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THE LONG-NOSED BAT, LEPTONYCTERIS: AN ENDANGERED SPECIES IN THE SOUTHWEST?

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The long-nosed bat, formerly known as *Leptonycteris sanborni* Hoffmeister, was ruled by the United States Fish and Wildlife Service to be an endangered species throughout its range in the southwestern United States and in México (Shull, 1988). As background, Shull (1988:25271–25272) gave the following:

> These bats are adapted for life in arid country, and are found mainly in desert scrub habitat in the U.S. parts of their range. Farther south they sometimes occur at high elevations on wooded mountains.... [They] feed on nectar and pollen, especially of the flowers of paniculate agaves (century plants) and large cacti. An intimate mutual relationship seems to be involved, with the bats depending on the plants for food, and the plants requiring the bats as pollinators. In recent decades, human exploitation of agaves may have contributed substantially to a drastic reduction in populations of *Leptonycteris*, which in turn caused a serious decline in the reproductive rate of certain agaves (Howell 1974, 1976, pers. comm., Howell and Roth 1981).

In a "Summary of factors affecting the species," Shull (1988) presented essentially five interrelated factors as justification for the ruling: 1) a long-term decline in *Leptonycteris* populations; 2) recent reports of the absence of the species; 3) a decline in pollination of agaves; 4) an earlier U. S. Fish and Wildlife Service study, and 5) concern for death of an ecosystem. The evidence cited in support of each justification is analyzed in the sections to follow. In the summary of this ruling, Shull stated (p. 25271) that numbers of *Leptonycteris* "... have declined in recent years and remaining populations are jeopardized by disturbance of roosting sites, loss of food sources, and direct killing by humans."

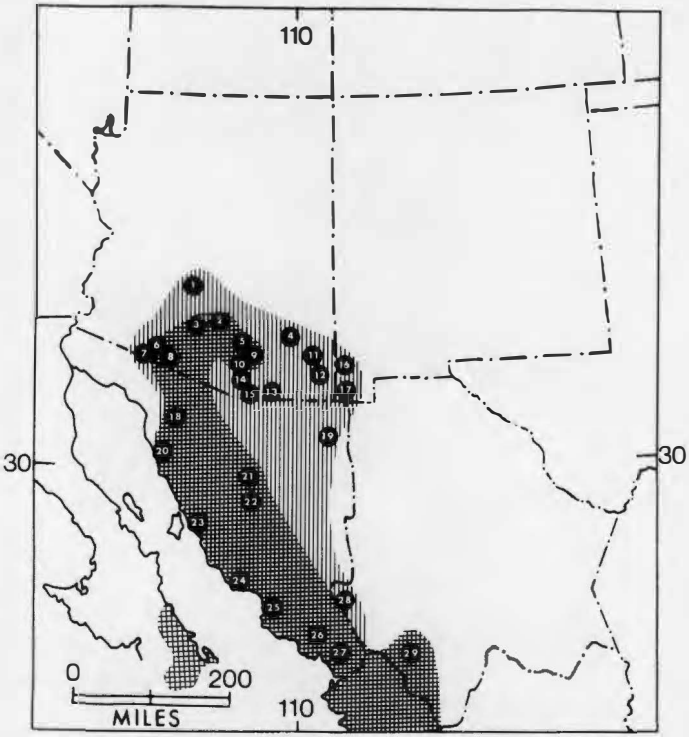

FIG. 1.—Map showing the geographic distribution of the localities listed in the Appendix for *Leptonycteris*. Cross-hatching indicates late spring and early summer records. Vertical lines indicate late summer and early fall records.

At the time of the Fish and Wildlife Service ruling in September 1988, *Leptonycteris sanborni* generally was recognized as the scientific name of this bat. In October 1988, Arita and Humphrey published the results of a systematic study in which they concluded that *Leptonycteris sanborni* Hoffmeister, 1957, is a junior synonym of *Leptonycteris yerbabuenae* Martínez and Villa-R., 1940, and solidified the use of this somewhat controversial name by the designation of a neotype for it. They also arranged *yerbabuenae* as a subspecies of the earlier-named *Leptonycteris curasoae* Miller, 1900. Thus, under the rules of the International Congress of Zoological Nomenclature, the currently acceptable name for the long-nosed bats of southern Arizona, southwestern New Mexico, and much of México is *Leptonycteris curasoae yerbabuenae*. Quoted references to *Leptonycteris sanborni* and to Sanborn's bat in the following text actually refer to this taxon.

Following is a discussion of the factors presented as justification for the ruling of "endangered" by the United States Fish and Wildlife Service.

The relationship of their findings to our results from surveying available records is given in a later section. Locality numbers correspond to those given in the Appendix and shown on the map in Figure 1.

Long-Term Decline in Populations

Shull (1988) reported that Howell (1974, 1976, personal communication) and Howell and Roth (1981) were important sources of information concerning the long-term decline of *Leptonycteris* populations. Following are some statements from these papers, most of which were quoted by Shull in her report.

