Myotis yumanensis (Chiroptera: Vespertilionidae)

Janet K. Braun, Blia Yang, Sara B. González-Pérez, and Michael A. Mares

Sam Noble Museum, University of Oklahoma, 2401 Chautauqua Avenue, Norman, OK 73072, USA; jkbraun@ou.edu (JKB)
Department of Zoology, University of Oklahoma, Norman, OK 73072, USA; bliayang@ou.edu (BY)
Sam Noble Museum and Department of Zoology, University of Oklahoma, Norman, OK 73072, USA; gops@ou.edu (SBG-P);
mamares@ou.edu (MAM)

Abstract: *Myotis yumanensis* (Allen, 1864) is a vespertilionid bat commonly called the Yuma myotis. The species exhibits considerable geographic variation in coloration and size. It is 1 of about 100 species of *Myotis* worldwide and 1 of 17 species of *Myotis* in the United States. Although common throughout western North America generally at low elevations in desert or semidesert habitats, it is absent from the Great Basin. It is not of special conservation status, but protection of habitat especially along stream corridors is a concern.

Key words: bat, Canada, Mexico, North America, United States, vespertilionid, Yuma myotis

www.mammalogy.org

Myotis yumanensis (Allen, 1864)
Yuma Myotis

Vespertilio yumanensis H. Allen, 1864:58. Type locality "Fort Yuma," Imperial County, California. Restricted to "Old Fort Yuma" by Miller (1897:66) and modified to "Old Fort Yuma, Imperial County, California, on right bank of Colorado River, opposite present town of Yuma, Arizona" by Miller (1924:69).

Vespertilio nitidus H. Allen, 1864:60. Part, not *V. oregonensis*. Specimens listed given on pages 61 and 62 contain several species, including *yumanensis*, that now are recognized.

V[espertilio]. obscurus H. Allen, 1866:281. Type locality "Lower California" [Baja California], Mexico. Part, not *V. oregonensis* Allen 1864:61.

V[espertilio]. macropus H. Allen, 1866:288. Type locality "near Fort Majaor, Colorado River, New Mexico;" corrected to "near Fort Major, Colorado River, New Mexico" by H. Allen (1893:100) and corrected to "Colorado River, near Fort Mojave, [Mojave County], Arizona" by Lyon and Osgood (1909:271). Preoccupied by *Vespertilio macropus* Gould, 1854:pl. 47.

Vespertilio lucifugus Dobson, 1878:328. Part, not Leconte, in McMurtrie 1831:431.

Vespertilio nitidus (pedomorphic variety) H. Allen, 1893:72, 73. Not H. Allen, 1862:247.

Vespertilio gryphus lucifugus Var. (a) H. Allen, 1893:78. Part. Specimens listed given on pages 79 and 80 contain several species, including *yumanensis*, that now are recognized.

Vespertilio gryphus Var. (b) H. Allen, 1893:80. Part. Specimens listed given on page 86 contain several species, including *yumanensis*, that now are recognized.

Vespertilio albescens H. Allen, 1893:72, 87. Part, not Geoffroy Saint-Hilaire, 1806:204. Specimens listed given on page 88 contain several species, including *yumanensis*, that now are recognized. But see also *Vespertilio nitidus macropus* H. Allen, 1893:100.

Fig. 1.—An adult *Myotis yumanensis* in flight. Copyright by J. Scott Altenbach.

Vespertilio nitidus Var. (a) *Vespertilio nitidus macropus*: H. Allen, 1893:100. Name combination; considered a pedomorphic variety of *V. nitidus*.

Myotis yumanensis: Miller, 1897:66. First use of current name combination.

Myotis yumanensis saturatus Miller, 1897:68. Type locality "Hamilton," Skagit County, Washington. Not *Myotis lanaceus saturatus* Kuzyakin, 1934 (not seen cited in Horáček et al. 2000; see "Nomenclatural Notes").

Myotis californicus Miller, 1897:69. Part, not Audubon and Bachman, 1842:285.

Myotis californicus durangae J. A. Allen, 1903:612. Type locality "Rio Sestin, northwestern Durango," Mexico.

Myotis californicus durangoae Trouessart, 1904:93. Incorrect subsequent spelling of *Myotis californicus durangae* J. A. Allen, 1903.

Myotis californicus durangoe Elliot, 1905:478. Incorrect subsequent spelling of *Myotis californicus durangae* J. A. Allen, 1903.

Myotis yumanensis yumanensis: Miller, 1912:56. Name combination.

Myotis yumanensis sociabilis H. W. Grinnell, 1914:318. Type locality "Old Fort Tejon, 3200 feet altitude, Kern County, California;" modified to "Old Fort Tejon, Tehachapi Mountains, Kern County, California" by Dalquest (1947:227).

Myotis yumanensis sociabilis G. M. Allen, 1919:1. Not *Myotis yumanensis sociabilis* H. W. Grinnell, 1914.

Myotis yumaensis yumaensis Strecker, 1926:9. Incorrect subsequent spelling of *Myotis yumanensis yumanensis* Miller, 1912.

Myotis lucifugus phasma Miller and G. M. Allen, 1928:53. Type locality "Snake River, south of Sunny Peak, Routt County, Colorado."

Myotis yumanensis lutosus Miller and G. M. Allen, 1928:72. Type locality "Patzcuaro, Michoacan, Mexico."

Myotis yumanensis lambi Benson, 1947:45. Type locality "San Ignacio, lat. 27°17′," Baja California Sur, Mexico."

Myotis yumanensis oxalis Dalquest, 1947:228. Type locality "Oxalis, San Joaquin Valley, Fresno County, California."

Myotis yumanensis phasma: Harris and Findley, 1962:192. Name combination.

CONTEXT AND CONTENT. Order Chiroptera, family Vespertilionidae, subfamily Myotinae, genus *Myotis* (Simmons 2005). Six subspecies are recognized (Simmons 2005):

M. y. lambi Benson, 1947:45. See above.
M. y. lutosus Miller and G. M. Allen, 1928:72. See above.
M. y. oxalis Dalquest, 1947:228. See above.
M. y. saturatus Miller, 1897:68. See above.
M. y. sociabilis H. W. Grinnell, 1914:318. See above.
M. y. yumanensis H. Allen, 1864:58; see above; *durangae* J. A. Allen, *macropus* H. Allen, *obscurus* H. Allen, *phasma* Miller and G. M. Allen are synonyms.

NOMENCLATURAL NOTES. Some authors have suggested that an older name for this species may be *subulatus* Say in James (1823). Glass and Baker (1965) recommended that *subulatus* be suppressed, but Koopman (1994) suggested that *subulatus* is an older name for this species. Hall (1981) used *subulatus* for the species currently recognized as *Myotis leibii*.

No holotype was designated in the original description by Allen (1864); specimen catalog numbers 5367 (a lot of 36 individuals, although the catalog of the United States National Museum of Natural History [USNM] records only 8—Lyon and Osgood 1909:291), 6019, 6020, and 6021 (all alcoholic preparations) are listed as syntypes by Allen (1864:59). Allen (1866:285) later records that it, "is unfortunate that the original specimens of this bat, recorded in the Memoir [H. Allen 1864], are unavailable for comparison. They were mislaid during the fire at the Smithsonian Institution in January, 1865, and have not since been found." To date, no neotype has been selected to replace the syntypes, which were destroyed or lost. Specimen catalog number USNM 5537 listed by Allen (1866:284) was not located in the USNM database as of 2 April 2009; earlier, Allen (1864:60) had listed this specimen as *Vespertilio nitidus* and later Miller (1897:38) indicated that this specimen was *M. californicus* based on the "very small hind foot."

Descriptions of the type specimens in the USNM are given by Lyon and Osgood (1909) and Poole and Schantz (1942). Type specimens for all names given above are present in the collections at the American Museum of Natural History (*durangae* AMNH 21459), Museum of Vertebrate Zoology (*lambi* MVZ 38194; *oxalis* MVZ 102011; *sociabilis* MVZ 5158), or USNM (*lutosus* USNM 50783; *macropus* USNM 84549; *obscurus* USNM 8223; *phasma* USNM 148159; *saturatus* USNM 17399).

The original tag for the type specimen of *Myotis californicus durangae* has the locality as "Mex. Dur. San Gabriel" and date as "16 June 1903" not "Rio Sestin" and "15 April 1903" as given in the type description (Allen 1903:612; research.amnh.org/mammalogy/types/detail.php).

Myotis lanaceus saturatus was described by Kuzyakin (1934) and replaced with *kuzyakini* by Rossolimo and Pavlinov (1979; not seen cited in Simmons 2005). These names currently are synonyms of *Myotis emarginatus emarginatus* (Simmons 2005).

DIAGNOSIS

Myotis yumanensis (Fig. 1) is distinguished from other species of North American *Myotis* (*M. californicus*—Californian myotis, *M. ciliolabrum*—western small-footed myotis, *M. melanorhinus*—dark-nosed small-footed myotis, and *M. volans*—long-legged myotis) by the absence of a keeled calcar. Compared with *M. vivesi* (fish-eating myotis), *M. yumanensis* has a smaller forearm (< 38 versus > 56 mm) and compared with *M. fortidens* (cinnamon myotis), *M. yumanensis* has premolars 3/3 versus 2/2. *M. yumanensis* has a length of ear < 16 mm and ears extending < 2 mm beyond the nose when laid forward, whereas *M. evotis* (long-eared myotis) and *M. auriculus* (southwestern myotis)

have ear lengths > 16 mm and extending > 2 mm beyond the nose when laid forward. *M. yumanensis* is distinguished from *M. peninsularis* (peninsular myotis) and *M. thysanodes* (fringed myotis) by the absence of a sagittal crest and fringed uropatagium, respectively. Compared with *M. velifer* (cave myotis), *M. yumanensis* lacks a sagittal crest, has a greatest length of skull < 15 mm, and a length of forearm < 38 mm.

Myotis yumanensis is most similar to *M. lucifugus*, little brown myotis (Miller and Allen 1928; Villa Ramírez 1967; Barbour and Davis 1969; Harris 1974; Parkinson 1979; Hall 1981; Herd and Fenton 1983; Adams 2004). However, compared with *M. lucifugus*, *M. yumanensis* has dorsal hairs that are shorter with paler tips, the pelage is duller and not glossy, the ears are paler, the tragus is larger and has a semicircular border, and the tail is relatively longer. *M. yumanensis* generally is smaller in size (length of forearm 32–38 versus 33–41 mm; greatest length of skull < 14 versus > 14 mm), the braincase rises at an abrupt angle from the rostrum, and the mastoid breadth is smaller. *M. yumanensis* and *M. lucifugus* also differ in wing morphology and flight performance (Aldridge 1986). Mean wingspan (0.24 versus 0.25 m), aspect ratio (6.69 versus 6.80), and length of forearm (35 versus 38 mm) differ significantly between the 2 species.

Myotis yumanensis and *M. lucifugus* are more similar in size and appearance west of the Continental Divide in Colorado (Davis and Barbour 1970; Parkinson 1979). In a study of field identification of *M. yumanensis* and *M. lucifugus*, Rodhouse et al. (2008) and Weller et al. (2007) found that use of a combination of characters identified individuals with a higher degree of confidence. Weller et al. (2007) found that mean values for length of forearm were smaller and that characteristic frequency of echolocation and minimum frequency of echolocation calls were higher for *M. yumanensis* compared with *M. lucifugus*. Because of the considerable overlap in these traits, use of both length of forearm and characteristic frequency of echolocation identified individuals with a higher degree of confidence (Weller et al. 2007). Rodhouse et al. (2008), using post hoc genetic analysis, found that only 18% of *M. yumanensis* were correctly identified using length of forearm only, whereas when length of forearm was combined with pelage sheen, ear color, or slope of the forehead, the percentage of individuals correctly identified was 95%, 78%, and 88%, respectively.

