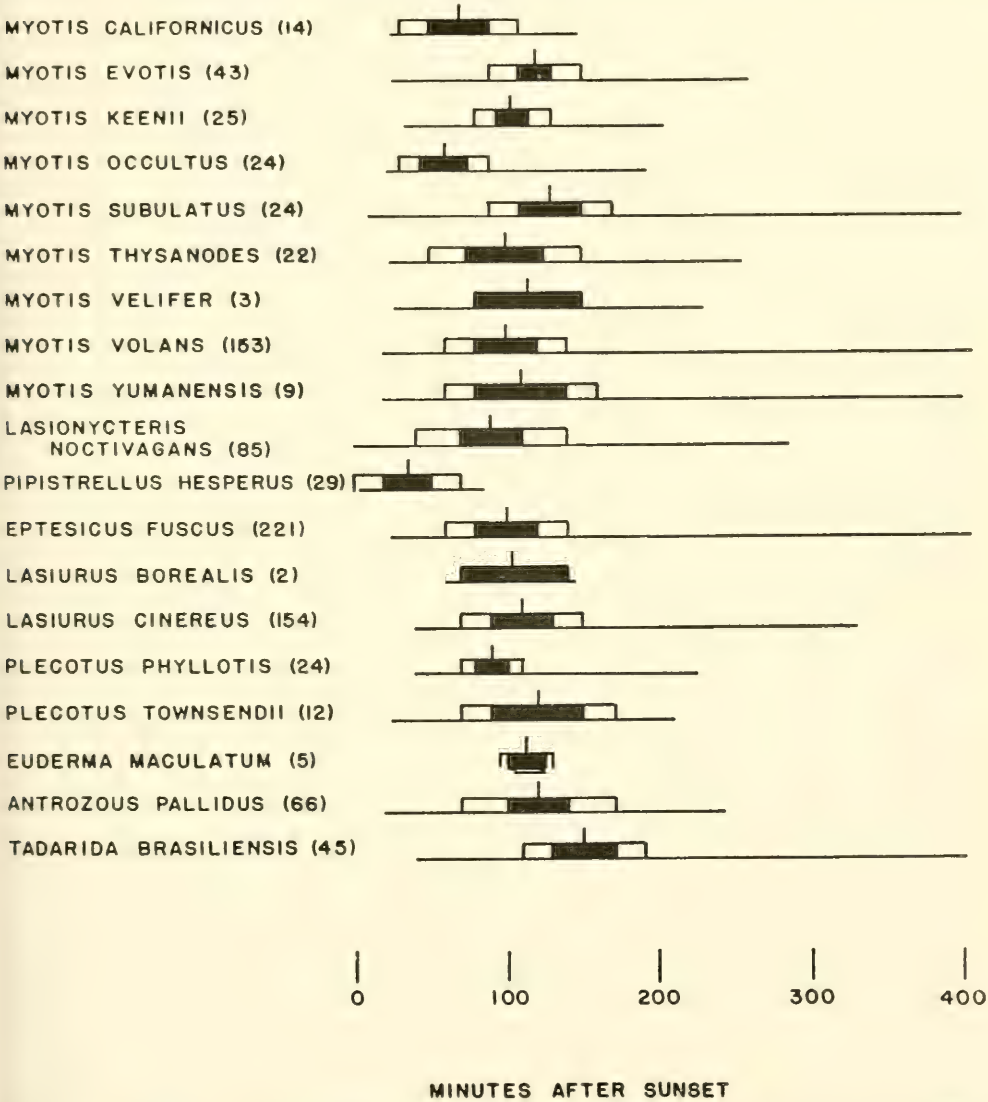

Figure 2. Range of time, expressed in minutes after sunset, in which each of 19 species of bats was active. The horizontal line represents the range, the central vertical line indicates the arithmetic mean, the shaded area represents plus or minus two standard errors of the mean, and the unshaded area encloses plus or minus one standard deviation. For each species, the total number of bats for which data are available is given in parentheses. Time of sunset was corrected for latitude after being taken from tables furnished by the United States Weather Bureau.