Howell (1972:180–181) reported that the

> . . . United States populations of *L. nivalis* and *L. sanborni* are severely diminished or non-existent (Easterla, personal communication, 1970). The huge maternity colony in Colossal Cave, Pima Co., Arizona, which provided specimens for much of the taxonomic, physiological, and ecological work on *L. sanborni* no longer gathers in that spot and has not been seen in the last three years. The same species had congregated in a mixed-sex colony in Buckalew [=Buckelew] Cave, Cochise Co., Arizona. This was a colony of up to 1000 bats, but no bats were seen by the author during the last two years, even though bi-monthly summer checks were made.

Howell and Roth (1981:1) reported the decline in nectar-feeding bats in southeastern Arizona as follows:

> Data from studies by Hayward and Cockrum (1971) and Easterla (1972) show a steady decrease in nectar-feeding bat populations, at least in the northern part of their range. J. Mierhauser [*sic*], Head Naturalist of Colossal Cave State Park [*sic*], Arizona, has watched the *Leptonycteris* populations in that cave decline from approximately 5000 to 5 or 6 bats within the past 5 yrs (*personal communication*). In the 1950's, Colossal Cave held 10,00–20,000 nectar bats.

The estimate of 10,000 to 20,000 nectar-feeding bats in Colossal Cave appeared first in print in this paper. The source of the estimate is not clear. This estimate was reported by Shull (1988:25272) as "Until the 1950's a single roosting colony, at Colossal Cave in Pima County, Arizona, contained as many as 20,000 . . . ." To our knowledge, no earlier source gives an estimate of nectar-feeding bats in Colossal Cave as any more than 5000. We address the question of size of populations in a single roost in the discussion section.

We think that neither the findings of Hayward and Cockrum (1971; cited below) or the conclusions of Howell and Roth (1981) support the statement by Shull (1988:25272) that:

> . . . a deterioration in status was noted some years ago. Hayward and Cockrum (1971) reported that populations of many colonies in Arizona and northwestern Mexico had greatly declined and some had completely disappeared.

TABLE 1.—*Estimates of* Leptonycteris nivalis *in cave at Mount Emory, Big Bend National Park, Texas, on seven different dates (from Easterla, 1972).*

1967 (4 July)	10,650
1968 (29 May)	none
1968 (1 July)	5,000
1969 (1 August)	3,900
1970 (20 June)	none
1970 (12 August)	none
1971 (15 July)	8,025

Easterla (1972) was concerned with the population of *Leptonycteris nivalis* in Big Bend National Park, Texas. The dates and his estimates of populations are given in Table 1. Easterla (1972:291) commented:

> The 1970 absence of *L. nivalis* at Mt. Emory cave seems amazing, especially since thousands were present the three previous years. Reasons for the absence are unknown .... From 1967 to 1969, a decline in the Mt. Emory cave population of *L. nivalis* was recorded. It is not known whether this fluctuation was natural or caused by man. Apparently the *L. sanborni* population in Arizona has been decreasing over the past few years (Robert Baker, Bruce Hayward, Donna Howell, Russell Davis—pers. comm.).

Easterla (1972:291–292) then speculated that the Big Bend population, being on the northern edge of the range of the species, was a "spillover" colony, present only during years of high population or low food supply (or both) in México. He followed this with:

> Since the above was written I visited Mt. Emory cave on 15 July 1971. The *L. nivalis* had returned and I estimated a population of 8,025 ... apparently the bats had just arrived as there were few *Leptonycteris* droppings .... The return again of *L. nivalis* to Mt. Emory cave probably indicates a high population and/or low food supply in Mexico.

Another possibility is that *L. nivalis* was present at Mt. Emory cave every summer. Perhaps population maxima were similar each summer during the latter part of July and the reported 1967–1969 absence or "decline" only reflects a lack of observations when the population was present.

As discussed by Cockrum (1991), in the northern part of the range, *L. c. yerbabuenae* maternity roosts exist at lower elevations from early May until late June or early July. At that time, maternity colony occupants as well as some males from southern roosts move into transient roosts at higher elevations of southern Arizona and southwestern New Mexico. A given transient roost may be used for only a few days or a few weeks in a given year. If *L. c. yerbabuenae* and *L. nivalis* have

similar seasonal movements, the visits to the cave at Mt. Emery in May 1970 and June 1970 may have been before the arrival of the bats. By the time of Easterla's visits in August, the bats may have left the area. In any case, it seems to us that Easterla's 1972 paper should not be cited as documenting a long-term decline of the populations of *Leptonycteris nivalis* and certainly should not be used to imply the decline of population of *L. c. yerbabuenae*.

Much of the paper by Hayward and Cockrum (1971) was based on data collected in a maternity roost at Colossal Cave for a master's thesis (Beatty, 1955) under Cockrum's direction; the data from the period 1955–1960 were accumulated by Cockrum, his wife, and sons. Several years later, Cockrum gave the data to Bruce Hayward who added his own observations for publication of the 1971 report.