GENERAL CHARACTERS

Myotis yumanensis is a small species of *Myotis*. Fur is short (about 5–6 mm) and dull (not glossy) in color. General color of the dorsum is usually gray or brown to pale tan. Hairs of the dorsum are bicolored, with dark bases and slightly paler tips. Venter is paler, whitish to buffy. Membranes usually pale brown to gray. Dorsal fur of the uropatagium is sparse and nearly reaching the knees; sparse hairs are visible (with magnification) on the posterior edge of the uropatagium but do not constitute a fringe. The minute terminal vertebra of the tail is free from the dorsal surface of the uropatagium. Plagiopatagium attaches at the metatarsus,

just proximal to the bases of the toes. Calcar is straight, long, and unkeeled. The calcar extends about 60% of the length between the hind foot and the tail and terminates in a minute lobule. Hind feet are large and broad; the ratio of hind foot length to length of the tibia ranges from 50% to 54%. Ears are usually pale brown to gray, of moderate length, and extend beyond the nares when laid forward. Tragus is slim, straight, with a bluntly rounded tip; the basal lobe is large and somewhat semicircular in shape. Skull is medium sized for a *Myotis* (Fig. 2). Braincase
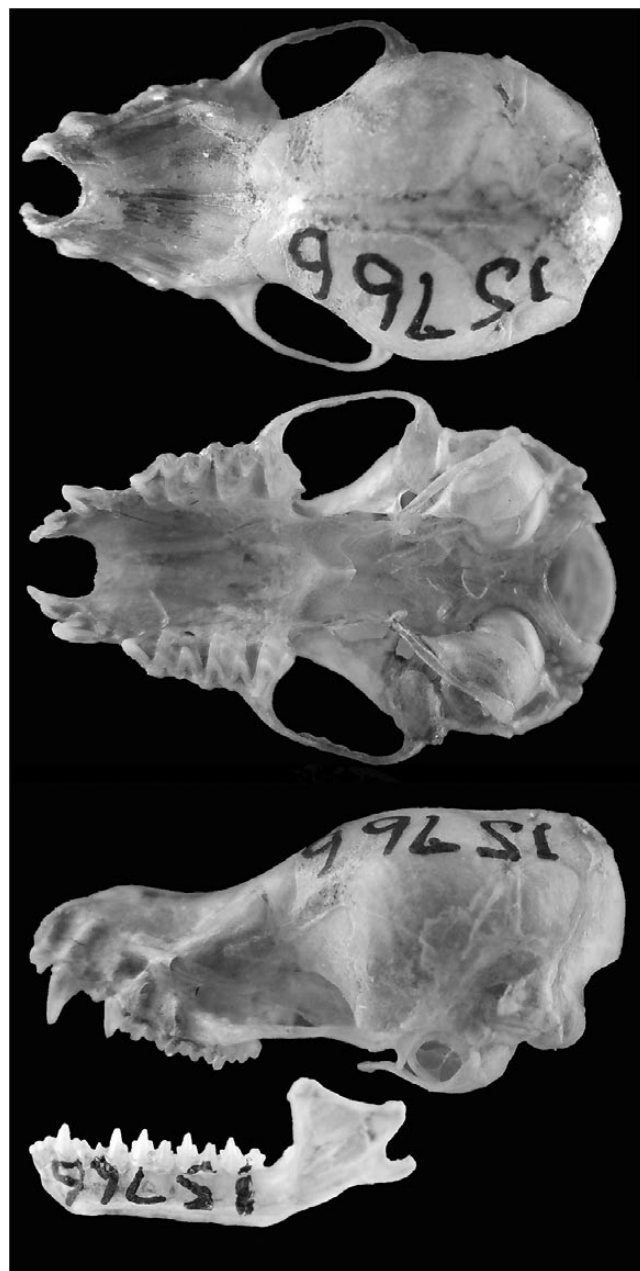

Fig. 2.—Dorsal, ventral, and lateral views of skull and lateral view of mandible of an adult female *Myotis yumanensis* (OMNH [Sam Noble Museum] 15766) from 2.5 miles N, 1 mile E Kenton, Cimarron Co., Oklahoma, United States. Greatest length of skull is 13.95 mm. Used with permission of the photographer M. A. Mares.

is globose. Sagittal crest is absent and forehead rises abruptly when viewed in lateral profile. Rostrum is broad; palate is short and broad. Molars dilambdodont; crowns longer in proportion to width. The middle upper premolars are aligned on the toothrow (Miller 1897; Miller and Allen 1928; Dalquest 1947; Álvarez et al. 1994; Koopman 1994).

Ranges of external measurements (mm, $n = 116$, sexes combined) of *M. yumanensis* (Miller and Allen 1928) were: length of head and body, 37.8–49.0; length of tail, 27.0–39.8; length of hind foot, 6.2–9.4; length of ear, 11.0–14.6; length of forearm, 32.0–38.0; length of 3rd metacarpal, 28.6–36.0. Mean wing measurements for *M. yumanensis* were: span, 238 and 240 mm ($n = 42$—Herd and Fenton 1983; $n = 13$—Aldridge 1986); area, 9,100 mm^2; wing loading (N/m^2), 6.69; aspect ratio, 6.45; wing-tip area ratio, 0.76; wing-tip length ratio, 1.17; wing-tip shape index, 2.17 ($n = 13$—Aldridge 1986).

Ranges of cranial measurements (mm, sexes combined) of *M. yumanensis* were: greatest length of skull, 13.4–14.1 ($n = 60$—Miller and Allen 1928), 12.95–14.45 ($n = 42$—Herd and Fenton 1983); condylobasal length, 12.0–13.2 ($n = 62$—Miller and Allen 1928); condylocanine length, 11.60–12.60 ($n = 42$—Herd and Fenton 1983); zygomatic breadth, 7.8–8.8 ($n = 46$—Miller and Allen 1928); least interorbital breadth, 3.4–4.8 ($n = 63$—Miller and Allen 1928), 3.50–3.90 ($n = 42$—Herd and Fenton 1983); braincase breadth, 6.6–7.4 ($n = 63$—Miller and Allen 1928), 6.75–7.25 ($n = 42$—Herd and Fenton 1983); mastoid breadth, 6.90–7.45 ($n = 42$—Herd and Fenton 1983); occipital depth, 4.6–5.4 ($n = 62$—Miller and Allen 1928), 4.65–5.25 ($n = 42$—Herd and Fenton 1983); greatest maxillary breadth, 5.05–5.55 ($n = 42$—Herd and Fenton 1983); rostral width, 3.20–3.55 ($n = 42$—Herd and Fenton 1983); length of maxillary toothrow, 4.6–5.2 ($n = 63$—Miller and Allen 1928), 4.75–5.20 ($n = 42$—Herd and Fenton 1983); length of P4M3 series, 3.40–3.75 ($n = 42$—Herd and Fenton 1983); braincase depth, 5.90–6.65 ($n = 42$—Herd and Fenton 1983).

Males were significantly smaller than females in some external and cranial measurements (e.g., 5th metacarpal, braincase breadth, and condylocanine length—Herd and Fenton 1983). Sexual dimorphism in length of the forearm was found to be not significant by Myers (1978), but in other studies males were found to have a significantly lower body-to-forearm ratio than females, length of head and body and length of forearm were significantly larger in females, and males had less average mass than females (Dalquest 1947; Williams and Findley 1979). Mass, however, varied depending on reproductive stage of females and stomach contents in both genders, 5.5–6.3 g for males and non-pregnant females.

Myotis yumanensis exhibits considerable geographic variation in color (Miller and Allen 1928; Dalquest 1947). Coloration is a dull brown in the central portion of the distribution, dark brown in the northwest, pale in the southwest, and dark brown in specimens in the Mexican highlands (Miller and Allen 1928). This species is widespread in California and the 4 subspecies in the state may be distinguished based on color (Dalquest 1947;

Harris 1974). Size varies clinally from small in the southwestern part of the range (Sonora and southern Baja Peninsula) to large in northeastern Utah–northwestern Colorado (Harris 1974; Bogan 1999).

DISTRIBUTION

Myotis yumanensis occurs in North America as far north as British Columbia, Canada southward through the western United States (Washington, Oregon, Idaho, Utah, Colorado, Nevada, California, New Mexico, and Arizona) and eastward to Montana, Oklahoma, and Texas, reaching as far south as Hidalgo, Morelos, and Michoacán, México (Fig. 3; Miller and Allen 1928; Dalquest 1947; Glass and Ward 1959; Davis and Barbour 1970; Harris 1974; Mollhagen and Bogan 1997; Adams 2004). The species may also occur in southwestern Wyoming, although no confirmed records have been reported; a specimen from Sheridan County that was identified as *M. yumanensis* (Clark and Stromberg 1987) is likely a *M. lucifugus* (Bogan and Cyan 2000). Although *M. y. lambi* could represent a geographically isolated subspecies, Bogan (1999) suggests that it may be found throughout most of the southern part of the Baja Peninsula.

Myotis yumanensis occurs primarily at low and intermediate elevations, although an individual was captured at 3,353 m on Mt. Whitney, California (Allen 1939) and some higher elevation records are known from localities in the Southwest and Mexico (Bogan 1999). The range of the species was restricted greatly during the Late Pleistocene (Harris 1974). Throughout much of its distribution, *M. yumanensis* is sympatric with *M. lucifugus* (Dalquest 1947; Harris 1974; Adams 2004). No fossils are known.

FORM AND FUNCTION

Form.—Dental formula of *Myotis yumanensis* is i 2/3, c 1/1, p 3/3, m 3/3, total 38. P2 and P3 are smaller than P4 and the middle upper premolar is aligned in the toothrow (Miller and Allen 1928; Koopman 1994). P2 and P3 are about equal in size, but when viewed from the side, the P2 is less than one-half the height of P3; the anterior of P2 is slightly overlapped by the cingulum of the canine and the posterior of P3 is partially covered by the cingulum of P4 (Miller and Allen 1928). Upper molars have a well-developed protoconule and accessory or secondary ridges; the hypocone on the anterior and middle upper molars is absent or poorly developed (Miller and Allen 1928; Koopman 1994).

The sternum is slender; the length is more than twice the breadth of the presternum. A small median lobe is present on the presternum. Ribs number 6 or 7. The coracoid process of the scapula is curved outward. The 7th cervical vertebra is not connected to the 1st thoracic vertebra (Koopman 1994).