males, whereas the numbers of bats present later in the season may be the result of premigratory or prehibernatory groupings of some species (Table 2). The abundance of certain species (*Lasionycteris noctivagans* and *Lasiurus cinereus*) early and again late in the collecting season is a reflection of migratory movements of these animals through the study area (Findley and Jones, 1964). The small numbers of bats taken in the study area during August may have been caused by heavy rains during late July and August and resultant abundance of watering places. Observations during the rainy period indicated some decrease in numbers of bats in areas where heavy concen-

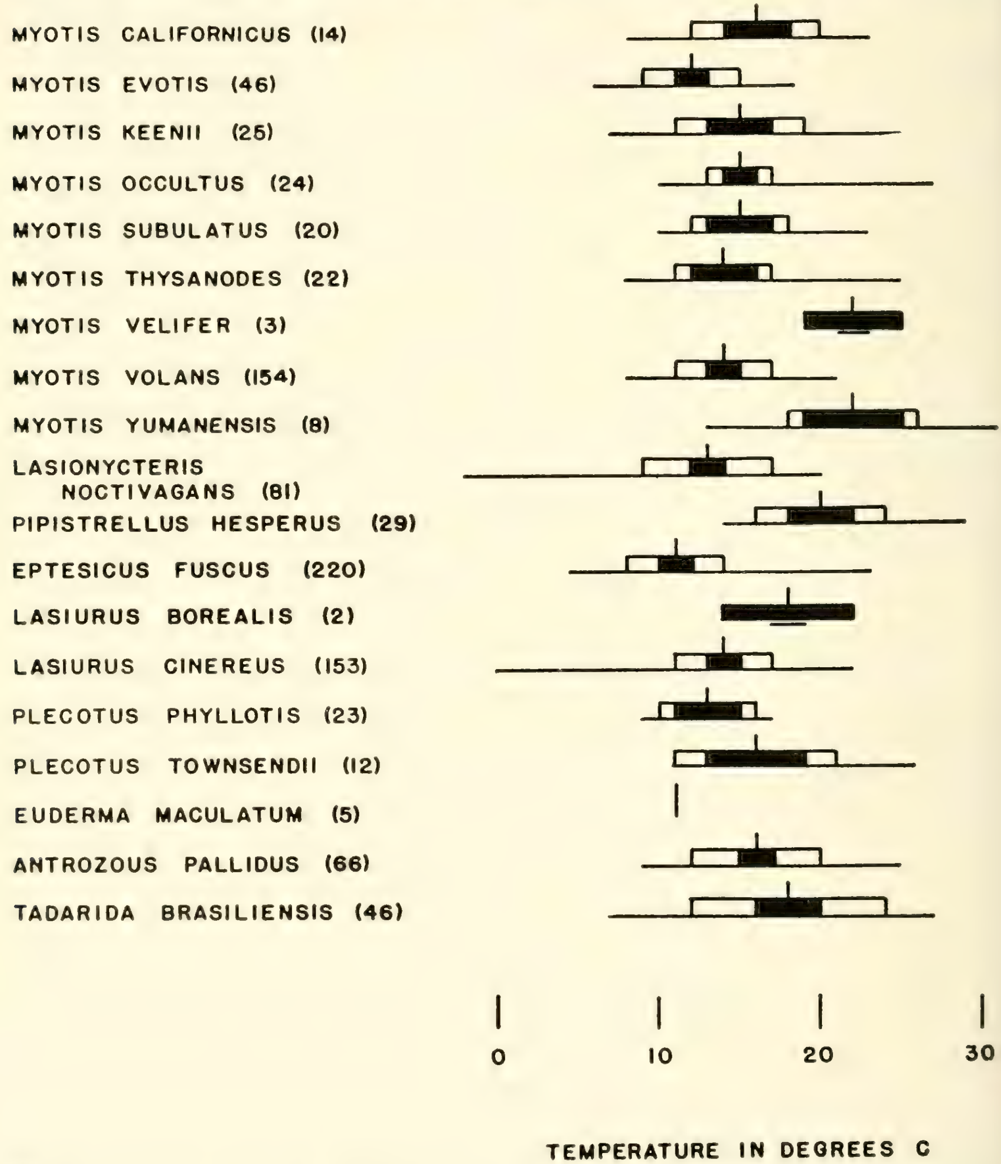

Figure 3. Range of air temperature in which each of 19 species of bats was active. The horizontal line represents the range, the central vertical line indicates the arithmetic mean, the shaded area represents plus or minus two standard errors of the mean, and the unshaded area encloses plus or minus one standard deviation. For each species, the total number of bats for which data are available is given in parentheses.