Hayward and Cockrum's (1971) paper has been cited time and again as documenting the "long term decline" in *Leptonycteris* populations. The only part in which population declines were mentioned is one sentence in text (p. 85)—"*Leptonycteris* populations at many of the colonies reported in this paper have greatly diminished—in fact, some, such as Colossal Cave, seem to have completely disappeared in the last five years"; and two sentences in the summary (p. 121)—"Only a few maternity sites in Arizona (none in New Mexico) are known. In recent years the numbers have become greatly reduced and the population studied in this paper is now non-existent." Although these three sentences do not document a long-term decline, they appear to accurately reflect the conclusion of the paper: that populations in the few colonies then known in the Chiricahua Mountain area had declined and the population at Colossal Cave was "now non-existent." These findings do not document a long-term, area-wide decline in the populations of *Leptonycteris curasoae yerbabuenae*.

The major factors that contributed to the disappearance of *Leptonycteris* from Colossal Cave were not mentioned in the Hayward and Cockrum paper. Colossal Cave long had been a summer roost for various kinds of bats (Beatty, 1955; Anon., 1988*b*; and Appendix). In 1905, some nine to 13 (depending on source of estimate) railroad cars of guano were removed from the cave. Thus an undisturbed substrate to examine for skeletal remains and for guano analysis is absent. During the early 1920s (not the 1950s as in some reports), the cave was opened to commercial tours and efforts were immediately initiated to drive the bats from the cave. In the mid-1930s, under the direction of the National Park Service, the cave was "improved" as a part of a Civilian

Conservation Corps project and one entrance was enlarged and a series of walkways and steps were constructed.

During the 1940s and 1950s, bat repellent measures were continued. Most were nonlethal attempts to drive the bats elsewhere. Lights, chemicals, ultrasonic devices, fake snakes and owls, and bat "drives" were utilized. In the mid-1950s, Colossal Cave served as a maternity roost for three species—*Myotis velifer*, *Plecotus townsendii*, and *Leptonycteris curasoae yerbabuenae*.

By the late 1950s, there was widespread concern, fostered by the U. S. Public Health Service, Communicable Disease Center, that bats were a health hazard in the spread of rabies. Various local and state agencies as well as the economic pressures associated with purchasing public liability insurance caused increased efforts to "move the bats out of Colossal Cave." In 1966, an exhaust fan system was installed to eliminate bat odors from the tour area. This appears to have been the final factor causing *Leptonycteris* and other species to abandon this maternity roost (perhaps because of the air movement, possibly by the partial blockage of entrances to the cave, or related to changes in temperature at the roost site caused by changes in air movement).

The roost in Buckelew Cave and in the mine tunnel north of Paradise, in the Chiricahua Mountains, were transient roosts that were visited by a number of biologists including those from the nearby Southwestern Research Station of the American Museum of Natural History (see Cockrum and Ordway, 1959, and Appendix). Howell (1972:180) reported that Buckelew Cave "was a colony of up to 1000 bats, but no bats were seen by the author during the last two years, even though bi-monthly summer checks were made." Yet in the same paper Howell (1972:5–6) reported that she had taken 166 *Leptonycteris* for use in her studies of nutrition. Most reportedly came from Buckelew Cave and the mine tunnel north of Paradise. Again, in 1975 and 1976, *Leptonycteris* taken from an unspecified roost in the Chiricahua Mountains, were repeatedly handled in the attachment of light tags, confined to the roost throughout the night, and only permitted to exit to feed on the following night (Howell, 1979).

Such visits, collections, and disturbances at the maternity roost in Colossal Cave and at the transient roosts in the Chiricahua Mountain area probably drove the bats to use alternate roosts. Some biologists speculate that the exclusion of the bats from the maternity colony site in Colossal Cave caused, directly or indirectly, their demise. However some females originally banded in Colossal Cave were recovered in

later years in a small maternity roost on Saguaro National Monument (Appendix, locality 9a).

Recent Reports of Absence of Species

Shull (1988:25272) stated that:

> A 1974 survey of all localities in the U.S., from which the species had been reported, found only 135 individuals (Howell and Roth 1981). Until the 1950's a single roosting colony, at Colossal Cave in Pima County, Arizona, contained as many as 20,000 *L. sanborni*, but that colony has now vanished.

Howell and Roth (1981:1) reported:

> D. Howell and Dr. S. Humphrey, University of Florida, visited all known United States localities for *Leptonycteris sanborni* in 1974 and found 135 animals. General habitat destruction coupled with *Agave* exploitation in northern Mexico (for food and 'home brew' alcoholic beverages) may be instrumental in this bat decline.

Apparently the results of the Howell and Humphrey survey of 1974 never were published. Howell and Roth also wrote (1981:3):

> In Arizona during 1976 and 1977, the senior author (D. J. Howell) visited every published United States locality for *Leptonycteris sanborni* and all caves and mines in the vicinity of those localities....

Howell and Roth failed to give the results of their 1976–1977 survey, but on a later page (1981:4) they recorded the following:

> In our survey of known *Leptonycteris* roosts and nearby caves and crevices that might serve as potential roosts we found no bats in the Chiricahua or Rincon mountain areas; however, a colony of approximately 200 *L. sanborni* remained in the Patagonia area.

Unfortunately no details were furnished as to when and where the observations were made.

Curiously, Howell (1979:24–25) reported, in a study of flock foraging of *Leptonycteris*, that she had made her studies in the foothills of the Chiricahua Mountains (no specific locality for the roost site was given) in August and early September of 1975 and 1976, the latter being the year when *Leptonycteris* reputedly was absent. Although no estimates of the number of bats in the roost(s) were given, and no comments were made as to population declines, bats certainly must have been present in order for her to carry out her studies. That bats were reported by the same author as present for one study but absent in the same year in another report needs clarification.