The kidney is unilobular, with an undivided, single papilla, and inner and outer medullary zones (Geluso 1978, 1980). Renal
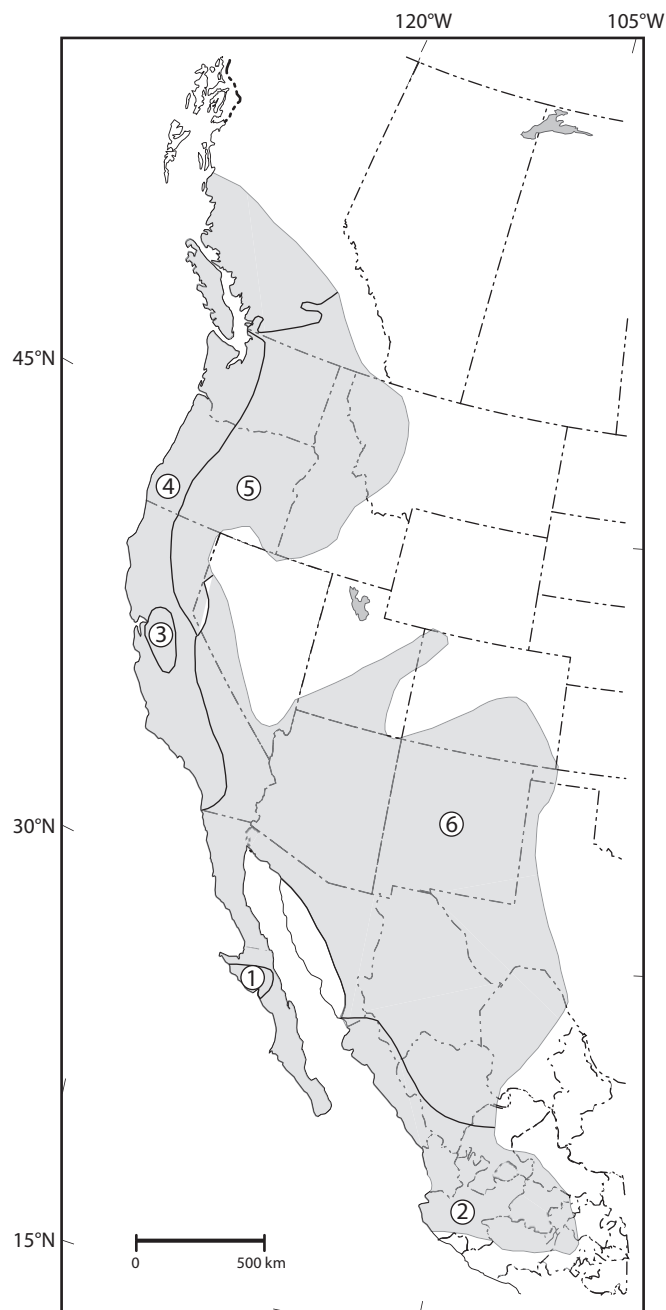
Fig. 3.—Geographic distribution of *Myotis yumanensis*. Subspecies are: 1, *M. y. lambi*; 2, *M. y. lutosus*; 3, *M. y. oxalis*; 4, *M. y. saturatus*; 5, *M. y. sociabilis*; 6, *M. y. yumanensis*. Map redrawn from Hall (1981) with modifications.

indices are: PMT (percent medullary thickness), 82.8; PMA (percent medullary area), 54.2; RMA (relative medullary area), 1.19; IM/C (ratio of inner medullary zone:cortex), 3.4; and M/C (ratio of medulla:cortex), 5.0.

Morphological parameters of the wing for female *M. yumanensis* were given by Aldridge (1986); mean wingspan, 0.24 m; mean wing area, 0.0091 m²; mean wing loading, 6.69 N/m²; mean aspect ratio, 6.45; mean wing-tip area ratio, 0.76; mean

wing-tip length ratio, 1.17; and mean wing-tip shape index, 2.17. *M. yumanensis* has a relatively short wingspan, rather high wing loading, and low aspect ratio, and wing tips are average in length and very rounded (Norberg and Rayner 1987).

Function.—The metabolic rate of *Myotis yumanensis* is 1.91 cm³ O₂/g per h (Ewing et al. 1970). The metabolic state (metabolic rate to ambient temperature) in early autumn (September) in New Mexico was variable (O'Farrell and Studier 1970). Most individuals exhibited a non–homeothermic-like metabolism, but some were partially homeothermic (thermoneutral zone of 32.5–36.5°C); during this time period, the fat index increased significantly (Ewing et al. 1970).

When confronted with high ambient temperatures in their diurnal roosts, *M. yumanensis* performs simple movements away from the center of heat stress, dispersing from tight clusters, and selecting a more appropriate microhabitat to avoid the full impact of thermal stress (Licht and Leitner 1967a). At ambient temperatures of 23–25°C, *M. yumanensis* was generally torpid; individuals that remained homeothermic or aroused from torpidity had body temperatures ranging from 30 to 35.5°C (Licht and Leitner 1967a). They present physiological stress at ambient temperature near 41°C (Licht and Leitner 1967a), died at a body temperature above 42°C if they were restricted from fanning their wings (Reeder and Cowles 1951) or within 40 min of exposure to an ambient temperature of 44.5°C (O'Farrell and Studier 1970), and a temperature between 45 and 50°C represented a potential lethal threat (Licht and Leitner 1967a). Individuals in distress had wet muzzles and venters, and a damp dorsum (O'Farrell and Studier 1970). *M. yumanensis* is able to maintain high body temperature when inactive at low ambient temperatures and enter torpor voluntarily (Betts 1997).

Thermoregulation in *M. yumanensis* was studied by Reeder and Cowles (1951). *M. yumanensis* elevated its body temperature from 11.5 to 31°C in about 15 min by assimilating ambient heat and shivering. At a body temperature of 33°C, *M. yumanensis* was able to launch flight and fly normally; however, at temperatures < 31°C, bats were unable to fly or flew with difficulty. When in flight for 4 min, individuals raised their body temperature from 33 to 40°C or 1.7°C/min; at 30 min of flight, body temperature was 40.8°C, suggesting that heat was dissipated at about the same rate that it was produced. Superficial observations on the degree of vascular change in the network of blood vessels in the flight membranes clearly revealed marked changes in the amount of blood passing through these tissues correlated with body temperatures (Cowles 1947; Reeder and Cowles 1951). At resting body temperatures of 40–41°C, heat was dispersed rapidly by the vasodilation of the vascular plexus in the wings and capillary plexi of naked membranes (uropatagium and ears) and was observed visually; vasodilation was not observed at body temperatures between 10 and 39°C. Reversal of the vasodilation, possibly by vasomotion, was gradual, taking up to 15 min (Reeder and Cowles 1951). When confined, *M. yumanensis* fanned with half-opened wings at a body temperature 33°C; at 34°C, fanning with half-opened wings (30 s)

alternated with open wings (5 s); and at 38°C, only open wing fanning was observed; fanning, however, was found to have minimal cooling effectiveness. The thermoregulation and heat dispersing mechanisms of *M. yumanensis* may maintain the body temperature below the level where male germinal tissues would be affected negatively; during spermatogenesis, which occurs during the hottest part of the year (July, August, September), the testes of breeding males descend into the uropatagium (Cowles 1947; Reeder and Cowles 1951).

Natural heat resistance, avoidance of the warmest areas in the shelter, salivation and licking for heat dissipation, combined with panting, are effective tools for *M. yumanensis* in extending survival at high ambient temperatures (Licht and Leitner 1967a, 1967b; O'Farrell and Studier 1970). Open-mouth panting and a wet muzzle were recorded to appear at body temperature of 41.5–42°C (Licht and Leitner 1967a).

Fat deposition was examined in female, male, and young *M. yumanensis* in late summer (mid-August to mid-September) before departure from a maternity roost in New Mexico (Ewing et al. 1970). During this time period, the fat index (g fat/g lean dry weight) in adult females increased significantly from 0.30 to 0.87 and the water index (g water/g lean dry weight) decreased significantly from 2.19 to 1.74. In fat-free adults, nonfat organic material and percent water increased significantly. Nine fatty acids and lipid phosphorous were present; the most common unsaturated fatty acids (as mean % total body fat) were: oleic (18:1), 45.0; palmitic (16:0), 18.3; and palmitoleic (16:1), 14.5. A prehibernation increase in unsaturated fatty acids may be correlated with a decrease in ambient temperatures. Fat deposition was greater in adults and females compared with young and males, respectively. The maximum days in hibernation assuming total inactivity is 192 days (Ewing et al. 1970).

Diurnal mass loss due to food and water deprivation in postlactating *M. yumanensis* in a maternity colony in New Mexico was examined by Studier et al. (1970). At a mean ambient temperature of 26.1°C and mean relative humidity of 32%, mean percent mass loss was 15.5% and ranged from 12.6% to 20.3%, and cumulative mass loss over a 14-h observation was 21.9%. *M. yumanensis* was found to have a low total mass loss tolerance; individuals died of water and food deprivation during the 2nd day of testing suggesting that *M. yumanensis* is unable to survive 2 successive days without rehydration.

The role of essential fatty acids (EFAs) in the diet of *M. yumanensis* was studied by Schalk and Brigham (1995). Differences among dietary fat scores for males, females, lactating females, and pregnant females were insignificant, but the scores for males and lactating females were significantly higher than fat scores for trapped insects. Although on some nights bats foraged on insects low in EFAs, a threshold level of dietary EFAs was maintained. Maintenance of a certain EFAs level in the diet of males and nonreproductive females may be important in torpor, while a diet high in EFAs may be important for lactating and pregnant females that have energy requirements.

Urine osmolality determined by water-deprivation experiments ranged from 2,000 to 3,350 mOsmol/kg with a mean of 2,640 mOsmol/kg (Geluso 1978). During experiments in which water was not available for 12 h, *M. yumanensis* exhibited the "plateau" urine concentration cycle; the maximum level of urine concentration was reached within 30 min of feeding and persisted at least until the 12 h before decreasing. *M. yumanensis* has relatively poor urine concentrating abilities and renal structures are similar to bat species that inhabit mesic environments. *M. yumanensis* occurs in dry environments but is more common in other habitats; in the desert, the species is found only near permanent sources of water (Barbour and Davis 1969; Findley et al. 1975; Geluso 1978, 1980; Hoffmeister 1986).

ONTOGENY AND REPRODUCTION

At birth, newborns are about 20% of their mother's mass; mass of 2 newborns and their mothers were: 1.4, 7.1 g; and 1.3, 6.8 g (Milligan 1993). Milligan and Brigham (1993) suggested that the age of the mother has effects on the sex of the young and the timing of birth. The older mother's young were more male-biased and were born earlier compared to a younger mother.

Newborns 1 day old or less had attached umbilical cords (Milligan and Brigham 1993). Between day 1 and day 4, young were pink and naked, and eyes were closed. At day 5, young were fully pigmented, covered dorsally and ventrally with sparse, soft, gray hairs, and eyes were open. By day 9, young were completely covered with light gray pelage. By day 13, hairs were blackish. In British Colombia, juveniles born in June and July could fly by early August (Milligan and Brigham 1993). A young *Myotis yumanensis* was described as dark blackish-gray in color by Dalquest (1947).

Females probably copulate in the autumn and the sperm remains dormant until spring (Dalquest 1947). Nonparous and postpartum females were captured in June and July in British Columbia (Aldridge 1986). Adults captured in August were parous (Herd and Fenton 1983). The lack of nonparous females late in the parturition season suggests that female *M. yumanensis* bears young in the summer following their birth (Herd and Fenton 1983). Males captured in June, July, and August showed signs of spermatogenesis (Herd and Fenton 1983).