trations were previously noted. Because of the increased availability of drinking water, bats probably were more widely dispersed during late July and August. Although water-hole samples of bats are considered herein as indicators of the entire community, it is realized that there is differential probability in the capture of bats in mist nets (Cockrum and Cross, 1964).

Bats are well known for marked periodicites in their normal habits (Griffin and Welsh, 1937). During the summer, bats of the species considered here probably spend the day in roosts and emerge after sundown to seek food and water. Depending perhaps on the abundance of food and on temperature, bats may return to the roosts after a time or may forage throughout the night. Gould (1961) reported that light intensity and rain are important factors that influenced the time of emergence of *Tadarida femorosacca,* and suggested that temperature and total solar radiation during the day did not affect the time of emergence. Baker (1961) noted a general trend in the emergence of *Tadarida brasiliensis* from late times of flight in May to early times of flight in October. Analysis of the data presented in Figs. 2 and 3 indicated that there is some correlation between air temperature and time capture of some species of bats. Members of one species, *Myotis evotis,* were active during a low range of temperature and were captured at time somewhat later than other related species, but for another species, *Pipistrellus hesperus,* the converse was true. Some bats (*Myotis yumanensis* and *Pipistrellus hesperus*) that were active during warm temperatures were taken either for a short period of time early in the evening or were active for longer periods of time only when warm temperatures prevailed. Drinking and feeding activity of bats apparently is correlated with the air temperature. Any relationship of temperature to the time of emergence of the species considered here is obscured by the nature of the data. The observations reported here do not permit speculation as to the distance bats may travel from roosts to watering areas and no evidence is available as to how soon after leaving the diurnal roosts bats approach water surfaces. Some bats may fly directly from roosts to water (Hayward and Davis, 1964), but other bats may follow an indirect route to water.

In general, the ranges of temperatures in which the species of bats were active coincide with distribution and habitat of the animals. The species *(Plecotus phyllotis)* that was active in a narrow range of temperature (9 to 17° C) is more limited in geographic distribution than those species (*Lasionycteris noctivagans* and *Lasiurus cinereus*) that were active through a wide range of temperature (minus 2 to 20° C and 0 to 22° C). *Myotis evotis,* for which a low temperature preference was indicated (6 to 18° C), was not taken at low elevations (below 7,000 ft) and *Myotis velifer, M. yumanensis,* and *Pipistrellus hesperus,* for which high temperature preferences were indicated (21 to 23° C, 19 to 31° C, and 14 to 29° C), were rarely taken at high elevations (above 7,000 ft). Preference for high temperatures suggest that some of the so-called lowland species of bats (*Myotis velifer, M. yumanensis,* and *Pipistrellus hesperus*) possibly are incapable of inhabiting highland areas, at least within the latitudes encompassed in this study. The converse may be true for the so-called highland form *(Myotis evotis).* On the other hand, the data indicate that some species (*Lasionycteris noctivagans* and *Lasiurus cinereus*), for which low temperature preferences are suggested, inhabit regions of high or low elevation and north or south latitudes concordant with season.

Activity of the bats included here, seemingly, was not affected by weather conditions, although Sheppard (1962) and Gould (1961) suggest that factors such as wind, humidity, cloud cover, and moonlight may influence the activity of bats. Wind and moisture seemed to influence only the number of bats caught, not the number observed. On many occasions bats were seen drinking, flying about, and striking a net blown so tightly by the wind that no animals became entangled in the mesh. Several times bats were captured when foggy conditions prevailed and on a few occasions were taken during heavy showers.