Other recent reports of the absence of *Leptonycteris* and an examination of some of the environmental implications of their supposed loss, are given below in the discussion of the U. S. Fish and Wildlife Service status report.

Decline in Pollination of Agaves

Shull (1988:25272–25273) stated that:

> Considerable evidence exists for the interdependence of *Leptonycteris* and certain agaves and cacti (a phenomenon known as chiropterophily) and for the simultaneous decline of the bats and agaves (Howell 1974,1976, pers. comm.; Howell and Roth 1981) .... Excess harvest, and other factors resulting in elimination of agaves, may have contributed substantially to the drastic decline in long-nosed bat populations. In turn, the drop in bat numbers of the past several decades has coincided with a decline in the reproductive rate of agaves.

Howell and Roth (1981:1) reported that:

> The pollination success of *Agave palmeri* is strongly dependent on nectar-feeding bats. In areas with very low or nonexistent bat populations, *Agave* seed set is < 5% of its maximum potential. A 30 year trend of declining seed set [in agaves] parallels a decline in bat numbers during that period. We speculate that habitat destruction and an increase in human use of *Agave* are causal factors.

Concerning "the impact of declining bat populations" (p. 4), they wrote:

> ... we found no bats in the Chiricahua or Rincon mountain areas; however, a colony of approximately 200 *L. sanborni* remained in the Patagonia area. Fruit set, and the number of mature seeds within each fruit, reflected the presence or absence of pollinators in these areas ....

Shull (1988:25273) made the following statement:

> ... herbarium specimens of *Agave palmeri* from the Rincon Mountains of Arizona indicate pollination success of 80–100 percent in 1938–1941, when the area supported the huge Colossal Cave colony of *L. sanborni*. In 1976, after this colony had practically disappeared, the fecundity of *A. palmeri* was 0–10 percent.

This appears to be based on the paper by Howell and Roth (1981). In this publication, these authors reported (p. 3) that they:

> ... examined fruit capsules from herbarium specimens [University of Arizona Herbarium] of three chiropterophilous *Agave* species from southern Arizona: *A. palmeri* ($N = 70$); *A. parryi* ($N = 140$); and *A. deserti* ($N = 30$).

And on page four they noted that:

> Herbarium specimens of the dry fruiting capsules of paniculate agaves indicate a decline in pollination success over the 30 years that *Leptonycteris*' populations have been diminishing. *Agave palmeri* pods from Rincon mountain area showed 80% fecundity ($N = 10$ fruits) in 1938, 90–100% fecundity ($N = 30$) in 1940 and 1941, but 0–10% fecundity ($N = 30$) in 1976. The seed set of *Agave deserti* fruits dropped from 80% ($N = 20$) in 1930 to 50% ($N = 10$) in 1957. *Agave parryi* fruits had 90% seed set in 1935 ($N = 20$), 70% in 1940 ($N = 20$), but from my own 1976 counts ($N = 100$) *A. parryi*, with 4% seed set, was faring as poorly as *A. palmeri* in recent years.

Because neither *Agave deserti* nor *Agave parryi* seem to occur in the Rincon Mountains (Gentry, 1982), Cockrum examined material in the University of Arizona Herbarium in an effort to determine the

TABLE 2.—*All pertinent specimens of* Agave *in the University of Arizona Herbarium (see text for discussion). For each, the species, catalogue number, collection date, locality, distance from Colossal Cave, the number of seed capsules and the percentage of seed set are given.*

Agave palmeri

#92388, 3 November 1938, Arizona, Cochise County, "Dragoon to Benson, 4500'" [± 30 mi. ESE Colossal Cave], 6 capsules, ± 60 percent set.

#40462, 15 April 1940, Arizona, Santa Cruz County, "1 mi. E Canelo, Huachuca Mts." [± 40 mi. SSE Colossal Cave], 22 capsules, 1 capsule with + 80 percent set; most 40 to 50 percent set, 5 > 30 percent set.

#40460, 16 April 1940, Arizona, Cochise County, "midway between Bisbee/Douglas, 3500'" [±70mi. SE Colossal Cave], 21 capsules, 1 with ± 100 percent set, several with varied (10 to 80 percent) set, at least 10 with no set.

Agave deserti

#92530, 16 November 1930, Arizona, Pinal County, "Table Top Mountain, 30 mi. W Casa Grande" [± 110 mi. NW Colossal Cave], 22 capsules, none open.

#265315, 9-11 November 1950, Arizona, Yuma County, "N slope Harquehala Mts." [± 200 mi. NW Colossal Cave], 3 capsules, none with seeds set.

Agave parryi

#92208, 21 July 1938, Arizona, Gila County, "33 mi. NE Globe, 5500 ft." [± 120 mi. N Colossal Cave], 3 capsules, 1 open, 50 percent set.

#42115, 15 April 1940, Arizona, Santa Cruz County, "Canelo Hills, 5000'" [± 40 mi. SSE Colossal Cave], 4 capsules, ± 30 percent set.