Peak of pregnancies varies with geographical regions. The peak of pregnancies in British Columbia occurred in June and July (Milligan and Brigham 1993). Pregnant females have been reported from April to June in California (Dalquest 1947; Pierson and Rainey 1998; Szewczak et al. 1998), in May and June in British Columbia (Herd and Fenton 1983), in New Mexico (Mumford 1957; Commissaris 1959), in Oklahoma (Dalquest 1947), and in Mexico (Jones et al. 1972; Bogan 1999; López-González and García-Mendoza 2006), between June and August in California (Evelyn et al. 2004), and in July in Idaho (Betts 1997) and Colorado (Finley et al. 1983). Crown-rump lengths for embryos range from 2 to 23 mm (Dalquest 1947; Cockrum 1955; Mumford 1957; Commissaris 1959; Davis and

Barbour 1970). Pregnant lactating females have been reported in July in Colorado (Davis and Barbour 1970). Lactating females have been reported in May to August in California (Dalquest 1947; Pierson and Rainey 1998; Szewczak et al. 1998), in June to August in British Columbia (Fenton et al. 1980; Herd and Fenton 1983; Grindal et al. 1992; Nagorsen and Brigham 1993; Betts 1997), and in August in Mexico (Watkins et al. 1972; Bogan 1999). Post-lactating adult females have been reported in July and early August (Herd and Fenton 1983; Grindal et al. 1992; Milligan and Brigham 1993; Nagorsen and Brigham 1993; Betts 1997) in British Columbia and between June and August in California (Pierson and Rainey 1998; Evelyn et al. 2004).

Myotis yumanensis has 1 young per year (Miller and Allen 1928; Dalquest 1947; Davis and Barbour 1970; Fenton et al. 1980; Milligan and Brigham 1993). Young are born in late May or early June, and females become reproductively active the season after they are born; nursery roosts are vacated in autumn (Barbour and Davis 1969). Young have been reported between early June and early July in British Columbia with most births occurring in late June (Milligan and Brigham 1993) and in July and August (Grindal et al. 1992; Nagorsen and Brigham 1993; Betts 1997), by the end of June and mid-July in New Mexico (Commissaris 1959), in July in Idaho (Betts 1997), and in July and August in California (Pierson and Rainey 1998; Szewczak et al. 1998). Females carrying infants were found in July in British Columbia (Milligan 1993).

Myotis yumanensis living in desert areas seems to have their young no earlier than those residing in more temperate areas. High levels of precipitation may delay reproduction in *M. yumanensis* (Grindal et al. 1992). *M. yumanensis* may attain breeding condition at a younger age than *M. lucifugus* (Herd and Fenton 1983).

ECOLOGY

Population characteristics.—Natal sex ratio for volant juveniles and nonvolant juveniles was equal in British Colombia; mortality for nonvolant juveniles was not sex biased (Milligan and Brigham 1993). For much of the year, the 2 sexes remain separated (Dalquest 1947). During the summer, sex ratio varied from near equal, to a male bias, followed by a female bias. Older females (not larger females) generally gave birth earlier than younger females and produced a greater proportion of males (Milligan and Brigham 1993). Life span of *Myotis yumanensis* is about 5 years (Dalquest 1947), although a minimum age for longevity has been reported as 8 years and 10 months (Cockrum 1973). Frick et al. (2007), however, in a study of the effects of environmental contamination on demography and population growth, found reduced juvenile survival; adult female survival was higher than juvenile female survival suggesting stage-specific mortality risks. In northwestern California, *M. yumanensis* was the most abundant species captured in nets (Pierson and Rainey 1998).

Space use.—*Myotis yumanensis*, no matter the habitat, occurs where open water is present. The odds of predicting the presence of *M. yumanensis* were 20% greater when distance to lakes and ponds decreased by 2,000 m. Highest predicted probabilities of occurrence (50–70%) for *M. yumanensis* were in areas where distances to lakes and ponds were < 800 m. Mean differences at capture and noncapture sites were significant for distance to lake and ponds, elevation, path richness, and canopy closure (Duff and Morrell 2007).

Myotis yumanensis often occurs in areas that are treeless (Barbour and Davis 1969), inhabiting arid zones like deserts and thorn scrub (Ceballos and Oliva 2005). However, on Vancouver Island, British Columbia, *M. yumanensis* occurs in the Coastal Western Hemlock zone (< 900 m, forests dominated by western hemlock [*Tsuga heterophylla*], western red-cedar [*Thuja plicata*], and amabilis fir [*Abies amabilis*]) and the Mountain Hemlock zone (> 800 m, forests dominated by mountain hemlock [*Tsuga mertensiana*], yellow-cedar [*Chamaecyparis nootkatensis*], and amabilis fir [*Abies amabilis*]—Kellner and Harestad 2005). *M. yumanensis* is generally considered to be an inhabitant of lower elevations and riparian situations, often in otherwise arid country, but often is associated with relatively large bodies of permanent water (Findley 1969; Whitaker et al. 1977; Geluso 1978, 1980; Hoffmeister 1986; Brigham et al. 1992; Szewczak et al. 1998; Oliver 2000).

Myotis yumanensis takes shelter in caves and abandoned buildings and uses different roosting places each night. This species is adapted to man-made structures and inhabits abandoned buildings, preferring crevices as shelter; there are very few records of the species being found in "natural" retreats. Daytime retreats seem to be of 2 types: favored and temporary. Their natural retreats probably include caves, hollow trees, loose pieces of bark, and cracks in dead trees. Daytime retreats of *M. yumanensis* are within a short distance of water, near trees, and where the light is dim (Dalquest 1947).

Myotis yumanensis has been observed roosting on limestone and sandstone cliff crevices in Verde River, Arizona and it also used abandoned swallow mud nests to roost (Vaughan 1980). Bats are more likely choose mines on the basis of high relative humidity to establish maternity colonies where they form tight clusters (Betts 1997). Bridges also play an important role as day roosts and maternity colonies for these bats (Pierson and Rainey 1998; Adam and Hayes 2000; Geluso and Mink 2009).

Diet.—Trawling is characteristic of myotids of the *Leuconoe* subgenus (Findley 1972) including *Myotis yumanensis* in North America (Norberg and Rayner 1987). Based on morphometric analysis, *M. yumanensis* is considered an aerial feeder (Fenton and Bogdanowicz 2002). In Utah, *M. yumanensis* was found foraging above emergent vegetation along a reservoir's shore in an area characterized by creosote (*Larrea*) and mesquite (*Prosopis*) bushes and from narrow recesses between the gables and roof supports of a chapel (Stock 1970). Diet of *M. yumanensis* includes beetles and soft-bodied insects such as flies, termites, moths, and mayflies (e.g.,

Trichoptera, Ephemeroptera, Diptera, Lepidoptera, Orthoptera, Isoptera, Hemiptera, Homoptera, Orthoptera, Hymenoptera, Neuroptera, and Coleoptera—Barbour and Davis 1969; Easterla and Whitaker 1972; Whitaker et al. 1977; Herd and Fenton 1983; Brigham et al. 1992; Kellner and Harestad 2005). *M. yumanensis* also feeds on ants (*Pogonomyrex*—Vaughan 1980) and arachnids (Kellner and Harestad 2005).

Preferences for prey vary by age-class of *M. yumanensis*, with adults consuming a greater proportion of insects of Trichoptera and Ephemeroptera and fewer Diptera, and subadults consuming proportionally more Diptera (Herd and Fenton 1983; Ober and Hayes 2008). Isoptera, Homoptera (Whitaker et al. 1981), and Coleoptera also were found in the diet (Easterla and Whitaker 1972). Diet appears to vary with insect availability rather than actual differences in prey selection, suggesting opportunistic feeding behavior (Fenton and Morris 1976; Vaughan 1980; Brigham et al. 1992).

Taxonomic composition of the diet varied among nights; after early July in British Columbia, trichopterans and dipterans (primarily chironomids) comprised the diet (Brigham et al. 1992). Highest percentage of occurrence of prey groups in fecal samples of *M. yumanensis* captured between May and September in British Columbia was for Diptera, followed by Neuroptera, Lepidoptera, and Hymenoptera; Coleoptera, Arachnida, and Trichoptera had the lowest percentage occurrence of all groups (Kellner and Harestad 2005). In western Oregon, the primary diet (% volume, % frequency) was Diptera (Chironomidae; 37.7, 60.6), Isoptera (18.8, 32.0), unidentified Diptera (14.8, 36.0), unidentified Lepidoptera (14.8, 32.0), and internal organs of large insects (5.8, 12.0); Coleoptera, Hemiptera, and Homoptera comprised a minor part of the diet (Whitaker et al. 1977). In eastern Oregon, the primary diet (% volume, % frequency) based on stomach analysis was Lepidoptera (22.9, 57.1), Homoptera (13.6, 28.6), Coleoptera (13.6, 28.6), Trichoptera (13.6, 14.3), Isoptera (12.9, 42.9), Diptera (10.0, 71.4), and unidentified insects (Whitaker et al. 1981). Although similar results were found in an analysis of scat, Isoptera and Trichoptera were found only in stomachs, and Hymenoptera and Neuroptera were found only in scat (Whitaker et al. 1981). In Big Bend National Park, Texas, 16 food items were recorded for *M. yumanensis*, but Lepidoptera comprised the greatest percent volume (39.5) and percent frequency (78.6—Easterla and Whitaker 1972). In general, stomachs contained large numbers (15–30) of small prey items; several stomachs contained mainly midges (23.9% volume; Diptera, Chironomidae). Ground beetles (Carabidae) were recorded in low percent volume (2.5%), but in high percent frequency (21.4). EFAs did not appear to be as important in the diet of *M. yumanensis*, suggesting that torpor may not be employed regularly (Schalk and Brigham 1995).

Diseases and parasites.—Ectoparasites of *Myotis yumanensis* include 15 species of mites: *Alabidocarpus calcaratus* (Astigmata: Listrophoridae—Whitaker and Wilson 1974) and *A. longipilis* (Pinichpongse 1963); *Cryptonyssus desultorius* (Mesostigmata: Macronyssidae—Whitaker and Easterla 1975; Ritzi et al. 2001); *Macronyssus crosbyi* (Mesostigmata:

Macronyssidae—Radovsky 1967; Whitaker and Wilson 1974; Whitaker et al. 1983); *Steatonyssus antrozoi* (Mesostigmata: Macronyssidae—Whitaker and Easterla 1975) and *S. emarginatus* (Radovsky 1967; Whitaker and Wilson 1974); an unidentified macronyssid (Mesostigmata: Macronyssidae—Whitaker et al. 1983); *Spinturnix americanus* (Mesostigmata: Spinturnicidae—Whitaker and Wilson 1974; Whitaker and Easterla 1975; Whitaker et al. 1983; Ritzi et al. 2001), *Spinturnix bakeri* (Herd and Fenton 1983), and *Spinturnix* (Holdenried et al. 1951; Krutzsch 1955); *Notoedres myotis* (Astigmata: Sarcoptidae—Whitaker and Easterla 1975) and *Notoedres* (*Bakeracarus*—Whitaker et al. 1983); *Nycteriglyphus* (Astigmata: Rosensteiniidae—Whitaker and Easterla 1975); *Leptotrombidium myotis* (Prostigmata: Trombiculidae—Walters et al. 2011) and an unknown trombiculid (Ritzi et al. 2001).