Distribution of certain tree-roosting bat species is influenced by vegetation. For the other species of bats reported herein, few data are available to indicate any direct correlation between bat distribution and specific vegetation. Distribution of bats perhaps is influenced by the availability of suitable roosting sites, proper amounts of food materials, and adequate water surfaces for drinking. Temperatures must be considered an important factor influencing certain activities and, perhaps, the distribution of bats.

Summary

Of the 19 species of bats occurring in the study area, 13 species were collected in highland areas (above 7,000 ft), six species were taken in lowland regions (below 7,000 ft), and one species was distributed equally in lowland and in highland areas. Only one species was restricted in distribution to a particular community.

Bats were most abundant in the study area during June and July. Females outnumbered males in the spring, but males were slightly more abundant than females during the summer and early fall.

Three species of bats were active during the first 1 hr and 40 min after sundown, nine species were active during a later period of time, and seven species were active during a period intermediate to the aforementioned groups.

Some species were taken in a narrow range of temperature (8° C); other species were taken in a wide range (20° C). Preferences for high temperatures were indicated by three species and preferences for low temperatures were detected for several species. The ranges of temperatures in which bats were active correlate with distribution and habitat of the animals.

Acknowledgments

James S. Findley, Eugene Fleharty, David Niles, John Wright, Eugene Schroeder, Arthur Harris, and Dick Forbes either helped in the field or contributed specimens from the study area. I received financial assistance from the National Science Foundation during 2 months in each of the summers of 1958 and 1959, and for 3 months during the summer of 1960.

Literature Cited

Bailey, V. 1931. Mammals of New Mexico. *N. Am. Fauna* 53:1-412.

Baker, J. 1961. What about bats? *Carlsbad Caverns Nat. Hist. Assoc.* 55 p.

Cockrum, E. L., and S. Cross. 1964. Time of bat activity over water holes. *J. Mammal.* 45:635-636.

Commissaris, L. 1959. Notes on the Yuma *Myotis* in New Mexico. *J. Mammal.* 40: 441-442.

Constantine, D. 1961a. Locality records and notes on western bats. *J. Mammal.* 42:404-405.

Constantine, D. 1961b. Spotted bat and big free-tailed bat in northern New Mexico. *Southwestern Nat.* 6:92-97.

Fenneman, N. 1931. *Physiography of western United States.* McGraw-Hill Book Company, Inc., New York. 714 p.

Findley, J. 1960. Identity of the long-eared Myotis of the Southwest and Mexico. *J. Mammal.* 41:16-19.

Findley, J., and C. Jones. 1964. Seasonal distribution of the hoary bat. *J. Mammal* 45:461-470.

Gould, P. 1961. Emergence time of *Tadarida* in relation to light intensity. *J. Mammal.* 42:405-407.

Griffin, D., and J. Welsh. 1937. Activity rhythms in bats under constant external conditions. *J. Mammal.* 18:337-342.

Hardy, E. 1941. *Climate of New Mexico. In* Climate and Man, Yearbook of Agriculture: 1011-1024. U. S. Dept. of Agriculture, Washington, D. C.

Harris, A. 1963. Ecological distribution of some vertebrates in the San Juan Basin, New Mexico. *Museum of New Mexico Press, Papers in Anthropol.* 8:1-63.

Hayward, B., and R. Davis. 1964. Flight speeds in western bats. *J. Mammal.* 45: 236-242.

Lowe, C. 1964. *Arizona landscapes and habitats. In* Vertebrates of Arizona. Univ. Arizona Press, Tucson. 132 p.

Mumford, R. 1957. *Myotis occultus* and *Myotis yumanensis* breeding in New Mexico. *J. Mammal.* 38:260.

Mumford, R. 1964. June bat records from Guadalupe Canyon, New Mexico. *Southwestern Nat.* 9:43-45.

Sheppard, F. 1962. An annotated checklist of the bats of Bernalillo County, New Mexico. *M. S. Thesis. Univ. New Mexico.* 101 p.

Vaughan, T., and P. Krutzsch. 1954. Seasonal distribution of the hoary bat in southern California. *J. Mammal.* 35:431-432.