#92110, 11 June 1940, Arizona, Coconino County, "W side Rim Rock Rd., 1½ mi. S Sedona" [± 200 mi. NNW Colossal Cave], 3 capsules, 1 open, 50 percent set.

geographic and seasonal origin of the samples mentioned by Howell and Roth. All material in the herbarium of the species and years indicated by Howell and Roth are recorded in Table 2. Note that no specimens of *Agave palmeri* taken in the year 1941 were in the collection or in the catalog. The only specimens of this species obtained in 1976 were part of a collection donated to the University of Arizona in 1987, six years after the publication of the Howell and Roth paper.

Obviously none of the herbarium material listed in Table 2 was taken in what would be considered the normal feeding range of the *Leptonycteris* roosting in Colossal Cave (see Shull report above). Further, at least the 1950 specimen of *A. deserti* and the 1935 and the June 1940 collection of *A. parryi* are from areas beyond the known range of the bat. Capsule (=fruit?) counts and estimates of seed-set in Table 2 differ enough from those of Howell and Roth to warrant additional investigation.

Another factor not mentioned by Howell and Roth (1981) is the possible influence of multiannual fluctuations in the amount and seasonal

distribution of rainfall on nectar production and seed-set and seed production in *Agave*. Rainfall in 1930, 1935, 1940, 1941, and 1957 was well above normal for much of southern Arizona, whereas 1975 and 1976 were exceedingly dry years (Anon., 1930–1976).

United States Fish and Wildlife Service Study

Shull (1988:25272) gave as another basis for the endangered species ruling:

> The recent Service-funded survey covered every previously known site of occurrence in the U.S., but found the species only in one place, a cave... that held about 500 individuals ... and two additional populations of *L. sanborni* are thought to survive in or near Cochise County, Arizona, one containing perhaps 300 individuals.

These comments are based on the reports of Wilson (1985*a*, 1985*b*) of a survey of the status of long-nosed bats begun in the early 1980s. Wilson (1985*b*:7–8) wrote:

> The initial step was to contact the curators of the forty largest mammal collections in North America and to assemble a list of known specimens and localities. From this list, a three year plan was established to survey for this species and the closely related *Leptonycteris nivalis* .... [We] surveyed localities in Texas, Nuevo Leon, Tamaulipas, Coahuila, and San Luis Potosi, from July 6 to August 4, 1983. We visited all known roosts and most sites where either species of *Leptonycteris* had been mist-netted in the Sierra Madre Oriental and surrounding areas (Wilson et al, 1985).

Between 10 May and 15 June 1984, Wilson and others (Wilson, 1985*b*:8):

> surveyed localities in the Districto Federal, Mexico, Guerrero, Jalisco, Michoacan, Morelos, Sinaloa, Nayarit, and Sonora .... In addition, we mist-netted almost every night....

His survey of "all known U. S. localities for *L sanborni*" was carried out from 10 to 25 July 1985 when (Wilson, 1985*b*:8):

> In addition to visiting every known roost and netting at all sites of previous capture, we interviewed biologists and conservation officials throughout the area to glean recent sightings or capture records not available in the published literature.

Findings from these activities lead Wilson to state (1985*b*:24–25):

> The single known colony remaining in the United States is... in Santa Cruz County, Arizona .... [However]... Feeding aggregations occur regularly at bird feeders at Portal in the Chiricahua Mountains and at Ramsey Canyon in the Huachuca Mountains .... By far the bulk of the range [of the species] lies in Mexico.... A catastrophe at the only remaining known U.S. roost would devastate the remaining population in this country.

Wilson followed this with a reference to the Howell and Humphrey 1974 report (which, as previously stated, apparently had never been

published—only referred to indirectly by Howell and Roth, 1981) of only 135 *Leptonycteris sanborni* in the United States. Wilson concluded (1985*b*:27):

> I recommend that, pursuant to the Endangered Species Act of 1973, as amended, *Leptonycteris nivalis* be listed as Threatened. [The use of *nivalis* was obviously a *lapsus*, as indicated by context.]

A critical examination of Wilson's (1985*b*) report reveals some weaknesses. The results of the survey of museum specimens is not given. No mention is made of the results of the survey of published records. Another is the high degree of probability that not all of the known roosts and collecting sites in New Mexico and Arizona could be visited in the time period given (p. 8) of "from 10 to 25 July, 1985," especially when his party also simultaneously "interviewed biologists and conservation officials throughout the area." The sites visited and the dates of the visits are not part of the report.

Even more serious is the obvious lack of understanding of the general chronology of movements of *Leptonycteris* in the area. Not only does Wilson's survey apparently fail to include several important localities, it included visits to places at the wrong time. For example, he reported (1985*b*:12):

> The Chiricahua Mountains in Cochise County used to house several colonies of *L. sanborni* in a variety of mine tunnels and natural caves. Gene Studier and I searched several of these on July 12 and 13, 1985.

The known day roosts in the Chiricahua Mountains involve one cave and a few mines, mostly occupied after mid-July (see Appendix and Cockrum, 1991). Because recoveries of banded individuals in this region indicated that movement between roosts was common (Bat banding records, University of Arizona), we are not certain that each roost should be classified as a colony. We suspect that visits to the same roosts just a month later would have revealed the presence of this species—as has been found at other localities in southern Arizona (Fig. 5 and Appendix).