Krutzsch (1955) and Whitaker et al. (1983) reported bat mite infestations as high as 10 mites per bat. In Oregon, prevalence of a single mite species ranged from 2% to 30% and 46% of *M. yumanensis* had mites (Whitaker et al. 1983). In Texas, of 7 mite species observed, prevalence for 5 species was low (8.33%) but was 25% and 33%, respectively, for *Cryptonyssus desultorius* and *Spinturnix americanus* (Ritzi et al. 2001). Sarcoptid mites (*Notoedres*), which were found only on the lip just anterior to the upper incisors, inhabited tubular structures that contained 1 mite and often an egg mass (Whitaker and Easterla 1975).

The ticks *Ornithodoros kelleyi* (Ixodides: Argasidae—Ritzi et al. 2001), *O. yumatensis* (Bradshaw and Ross 1961), and *Ornithodoros* (Holdenried et al. 1951) have been reported for *M. yumanensis*; the occurrence of *Dermacentor andersoni* (Ixodides: Ixodidae) may be accidental (Peterson 1960). Three species of flies, *Basilia rondanii* (Diptera: Nycteribiidae—Whitaker and Easterla 1975; Ritzi et al. 2001), *B. forcipata* (Diptera: Nycteribiidae—Peterson 1960, 1963; Herd and Fenton 1983), and *B. jellisoni* (Theodor and Peterson 1964), have been found.

Species of fleas found on *M. yumanensis* include *Myodopsylla collinsi* (Siphonaptera: Ischnopsyllidae—Whitaker and Easterla 1975; Haas et al. 1983; Ritzi et al. 2001), *M. gentilis* (Holdenried et al. 1951; Krutzsch 1955; Peterson 1960; Whitaker and Easterla 1975; Haas et al. 1983; Chilton et al. 2000; Ritzi et al. 2001; Ford et al. 2004), *M. palposa* (Haas et al. 1983), and *Myodopsylla* (Krutzsch 1955). Fleas were found in the fur of the body and the level of infestation ranged from 1 to 3 fleas per bat (Krutzsch 1955). Haas et al. (1983) noted that *M. palposa* on this species was a stray from the pallid bat (*Antrozous pallidus*) and that *M. yumanensis* was the most frequently reported host of *M. gentilis* in California. The parasitic bug *Cimex pilosellus* (Hemiptera: Cimicidae) was reported from *M. yumanensis* in California (Holdenried et al. 1951), Arizona (Bradshaw and Ross 1961), and Canada (Chilton et al. 2000).

The trematodes, *Acanthatrium* (Plagiorchiida: Lecithodendriidae) and *Lecithodendium*, were present in organs of *M. yumanensis* in northern California and tested positive for *Neorickettsia risticii*, the agent of Potomoc horse fever

(Pusterla et al. 2003). The ascarid nematode, *Seuratum cancellatum*, is known from *M. yumanensis* in Texas (Specian and Ubelaker 1976). Other endoparasites include 3 species of parasitic protozoa, *Trypanosoma vespertilionis* (Trypanosomatida: Trypanosomatidae—Mitchell 1956), *Eimeria pilarensis* (Eucoccidiorida: Eimeriidae—Scott and Duszynski 1997; Duszynski et al. 1999; Duszynski 2002), and *E. catronensis* (Scott and Duszynski 1997; Duszynski 2002). Species of cestodes (Cestoda) reported for *M. yumanensis* include *Hymenolepis christensoni* (Rausch 1975), *H. lasionycteridis* (Rausch 1975), and unidentified species of *Hymenolepis* (Voge 1955). Of 77 individuals tested, 2 *Trypanosoma* infections were found (Mitchell 1956); however, individuals tested for *T. cruzi* from localities in the southwestern United States were negative for blood parasites (Wood 1941, 1949, 1962). Prevalence of coccidia of *E. catronensis* was 28% in New Mexico (Scott and Duszynski 1997; Duszynski 2002); prevalence of *E. pilarensis* was 7% (Scott and Duszynski 1997) and 3% (Scott and Duszynski 1997) in California, 6% (Duszynski 2002) and 13% (Duszynski et al. 1999) in New Mexico.

Of 77 individuals examined, 1 *M. yumanensis* in California was infected with an unidentified species of malaria (Mitchell 1956). In Montana, the rabies virus has been reported in brain tissue but not in the salivary glands or other tissues of *M. yumanensis* (Bell et al. 1962). Bell et al. (1974) noted that rabies was absent from brain tissue. Mortality of weanling mice after intraperitoneal injection of rabies virus isolates from *M. yumanensis* was 18% and 30% (Bell et al. 1962).

Interspecific interactions.—*Myotis yumanensis* is known to roost with other species of bats, including the pallid bat (Licht and Leitner 1967a, 1967b), *Myotis thysanodes* (Ewing et al. 1970; O'Farrell and Studier 1970; Studier et al. 1970), *Myotis lucifugus occultus* (Ewing et al. 1970; O'Farrell and Studier 1970; Studier et al. 1970), and *Tadarida brasiliensis mexicana* (Brazilian free-tailed bat—Licht and Leitner 1967a, 1967b). In Colorado, *M. yumanensis* has been reported roosting in an attic with *M. lucifugus* and *M. volans*; *Eptesicus fuscus* (big brown bat) also was present but occupied another part of the attic (Davis and Barbour 1970).

In New Mexico, *M. yumanensis* roosts sympatrically in maternity colonies with *M. lucifugus* and *M. thysanodes* (Ewing et al. 1970; O'Farrell and Studier 1970; Studier et al. 1970). *M. yumanensis* roosted at the junction of 4 roof hips at the apex of an attic; *M. lucifugus* also was found in the attic but roosted in groups of 4–8 individuals at the junctions of the roof hips with the rafters and *M. thysanodes* roosted in a part that was physically separate (Studier et al. 1970).

In British Columbia, *M. yumanensis* was part of a bat fauna that included *M. lucifugus*, *M. volans*, *M. evotis/keenii* (Keen's myotis), *M. californicus*, and *Lasionycteris noctivagans* (silver-haired bat—Schalk and Brigham 1995; Kellner and Harestad 2005). In central Arizona, *M. yumanensis* was 1 of 7 species of bats captured, including *M. velifer*, pallid bat, *Pipistrellus hesperus* (western pipistrelle), Brazilian free-tailed bat, *M. leibii*

(eastern small-footed myotis), and *Corynorhinus townsendii* (Townsend's big-eared bat—Fenton and Morris 1976).

Although *M. yumanensis* overlaps *M. lucifugus* in foraging habitats in British Columbia, there is no evidence of intraspecific or interspecific aggression suggesting that food resources are either not limiting or not worth defending and that the partial segregation is a likely result of differences in flight performance (maneuverability and agility—Herd and Fenton 1983; Aldridge 1986).

BEHAVIOR

Grouping behavior.—Colonies of *Myotis yumanensis* have been reported numbering as high as 10,000 individuals in crevices at Davis Dam on the Colorado River (Adams 2004). Colonies and maternity colonies are formed in attics, buildings, caves, mines, under bridges, and abandoned cliff swallow nests; males are generally solitary (Howell 1920; Dalquest 1947; Commissaris 1959; Barbour and Davis 1969; Ewing et al. 1970; O'Farrell and Studier 1970; Studier et al. 1970; Banfield 1974; Parkinson 1979; Vaughan 1980; Brigham et al. 1992; Milligan and Brigham 1993; Geluso and Mink 2009). *M. yumanensis* tended to prefer roosting sites that were below 40°C between May and September in California (Licht and Leitner 1967b).

The temperature of 3 mines with maternity colonies in Idaho and Oregon from mid-May to mid-August ranged from 25 to 37°C (Betts 1997). When the mothers were away feeding, the temperature of the caves dropped 10–15°C. By June and July, the humidity of the caves rose to 90–100%. In a maternity colony in New Mexico (O'Farrell and Studier 1970; Studier et al. 1970), the population decreased rapidly in early September (O'Farrell and Studier 1970) and by late September all individuals had departed the roost (Ewing et al. 1970).

Reproductive behavior.—Older *Myotis yumanensis* mothers tend to produce offspring earlier than younger mothers (Milligan and Brigham 1993). This may be due to better body condition or access to warmer sections of hibernacula; young born at the beginning of the season to older mothers may be in better condition for hibernation than young born later in the season to younger mothers.

Females care equally for male and female young based on the absence of a significant difference in the length of the forearm in nonvolant juveniles (Milligan and Brigham 1993). Females carrying an infant appeared more agitated and more likely to bite the captor than females without young. Carrying of young appears to be related to protection (Milligan 1993).

Of 23 adult females banded at a maternity colony in British Colombia, 2 were captured in nets 0.5 km from the colony carrying a single young (4-day-old female, 5-day-old male). Young were attached to the teat and covered by the wing membranes of the mother. Young left at the roost huddled in groups in cracks in the highest and warmest part of the colony (Milligan 1993).

Communication.—*Myotis yumanensis* uses moderate-length, steeply swept frequency-modulated calls to hunt insects almost exclusively over water. The starting frequency varies widely, between 59 and 72 kHz, and sweeps abruptly down to 45–50 kHz (Adams 2004). Calls of *M. yumanensis* rarely exceed 70 kHz and have a distinctive lazy "S" shape (O'Farrell et al. 1999). *M. yumanensis* showed slight positive responses to playback of recorded foraging sounds of other bats (Fenton and Morris 1976).

The mean maximum and minimum frequency (kHz) and duration (ms) of calls of *M. yumanensis* varied with location. In Arizona, the echolocation measurements were: maximum frequency, 64.2 (55.73–72.67; *n* = 184—O'Farrell et al. 1999); minimum frequency, 47.7 (43.48–51.92; *n* = 184—O'Farrell et al. 1999); and duration, 3.2 (1.84–4.56; *n* = 184—O'Farrell et al. 1999). In New Mexico, the echolocation measurements were: maximum frequency, 69.5 (60.17–78.83; *n* = 142—O'Farrell et al. 1999); minimum frequency, 46.5 (44.4–48.6; *n* = 142—O'Farrell et al. 1999); and duration, 3.2 (2.22–4.18; *n* = 142—O'Farrell et al. 1999). The average frequency with maximum energy of search-phase echolocation calls in British Columbia was 55.7 kHz, the lowest frequency 38.5 kHz, and highest frequency 87.6 kHz (Herd and Fenton 1983).

Miscellaneous behavior.—*Myotis yumanensis* is nocturnal and emerges from day roosts at darkness and forages in open areas over the surface of streams and ponds (Barbour and Davis 1969; Herd and Fenton 1983; Van Zyll de Jong 1985; Brigham et al. 1992) or over land in cluttered or uncluttered areas or close to trees (Brigham et al. 1992). Activity is associated strongly with the capture of small-sized insects (Ober and Hayes 2008). Bats in British Columbia were caught about 1 h after sunset at 2240 h and 0.5 m above ground near the water where they were observed foraging (Milligan 1993). In western Oregon, bats emerged 20–30 min prior to full darkness and often fed just a few inches above the surface of the water, repeatedly flying regular routes; they flew up and down rivers and streams in relatively straight patterns and in circular patterns over ponds and small lakes (Whitaker et al. 1977).

In California, *M. yumanensis* is active near dusk and individuals drank occasionally but did not drink extensively until late dusk. *M. yumanensis* retires to resting places at intervals during the night. *M. yumanensis* hunts at high speeds and apparently fills its stomach in a few minutes. Individuals with stomachs full of insects have been captured at resting places 15 min after dusk (Dalquest 1947).

Myotis yumanensis generally is not active during the winter (Boyles et al. 2006). In a maternity roost in New Mexico in early autumn, *M. yumanensis* was in torpor in the morning and incapable of much movement for about 15 min after capture (O'Farrell and Studier 1970) but was active during the afternoon. During roosting, *M. yumanensis* is active and alert (Studier et al. 1970). *M. yumanensis* is thought to be a part-time resident in some areas, presumably because it migrates to winter quarters elsewhere. The species was reported to be a summer resident in Arizona but was rare in winter (Hoffmeister 1970). Dalquest (1947), however, suggested that it is unlikely that this species migrates, although it probably experiences incomplete hibernation in some areas. The observation of individuals during winter months at known summer roosts in bridges in New Mexico suggests that *M. yumanensis* may hibernate at nearby locations or does not migrate long distances (Geluso and Mink 2009).

Myotis yumanensis is a maneuverable flyer and is able to fly in clutter and avoid obstacles as indicated by a significant correlation with wing loading and wing area (Aldridge 1986). Mean flight speeds for 3 male *M. yumanensis* measured using a simulated mine tunnel were 7.5, 8.1, and 8.5 mph; minimum speed ranged from 6.6 to 7.6 mph and maximum speed ranged from 8.4 to 8.9 mph (Hayward and Davis 1964). Maximum speed of flight is directly correlated with mean length of forearm in *M. yumanensis*. Based on an average fat mass storage of 1.6 g, caloric content of fat, metabolic rate, average mass of 6.8 g, and flight speed, the calculated maximum flight distance for *M. yumanensis* is 168 miles (Ewing et al. 1970). Increase in body mass decreases an individual's maneuverability (Aldridge and Brigham 1988).

GENETICS

The diploid number (2n) is 44 chromosomes and the fundamental number (FN) is 50. Autosomal pairs consist of 3 large pairs and 1 small pair of metacentric chromosomes, and 17 pairs of acrocentric chromosomes varying in size from minute to small to medium. The X chromosome is a medium submetacentric and the Y chromosome is a small submetacentric or acrocentric (Baker and Patton 1967; Bickham 1979). The G-band pattern was described by Bickham (1979).

Myotis yumanensis and 4 other species of *Myotis* (*M. auriculus*—southwestern myotis, *M. evotis*, *M. milleri* [now included in *M. evotis*], *M. thysanodes*) were monomorphic for the same allele in 12 of 20 loci examined: tetrazoluim oxidase-1 (TO-1); tetrazoluim oxidase-2 (TO-2); α-glycerophosphate dehydrogenase (α-GPD); glutamic oxaloacetic transaminase-1 (GOT-1); glutamic oxaloacetic transaminase-2 (GOT-2); malate dehydrogenase-1 (MDH-1); malate dehydrogenase-2 (MDH-2); isocitrate dehydrogenase-1 (IDH-1); isocitrate dehydrogenase-2 (IDH-2); lactate dehydrogenase-1 (LDH-1); albumin (Ab); and malic enzyme (ME). Eight loci were polymorphic: leucine aminopeptidase (LAP); sorbital dehydrogenase (SDH); alcohol dehydrogenase (ADH); phosphoglucomutase (PGM); lactate dehydrogenase-2 (LDH-2); esterase-1 (ES-1); hemoglobin (Hb); and 6-phosphogluconate dehydrogenase (6-PGD). *M. yumanensis* was monomorphic for all loci except PGM and expressed 2 unique alleles at this locus. Analysis of electrophoretic data found *M. yumanensis* was most similar to *M. auriculus* (Reduker et al. 1983).

Based on electrophoretic analyses, Herd and Fenton (1983) concluded that *M. yumanensis* is monomorphic at 17 loci. No evidence of hybridization between *M. yumanensis* and *M. lucifugus* was found, and each one could be uniquely

characterized on the basis of the alleles present at the monomorphic loci. The absence of evidence for gene flow between samples of *M. lucifugus* and *M. yumanensis* indicates that these forms are reproductively isolated and distinct biological species.

Mitochondrial (cytochrome *b*, Cyt *b*; nicotinamide adenine dinucleotide dehydrogenase subunit 1, ND1; 12S ribosomal RNA, 12S rRNA; transfer RNA, tRNA; 16S ribosomal RNA, 16S rRNA) genes indicated that *M. yumanensis* is a member of a clade of species distributed primarily in the New World. *M. yumanensis* was sister to *M. velifer* rather than to *M. lucifugus* or *M. californicus*, species with which it has been confused (Ruedi and Mayer 2001; Hoofer and Van Den Bussche 2003; Bickham et al. 2004; Stadelmann et al. 2007). The phylogenetic relationship of *M. yumanensis* with other species of *Myotis* could not be resolved using a nuclear gene (recombination activating gene 2, RAG2—Stadelmann et al. 2007). However, in an analysis of mitochondrial ribosomal (12S rRNA, tRNA, and 16S rRNA) and nuclear DNA (apolipoprotein b [APOB], dentin matrix acidic phosphoprotein 1 [DMP1], RAG2, protein kinase C iota [PRKC1], signal transducer and activator of transcription 5A [STAT5A], and thyrotropin [THY]), *M. yumanensis* was sister to *M. velifer* in the combined analysis but was basal to the Neotropical clade of *Myotis* in the analysis of nuclear data (Lack et al. 2010).

Stadelmann et al. (2007) proposed a phylobiogeographic hypothesis of a radiation of *Myotis* from the Nearctic to South America; based on the results of their nuclear analyses, Lack et al. (2010:983) suggested that "perhaps *M. yumanensis* represents the closest extant relative of the Nearctic ancestor that gave rise to all Neotropical *Myotis*." Primers for portions of the 16S rRNA gene were developed to identify *M. yumanensis* in the Pacific Northwest from wing punch biopsy, fecal samples, and guano (Zinck et al. 2004).

CONSERVATION

Myotis yumanensis is considered a species of "Least Concern" by the International Union for Conservation of Nature and Natural Resources (2011); habitat loss is listed as the major threat. Evelyn et al. (2004:471) indicated "preservation of large diameter trees and protection of forested parkland, particularly along stream corridors, is vital to help provide potential roost sites and maintain bats and their insect-control activities in human-dominated areas."

LITERATURE CITED

ADAM, M. D., AND J. P. HAYES. 2000. Use of bridges as night roosts by bats in the Oregon coast range. Journal of Mammalogy 81:402–407.

ADAMS, R. A. 2004. Bats of the Rocky Mountain West. University Press of Colorado, Boulder.

ALDRIDGE, H. 1986. Manoeuvrability and ecological segregation in the little brown (*Myotis lucifugus*) and Yuma (*M. yumanensis*) bats (Chiroptera: Vespertilionidae). Canadian Journal of Zoology 64:1878–1882.

ALDRIDGE, H. D. J. N., AND R. M. BRIGHAM. 1988. Load carrying and maneuverability in an insectivorous bat: a test of the 5% "rule" of radio-telemetery. Journal of Mammalogy 69:379–382.

ALLEN, G. M. 1919. Bats from Mount Whitney, California. Journal of Mammalogy 1:1–5.

ALLEN, G. M. 1939. Bats. Harvard University Press, Cambridge, Massachusetts.

ALLEN, H. 1862. Descriptions of two new species of Vespertilionidae, and some remarks on the genus *Antrozous*. Proceedings of the Academy of Natural Sciences of Philadelphia 1862:246–248.

ALLEN, H. 1864. Monograph of the bats of North America. Smithsonian Miscellaneous Collections 165:1–85.

ALLEN, H. 1866. Notes on the Vespertilionidae of tropical America. Proceedings of the Academy of Natural Sciences of Philadelphia 18:279–288.

ALLEN, H. 1893. A monograph of the bats of North America. Bulletin of the United States National Museum 43:1–198.

ALLEN, J. A. 1903. List of mammals collected by Mr. J. H. Batty in New Mexico and Durango, with descriptions of new species and subspecies. Bulletin of the American Museum of Natural History 19:587–612.

ÁLVAREZ, T., S. T. ÁLVAREZ, AND J. C. LÓPEZ-VIDAL. 1994. Claves para murciélagos mexicanos. Escuela Nacional de Ciencias Biológicas, Instituto Politécnico Nacional, La Paz, Baja California Sur, México.

AUDUBON, J. J., AND J. BACHMAN. 1842. Descriptions of new species of quadrupeds inhabiting North America. Journal of the Academy of Natural Sciences of Philadelphia 8 (pt. 2):280–323.

BAKER, R. J., AND J. L. PATTON. 1967. Karyotypes and karyotypic variation of North American vespertilionid bats. Journal of Mammalogy 48:270–286.

BANFIELD, A. W. F. 1974. The mammals of Canada. National Museum of Natural Sciences, University of Toronto Press, Toronto, Ontario, Canada.

BARBOUR, R. W., AND W. H. DAVIS. 1969. Bats of America. The University Press of Kentucky, Lexington.

BELL, J. F., W. J. HADLOW, AND W. L. JELLISON. 1974. A survey of chiropteran rabies in western Montana. Public Health Reports 72:16–18.

BELL, J. F, G. J. MOORE, G. H. RAYMOND, AND C. E. TIBBS. 1962. Characteristics of rabies in bats in Montana. American Journal of Public Health 52:1293–1301.

BENSON, S. B. 1947. Description of a subspecies of *Myotis yumanensis* from Baja California, Mexico. Proceedings of the Biological Society of Washington 60:45–46.

BETTS, B. J. 1997. Microclimate in Hell's Canyon Mines used by maternity colonies of *Myotis yumanensis*. Journal of Mammalogy 78:1240–1250.

BICKHAM, J. W. 1979. Banded karyotypes of 11 species of American bats. Cytologia 44:789–797.

BICKHAM, J. W., J. C. PATTON, D. A. SCHLITTER, I. L. RAUTENBACH, AND R. L. HONEYCUTT. 2004. Molecular phylogenetics, karyotypic diversity, and partition of the genus *Myotis* (Chiroptera: Vespertilionidae). Molecular Phylogenetics and Evolution 33:333–338.

BOGAN, M. A. 1999. Family Vespertilionidae. Pp. 139–181 in Mamíferos del noroeste de México (S. T. Alvarez-Castañeda and J. L. Patton, eds.). Centro de Investigaciones Biológicas del Noroeste, S. C., La Paz, Baja California Sur, Mexico.

BOGAN, M. A., AND P. M. CYAN. 2000. The bats of Wyoming. Pp. 71–94 in Reflections of a naturalist: papers honoring Professor Eugene D. Fleharty (J. R. Choate, ed.). Fort Hays Studies, Hays, Kansas, Special Issue 1:1–241.

BOYLES, J. G., M. B. DUNBAR, AND J. O. WHITAKER, Jr. 2006. Activity following arousal in winter in North American verspertilionid bats. Mammal Review 36:267–280.

BRADSHAW, V. R., AND A. ROSS. 1961. Ectoparasites of Arizona bats. Journal of the Arizona Academy of Science 1:109–112.

BRIGHAM, R. M., H. D. J. N. ALDRIDGE, AND R. L. MACKEY. 1992. Variation in habitat use and prey selection by yuma bats, *Myotis yumanensis*. Journal of Mammalogy 73:640–645.

CEBALLOS, G., AND G. OLIVA. 2005. Los mamíferos silvestres de México. Fondo de Cultura Económica, México, D.F., México.

CHILTON, G., M. J. VONHOF, B. V. PETERSON, AND N. WILSON. 2000. Ectoparasitic insects of bats in British Columbia, Canada. Journal of Parasitology 86:191–192.