Concern for Death of an Ecosystem

Shull (1988:25273) gave another justification for ruling *Leptonycteris sanborni* to be an endangered species:

> Other agaves, as well as the saguaro and organ pipe cacti, may also be affected, and there is concern for the future of the entire southwestern desert ecosystems.

This statement probably was based on a speculation in Howell and Roth (1981:6) that:

> If *Agave* populations are diminishing, the decline of glossophagine bats may be hastened. The saguaro cactus (*Carnegiea gigantea*), and Organ Pipe cactus (*Stenocereus* = *Lemaireocereus thurberi*), for which the bats (in other months) are also important pollinators (Alcorn et al. 1961, McGregor et al. 1962), may be affected. The decline of such major plants as columnar cacti and agaves in desert areas could result in a decrease in animal diversity....

Wilson (1985*b*:25) also expressed concern that populations of agave in the region are being reduced.

> A more nebulous, but perhaps also more pernicious, threat lies in the continued loss of populations of agaves, which serve as the major food source, at least in the northern parts of the range. Howell and Roth (1981) suggested that the linkage between the bats and the plants is such that a downward spiral could be triggered by a decline in the population of either. Unfortunately, documenting an overall decline in agave populations throughout the range of *L. sanborni* is a difficult task indeed. However, the potential threat provided seems clear from Howell's studies.

Discussion

A survey of the available information concerning the distribution and numbers of *Leptonycteris* is necessary to evaluate any recent changes. Here these data are reviewed as to first reports, presence or absence records, and numbers.

First Reports

Only two occurrences of the genus *Leptonycteris* have been reported from the fossil record. Jones (1958) recorded bones as referable to the modern species *Leptonycteris nivalis* Saussure, from late Pleistocene deposits in the San Josecito Cave, San Josecito, Nuevo León. Similarly, Dalquest and Roth (1970) reported a lower jaw of *L. nivalis* from late Pleistocene material from Cueva del Abra, Tamaulipas.

None of the authors of early regional reports (Coues, 1867; Allen, 1895; Mearns, 1907; Bailey, 1932) nor any of those of early checklists of North American mammals (Elliot, 1907; Miller, 1912; Miller, 1923) listed this genus in the states of Arizona, New Mexico, Sonora, or Chihuahua.

The first record for Arizona was of specimens taken at Colossal Cave (Appendix, locality 9b) in 1930. The earliest published records are those of Campbell (1934) of specimens from the Huachuca and Patagonia mountain regions in 1933. The first records for New Mexico were specimens taken in 1958 from two localities in the southwestern part of that state (Jones and Findley, 1963). Miller and Kellogg (1955) listed the northernmost records for the northwest-west region as Carimechi, Chihuahua (Burt and Hooper, 1941), mountains of eastern Sonora (Burt, 1938), and southeastern Arizona (Campbell, 1934). Hall

(1981) provided a map that gave no indication of the seasonal aspect of the occurrence of the species.

Presence or Absence Records

A number of records of *Leptonycteris* are available from museum specimens, from the literature, from banding records in files at the University of Arizona, and from various unpublished field notes. Most are simply indications of the presence or absence of the species at a given time and place. Most of the considerable number of observations and specimens of *Leptonycteris* available from the northwestern part of the range (Fig. 1) are listed in the Appendix. Numbers on the map correspond with those in the Appendix. Figures 2 through 5 are maps that show the distribution of these sites in four time periods: 21 years beginning with 1930—the first record in the region; 21 years beginning with 1952—start of studies in region by Cockrum and students; 11 years beginning with 1974—the year that Howell and Humphrey found only 135 *Leptonycteris* in Arizona through 1985, the year that the U.S. Fish and Wildlife Service survey work was conducted; and four years beginning in 1986. *Leptonycteris* obviously has not disappeared from the area. However, mere presence does not give any indication of population size.

Population Size

Few estimates of population size are available (Appendix). Even when available, few indicate how the censuses were done. When numbers are low, one suspects that actual counts were made. Most larger numbers probably involved some sort of formal or informal estimations. Most are estimates of the number of bats in a day roost (see Cockrum, 1991, for definitions of roost types used here). Probably one of the more commonly used census techniques was to estimate the area covered by roosting bats and the number of bats per unit area. As discussed by Cockrum (1991), *Leptonycteris* normally roosts in the warmest areas available in a roost. In warm roosts, they hang at widely spaced intervals. In cool roosts, they usually hang in dense clusters, often near the entrance, perhaps to take advantage of the warmer, outside air. Obviously, both cluster size and density must be considered in estimating populations. Some estimates have been based, at least in part, on flight counts. Such counts are difficult, at best, in part because other species often occur in the same day roost.

As discussed by Cockrum (1991), the largest numbers of *Leptonycteris* in Arizona have been recorded at maternity colonies. Roosts larger than those we report apparently occur in central and southern México.