CLARK, T. W., AND M. R. STROMBERG. 1987. Mammals in Wyoming. University of Kansas Museum of Natural History, Lawrence.

COCKRUM, E. L. 1955. Reproduction in North American bats. Transactions of the Kansas Academy of Science 58:487–511.

COCKRUM, E. L. 1973. Additional longevity records for American bats. Journal of the Arizona Academy of Science 8:108–110.

COMMISSARIS, L. R. 1959. Notes on the Yuma myotis in New Mexico. Journal of Mammalogy 40:441–442.

COWLES, R. B. 1947. Vascular changes in the wings of bats. Science 105:362–363.

DALQUEST, W. W. 1947. Notes on the natural history of the bat, *Myotis yumanensis*, in California, with a description of a new race. American Midland Naturalist 38:224–247.

DAVIS, W. H., AND R. W. BARBOUR. 1970. Life history data on some southwestern *Myotis*. Southwestern Naturalist 15:261–263.

DOBSON, G. E. 1878. Catalogue of the Chiroptera in the collection of the British Museum. Taylor and Francis, London, United Kingdom.

DUFF, A. A., AND T. E. MORRELL. 2007. Predictive occurrence models for bat species in California. Journal of Wildlife Management 71:693–700.

DUSZYNSKI, D. W. 2002. Coccidia (Apicomplexa: Eimeriidae) of the mammalian order Chiroptera. Special Publication of the Museum of Southwestern Biology 5:1–45.

DUSZYNSKI, D. W., D. T. SCOTT, J. ARAGON, A. LEACH, AND T. PERRY. 1999. Six new *Eimeria* species from vespertilionid bats of North America. Journal of Parasitology 85:496–503.

EASTERLA, D. A., AND J. O. WHITAKER, JR. 1972. Food habits of some bats from Big Bend National Park, Texas. Journal of Mammalogy 53:887–890.

ELLIOT, D. G. 1905. A checklist of mammals of the North American continent, the West Indies and the neighboring seas. Field Columbian Museum, Zoological Series 6:1–761.

EVELYN, M. J., D. A. STILES, AND R. A. YOUNG. 2004. Conservation of bats in suburban landscapes: roost selection by *Myotis yumanensis* in a residential area in California. Biological Conservation 115:463–473.

EWING, W. G., E. H. STUDIER, AND M. J. O'FARRELL. 1970. Autumn fat deposition and gross body composition in three species of *Myotis*. Comparative Biochemistry and Physiology 36:119–129.

FENTON, M. B., AND W. BOGDANOWICZ. 2002. Relationships between external morphology and foraging behaviour: bats in the genus *Myotis*. Canadian Journal of Zoology 80:1004–1013.

FENTON, M. B., AND G. K. MORRIS. 1976. Opportunistic feeding by desert bats (*Myotis* spp.). Canadian Journal of Zoology 54:526–530.

FENTON, M. B., ET AL. 1980. Distribution, parturition dates and feeding of bats in south-central British Columbia. Canadian Field-Naturalist 94:416–420.

FINDLEY, J. S. 1969. Biogeography of southwestern boreal and desert mammals. Pp. 113–128 in Contributions in mammalogy (J. K. Knox, Jr., ed.). University of Kansas, Publications of the Museum of Natural History, Lawrence, Kansas.

FINDLEY, J. S. 1972. Phenetic relationships among bats of the genus *Myotis*. Systematic Zoology 21:31–52.

FINDLEY, J. S., A. H. HARRIS, D. E. WILSON, AND C. JONES. 1975. Mammals of New Mexico. University of New Mexico Press, Albuquerque.

FINLEY, R. B., JR., W. CAIRE, AND D. E. WILHELM. 1983. Bats of the Colorado Oil Shale Region. Great Basin Naturalist 43:554–560.

FORD, P. L., D. W. DUSZYNSKI, R. FAGERLUND, AND P. POLECHLA. 2004. Fleas and lice of mammals in New Mexico. United States Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-123, Fort Collins, Colorado.

FRICK, W. F., W. E. RAINEY, AND E. D. PIERSON. 2007. Potential effects of environmental contamination on Yuma Myotis demography and population growth. Ecological Applications 17:1213–1222.

GELUSO, K. N. 1978. Urine concentrating ability and renal structure of insectivorous bats. Journal of Mammalogy 59:312–323.

GELUSO, K. N. 1980. Renal form and function in bats: an ecophysiological appraisal. Pp. 403–414 in Proceedings of the Fifth International Bat Research Conference (D. E. Wilson and A. L. Gardner, eds.). Texas Tech Press, Lubbock.

GELUSO, K. N., AND J. N. MINK. 2009. Use of bridges by bats (Mammalia: Chiroptera) in the Rio Grande Valley, New Mexico. Southwestern Naturalist 54:421–429.

GEOFFROY SAINT-HILAIRE, E. 1806. Mémoire sur le genre et les espèces de Vespertilion, l'un des genres de la famille des chauve-souris. Annales du Muséum d'Histoire Naturelle, Paris 8:187–205.

GLASS, B. P., AND R. J. BAKER. 1965. *Vespertilio subulatus* Say, 1823: proposed suppression under the plenary powers (Mammalia, Chiroptera). Bulletin of Zoological Nomenclature 22:204.

GLASS, B. P., AND C. M. WARD. 1959. Bats of the genus *Myotis* from Oklahoma. Journal of Mammalogy 40:194–201.

GOULD, J. 1854. The mammals of Australia. Vol. 3, pt. 6. Taylor and Francis, London, United Kingdom.

GRINDAL, S. D., T. S. COLLARD, R. M. BRIGHAM, AND R. B. R. BARCLAY. 1992. The influence of precipitation on reproduction by *Myotis* bats in British Columbia. American Midland Naturalist 128:339–344.

GRINNELL, H. W. 1914. Three new races of vespertilionid bats from California. University of California Publications in Zoology 12:317–320.

HAAS, G. E., A. J. BECK, AND P. Q. TOMICH. 1983. Bat fleas (Siphonaptera: Ischnopsyllidae) of California. Bulletin of the Southern California Academy of Sciences 82:103–114.

HALL, E. R. 1981. The mammals of North America. John Wiley and Sons, New York.

HARRIS, A. H. 1974. *Myotis yumanensis* in interior southwestern North America, with comments on *Myotis lucifugus*. Journal of Mammalogy 55:589–607.

HARRIS, A. H., AND J. S. FINDLEY. 1962. Status of *Myotis lucifugus phasma* and comments on variation in *Myotis yumanensis*. Journal of Mammalogy 43:192–199.

HAYWARD, B., AND R. DAVIS. 1964. Flight speeds in western bats. Journal of Mammalogy 45:236–242.

HERD, R. M., AND M. B. FENTON. 1983. An electrophoretic, morphological, and ecological investigation of a putative hybrid zone between *Myotis lucifugus* and *Myotis yumanensis* (Chiroptera: Vespertilionidae). Canadian Journal of Zoology 61:2029–2050.

HOFFMEISTER, D. F. 1970. The seasonal distribution of bats in Arizona: a case for improving mammalian range maps. Southwestern Naturalist 15:11–22.

HOFFMEISTER, D. F. 1986. Mammals of Arizona. The University of Arizona Press and The Arizona Game and Fish Department, Tucson.

HOLDENRIED, R., F. C. EVANS, AND D. S. LONGANECKER. 1951. Host-parasite-disease relationships in a mammalian community in the central coast range of California. Ecological Monographs 21:1–18.

HOOFER, S. R., AND R. A. VAN DEN BUSSCHE. 2003. Molecular phylogenetics of the chiropteran family Vespertilionidae. Acta Chiropterologica 5:1–63.

HORÁČEK, I., V. HANÁK, AND J. GAISLER. 2000. Bats of the Palearctic Region: a taxonomic and biogeographic review. Pp. 11–157 in Proceedings of the VIIIth European Bat Research Symposium. Vol. 1: approaches to biogeography and ecology of bats (B. W. Woloszyn, ed.). Chiropterological Information Center, ISEZ PAN, Kraków, Poland.

HOWELL, A. B. 1920. Some California experiences with bat roosts. Journal of Mammalogy 1:169–177.

INTERNATIONAL UNION FOR CONSERVATION OF NATURE AND NATURAL RESOURCES. 2011. The International Union for Conservation of Nature and Natural Resources Red List of threatened species. Version 2011.2. www.iucnredlist.org. Accessed 28 May 2012.

JAMES, E. 1823. Account of an Expedition from Pittsburgh to the Rocky Mountains, Performed in the Years 1819, 1820 by order of the Hon. J. C. Calhoun, Secretary of War, under the Command of Maj. S.H. Long, of the U.S. top engineers. Compiled from the notes of Major Long, Mr. T. Say, and other gentlemen of the party, by Edwin James, botanist and geologist to the expedition. Longman, Hurst, Rees, Orme, and Brown, London, United Kingdom, 2:1–366.

Jones, J. K., Jr., J. R. Choate, and A. Cadena. 1972. Mammals from the Mexican state of Sinaloa II. Chiroptera. Occasional Papers of the Museum of Natural History, University of Kansas 6:1–29.

Kellner, A. M. E., and A. S. Harestad. 2005. Diets of bats in coastal rainforests on Vancouver Island, British Columbia. Northwestern Naturalist 86:45–48.

Koopman, K. F. 1994. Chiroptera: systematics. Handbook of Zoology, vol. VIII, pt. 60, Mammalia 1–217.

Krutzsch, P. H. 1955. Ectoparasites from some species of bats from western North America. Journal of Mammalogy 36:457–458.

Kuzyakin, A. P. 1934. Letutchie myshi g. Tashkenta i sistematitcheskie zametki o nekotorych formach Chrioptera s Kavkaza, Buchary i Turkmenii (The bats from Tashkent and systematical remarks on some Chiroptera from Caucasus, Bucharia and Turkmenia). Byulleten Moskovskoho Obshchestva Ispytalelei Prirody, Otdel Biologicheskii (Bulletin of the Society of Naturalists, Moscow, Biology Section) 43:316–330 (in Russian, not seen cited in Horáček et al. 2000).

Lack, J. B., Z. P. Roehrs, C. E. Stanley Jr., M. Ruedi, and R. A. Van Den Bussche. 2010. Molecular phylogenetics of *Myotis* indicate familial-level divergence for the genus *Cistugo* (Chiroptera). Journal of Mammalogy 91:976–992.

Licht, P., and P. Leitner. 1967a. Physiological responses to high environmental temperatures in three species of Microchiropteran bats. Comparative Biochemistry and Physiology 22:371–387.

Licht, P., and P. Leitner. 1967b. Behavioral responses to high temperatures in three species of California bats. Journal of Mammalogy 48:52–61.

López-González, C., and D. F. García-Mendoza. 2006. Murciélagos de la Sierra Tarahumara, Chihuahua, México. Acta Zoológica Mexicana 22:109–135.

Lyon, M. W., Jr., and W. H. Osgood. 1909. Catalogue of the type-specimens of mammals in the United States National Museum, including the Biological Survey Collection. Bulletin of the United States National Museum 62:1–325.

McMurtrie, H. 1831. Animal kingdom arranged in conformity with its organization, by the Baron Cuvier…translated from the French with notes and additions by H. M'Murtrie. G. &. C. &. H. Carvill, New York.

Miller, G. S., Jr. 1897. Revision of the North American bats of the family Vespertilionidae. North American Fauna 13:1–135.

Miller, G. S., Jr. 1912. List of North American land mammals in the United States National Museum, 1911. Bulletin of the United States National Museum 79:1–455.

Miller, G. S., Jr. 1924. List of North American Recent mammals 1923. Bulletin of the United States National Museum 128:1–673.

Miller, G. S., Jr., and G. M. Allen. 1928. The American bats of the genera *Myotis* and *Pizonyx*. Bulletin of the United States National Museum 144:1–218.

Milligan, B. N. 1993. Carrying of young by female Yuma bats (*Myotis yumanensis*). Northwestern Naturalist 74:55–56.

Milligan, B. N., and R. M. Brigham. 1993. Sex ratio variation in the Yuma bat (*Myotis yumanensis*). Canadian Journal of Zoology 71:937–940.

Mitchell, O. G. 1956. *Trypanosoma vespertilionis* from some southern California bats. Journal of Mammalogy 37:443–444.

Mollhagen, T. R., and M. A. Bogan. 1997. Bats of the Henry Mountains region of southeastern Utah. Occasional Papers, Museum of Texas Tech University 170:1–13.

Mumford, R. C. 1957. *Myotis occultus* and *Myotis yumanensis* breeding in New Mexico. Journal of Mammalogy 38:260.

Myers, P. 1978. Sexual dimorphism in size of vespertilionid bats. American Naturalist 112:701–711.

Nagorsen, D. W., and R. M. Brigham. 1993. Bats of British Columbia. University of British Columbia Press and Royal British Columbia Museum, British Columbia, Vancouver, Canada.

Norberg, U. M., and J. M. V. Rayner. 1987. Ecological morphology and flight in bats (Mammalia; Chiroptera): wing adaptations, flight performance, foraging strategy and echolocation. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences 316:335–427.

O'Farrell, M. J., B. W. Miller, and W. L. Gannon. 1999. Qualitative identification of free-flying bats using the anabat detector. Journal of Mammalogy 80:11–23.

O'Farrell, M. J., and E. H. Studier. 1970. Fall metabolism in relation to ambient temperatures in three species of *Myotis*. Comparative Biochemistry and Physiology 35:697–703.

Ober, H. K., and J. P. Hayes. 2008. Prey selection by bats in forests of western Oregon. Journal of Mammalogy 89:1191–1200.

Oliver, G. O. 2000. The bats of Utah. Utah Division of Wildlife Resources, Salt Lake City.

Parkinson, A. 1979. Morphologic variation and hybridization in *Myotis yumanensis sociabilis* and *Myotis lucifugus carissima*. Journal of Mammalogy 60:489–504.

Peterson, B. V. 1960 [1959]. New distribution and host records of bat flies, and a key o the North American species of *Basilia* Ribeiro (Diptera: Nycteribiidae). Proceedings of the Entomological Society of Ontario 90:30–37.

Peterson, B. V. 1963. Additional records of some American bat flies (Diptera: Nycteribiidae). Proceedings of the Entomological Society of Ontario 93:93–94.

Pierson, E. D., and W. E. Rainey. 1998. Bat distribution in the forested region of northwestern California. Report to California Department of Fish and Game, Contract #FG-5123-WM, Sacramento, California.

Pinichpongse, S. 1963. A review of the Chirodiscinae with descriptions of new taxa (Acarina: Listrophoridae) (Part two). Acarologia 5:266–278.

Poole, A. J., and V. S. Schantz. 1942. Catalog of the type specimens of mammals in the United States National Museum, including the Biological Surveys collection. Bulletin of the United States National Museum 178:1–705.

Pusterla, N., E. M. Johnson, J. S. Chae, and J. E. Madigan. 2003. Digenetic trematodes, *Acanthatrium* sp. and *Lecithodendrium* sp., as vectors of *Neorickettsia risticii*, the agent of Potomac horse fever. Journal of Helminthology 77:335–339.

Radovsky, F. J. 1967. The Macronyssidae and Laelapidae (Acarina: Mesostigmata) parasitic on bats. University of California Publications in Entomology 46:1–288.

Rausch, R. L. 1975. Cestodes of the genus *Hymenolepis* Weinland, 1858 (sensu lato) from bats in North America and Hawaii. Canadian Journal of Zoology 53:1537–1551.

Reduker, D. W., T. L. Yates, and I. F. Greenbaum. 1983. Evolutionary affinities among southwestern long-eared *Myotis* (Chiroptera: Vespertilionidae). Journal of Mammalogy 64:666–677.

Reeder, W. G., and R. B. Cowles. 1951. Aspects of thermoregulation in bats. Journal of Mammalogy 32:389–403.

Ritzi, C. M., L. K. Ammerman, M. T. Dixon, and J. V. Richerson. 2001. Bat ectoparasites from the Trans-Pecos Region of Texas, including notes from Big Bend National Park. Journal of Medical Entomology 38:400–404.

Rodhouse, T. J., S. A. Scott, R. C. Ormsbee, and J. M. Zinck. 2008. Field identification of *Myotis yumanensis* and *Myotis lucifugus*: a morphological evaluation. Western North American Naturalist 68:437–443.

Rossolimo, O. L., and I. Pavlinov. 1979. [Catalogue of mammal type species kept in the Zoological Museum of Moscow State University]. Sbornik Trudov Zoologicheskogo Muzeya MGU (Moskovskogo Gosudarstvennogo Universiteta) [Archives of the Zoological Museum, Moscow State University] 18:5–75 (in Russian, not seen cited in Simmons 2005).

Ruedi, M., and F. Mayer. 2001. Molecular systematics of bats of the genus *Myotis* (Vespertilionidae) suggests deterministic ecomorphological convergences. Molecular Phylogenetics and Evolution 21:436–448.

Schalk, G., and R. M. Brigham. 1995. Prey selection by insectivorous bats: are essential fatty acids important? Canadian Journal of Zoology 73:1855–1859.

Scott, D. T., and D. W. Duszynski. 1997. *Eimeria* from bats of the world: two new species from *Myotis* spp. (Chiroptera: Vespertilionidae). Journal of Parasitology 83:495–501.

Simmons, N. B. 2005. Order Chiroptera. Pp. 312–529 in Mammal species of the world: a taxonomic and geographic reference (D. E. Wilson

and D. M. Reeder, eds.). 3rd ed. The Johns Hopkins University Press, Baltimore, Maryland.

SPECIAN, R. D., AND J. E. UBELAKER. 1976. Redescription of a nematode, *Seuratum cancellatum* Chitwood, 1938, from bats in Texas. Proceedings of the Helminthological Society of Washington 43:59–65.

STADELMANN, B., L.-K. LIN, T. H. KUNZ, AND M. RUEDI. 2007. Molecular phylogeny of New World *Myotis* (Chiroptera, Vespertilionidae) inferred from mitochondrial and nuclear DNA genes. Molecular Phylogenetics and Evolution 43:32–48.

STOCK, A. D. 1970. Notes on mammals of southwestern Utah. Journal of Mammalogy 51:429–433.

STRECKER, J. K. 1926. A check-list of the mammals of Texas. The Baylor Bulletin 29:1–48.

STUDIER, E. H, J. W. PROCTER, AND D. J. HOWELL. 1970. Diurnal body weight loss and tolerance of weight loss in five species of *Myotis*. Journal of Mammalogy 51:302–309.

SZEWCZAK, J. M., S. M. SZEWCZAK, M. L. MORRISON, AND L. S. HALL. 1998. Bats of the White and Inyo Mountains of California–Nevada. Great Basin Naturalist 58:66–75.

THEODOR, O., AND B. V. PETERSON. 1964. On some new species of Nycteribiidae (Diptera: Pupipara). Great Basin Naturalist 3/4:107–115.

TROUESSART, E.-L. 1904. Catalogus mammalium tam viventium quam fossilium. Quincuennale Supplementum anno 1904. R. Friedländer and Sons, Berolini [Berlin], Germany.

VAN ZYLL DE JONG, C. G. 1985. Handbook of Canadian mammals: bats. National Museums of Canada, Ottawa, Ontario, Canada.

VAUGHAN, T. A. 1980. Opportunistic feeding by two species of *Myotis*. Journal of Mammalogy 61:118–119.

VILLA RAMÍREZ, B. 1967. Los murciélagos de México. Su importancia en la economía y la salubridad, su clasificación sistemática. Instituto de Biología, Universidad Nacional Autónoma de México, México, D.F.

VOGE, M. 1955. A list of cestode parasites from California mammals. American Midland Naturalist 54:413–417.

WATKINS, L. C., J. K. JONES, Jr., AND H. H. GENOWAYS. 1972. Bats of Jalisco, Mexico. Special Publications, Museum of Texas Tech University 1:1–44.

WALTERS, B. L., J. O. WHITAKER, Jr., N. S. GIKAS, AND W. WRENN. 2011. Host and distribution lists of chiggers (Trombiculidae and Leeuwenhoekiidae), of North American wild vertebrates north of Mexico. Faculty Publications from the Harold W. Manter Laboratory of Parasitology 697:1–183.

WELLER, T. J., S. A. SCOTT, T. J. RODHOUSE, P. C. ORMSBEE, AND J. M. ZINCK. 2007. Field identification of the cryptic vespertilionid bats, *Myotis lucifugus* and *M. yumanensis*. Acta Chiropterologica 9:133–147.

WHITAKER, J. O., Jr., AND D. A. EASTERLA. 1975. Ectoparasites of bats from Big Bend National Park, Texas. Southwestern Naturalist 20:241–254.

WHITAKER, J. O., Jr., C. MASER, AND S. P. CROSS. 1981. Food habits of bats of eastern Oregon bats, based on stomach and scat analyses. Northwest Science 55:281–292.

WHITAKER, J. O., Jr., C. MASER, AND L. E. KELLER. 1977. Food habits of bats of western Oregon. Northwest Science 51:46–55.

WHITAKER, J. O., Jr., AND N. WILSON. 1974. Host and distribution lists of mites (Acari), parasitic and phoretic, in the hair of wild mammals of North America, north of Mexico. American Midland Naturalist 91:1–67.

WHITAKER, J. O., Jr., C. E. YUNKER, AND C. MASER. 1983. Acarine ectoparasites (mites) of bats of Oregon. Northwest Science 57:97–106.

WILLIAMS, D. F., AND J. S. FINDLEY. 1979. Sexual size dimorphism in vespertilionid bats. American Midland Naturalist 102:113–126.

WOOD, S. F. 1941. New localities for *Trypanosoma cruzi* Chagas in southwestern United States. American Journal of Hygiene 34:1–13.

WOOD, S. F. 1949. Additional observations on *Trypanosoma cruzi* Chagas, from Arizona in insects, rodents, and experimentally infected animals. American Journal of Tropical Medicine and Hygiene S1-29:43–55.

WOOD, S. F. 1962. Blood parasites of mammals of the Californian Sierra Nevada foothills, with special reference to *Trypanosoma cruzi* Chagas and *Hepatozoon leptosoma* sp. n. Bulletin of the Southern California Academy of Sciences 61:161–176.

ZINCK, J. M., D. A. DUFFIELD, AND P. C. ORMSBEE. 2004. Primers for identification and polymorphism assessment of vespertilionid bats in the Pacific Northwest. Molecular Ecology Notes 4:239–242.

Associate Editor of this account was ERIC RICKART. Editor was MEREDITH J. HAMILTON.