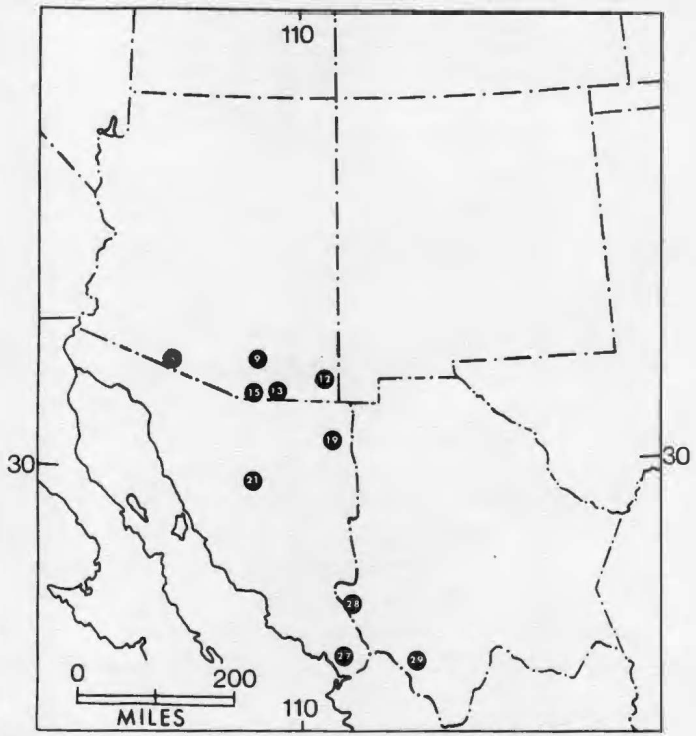

FIG. 2.—Map showing the geographic distribution of the 14 sites (10 dots on map) of records for a 21-year period, 1930–1951. Locality numbers are those given in the Appendix.

Prior to the 1988–1989 surveys of Petryszyn (unpublished data), only two or three maternity roosts were known in the United States. The one that formerly occurred at Colossal Cave may have contained as many as 5000 bats (Appendix, locality 9b). A maternity roost at Old Mammon Mine (Appendix, locality 3a) was probably larger than the one at Colossal Cave. Hoffmeister (1959:15) reported that on 20 July 1957:

> Some of the adult females were pregnant; others had associated young that were capable of flight. There were at least 300 *Leptonycteris* in one cluster.

He also noted that on 24 June 1958:

> . . . there was an immense colony of between one and two thousand newborn and nursing *Leptonycteris* just inside the mine entrance . . . .

Perhaps 200 to 300 females have continued to utilized a rock crevice on the Saguaro National Monument (Appendix, locality 9a) as a maternity roost.

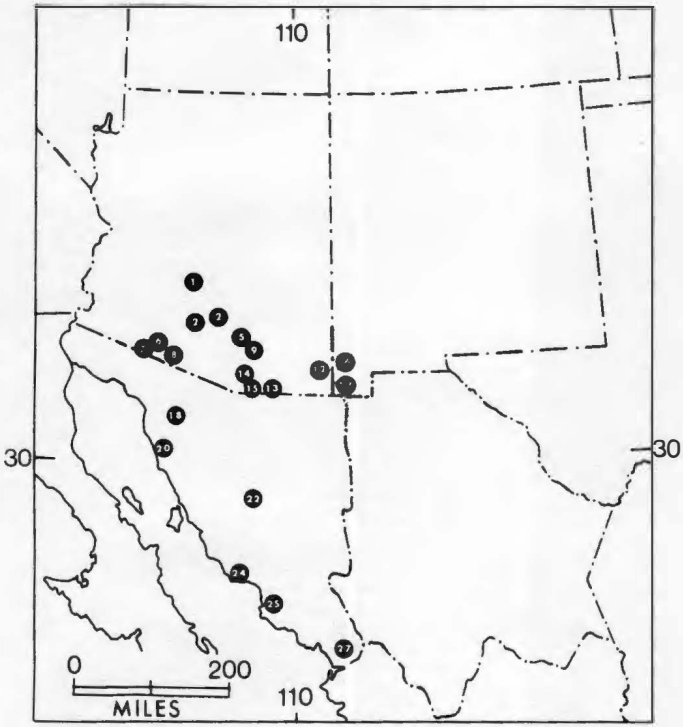

FIG. 3.—Map showing the geographic distribution of the 31 sites (20 dots on map) of records for a 21-year period, 1952–1973. Locality numbers are those given in the Appendix.

Population estimates available for roosts in Arizona, New Mexico, and Sonora are listed in Table 3. Estimates, made at various dates between 1950 and 1988, range from 13 to 10,000. The highest were obtained in the 1960s when Cockrum and students made efforts to visit roosts at appropriate times, and in the late 1980s when Petryszyn made his visits. Few counts were made in the period from 1970 to 1988, and these visits to roosts often occurred when bats were not likely to be present.

Furthermore, often in considerable numbers, nectar-feeding bats have been observed at hummingbird feeders in southern Arizona (see Appendix, localities 10b, 12e, and 13e, and Wilson, 1985*b*). Observations and photographs of bats at these feeders indicate that most were *Leptonycteris*. Some were *Choeronycteris mexicana*, which occurs in much of the same region (Hall, 1981; Hoffmeister, 1986). *Choeronycteris* in southern Arizona apparently does not congregate in large groups, and does not occur in the lower elevations utilized by *Leptonycteris* in May

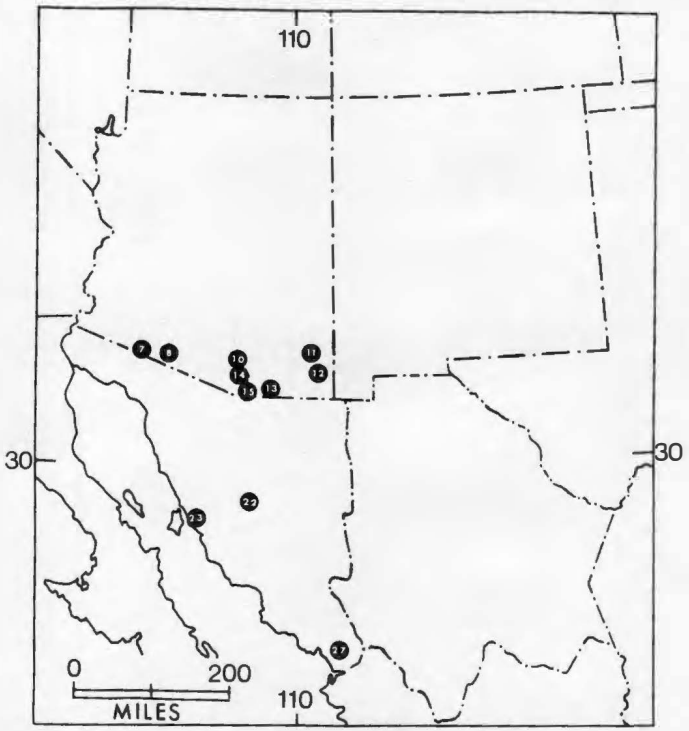

FIG. 4.—Map showing the geographic distribution of the 16 sites (11 dots on map) of records for an 11-year period, 1974–1985. Locality numbers are those given in the Appendix.

and June. However, it does occur at elevations above 4000 feet in relatively low numbers from May through October (Cockrum and Ordway, 1959; Hoffmeister, 1986).

Use of hummingbird feeders by *Leptonycteris* appears to conflict with speculations concerning the importance of color and scent in attracting nectar-feeding bats to chiropterophilous flowers. As summarized by Howell (1976:53):

> The characteristics of chiropterophilous flowers reflects their dependence upon bats for reproduction. Such flowers open at night and are white or light in color. They have a peculiar musky, or "batty," odor. On moonlit nights, bat-pollinated flowers stand out almost as if they were fluorescent. The odor, which may be noticeable only after dark, often forms an aura that surrounds the tree. The odoriferous substance has been found to contain butyric acid; since bat body musk also contains butyric acid, it has been hypothesized that the odor that attracts bats to bats also attracts bats to flowers.

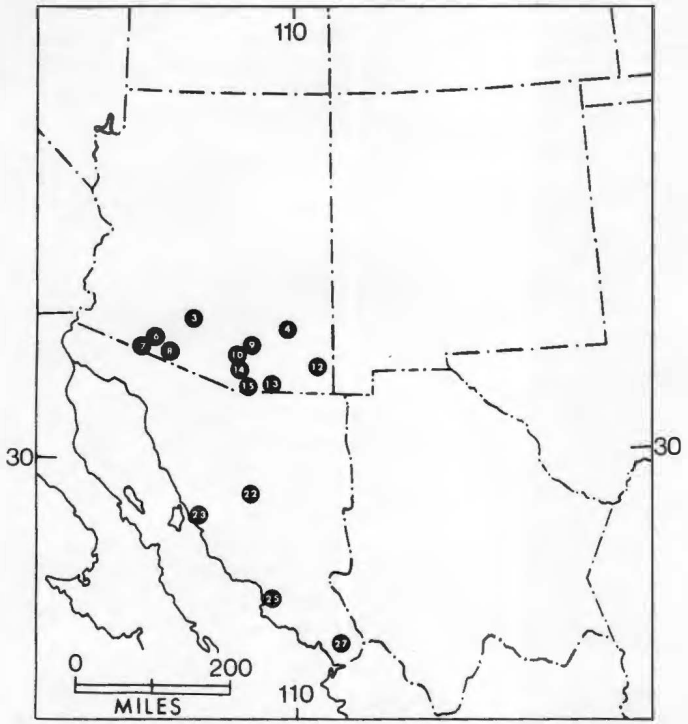

FIG. 5.—Map showing the geographic distribution of the 25 sites (15 dots on map) of records for a three-year period, 1986–1988. Locality numbers are those given in the Appendix.

This obviously does not apply to the essentially colorless, odorless hummingbird food being dispensed from generally bright red plastic "flowers" on feeders.

Some observers have recorded the amount of sugar solution taken by these bats in a given night from hummingbird feeders. If some crude assumptions are made (hummingbird food has the same weight to volume ratio as water, bats fed only at the feeders being monitored and not at plants or at other hummingbird feeders in their feeding range, and Carpenter's (1969) calculated feeding rate of 20 cubic centimeters per night is somewhat accurate) estimates of the minimum numbers of bats visiting feeders can be calculated.

The Spofford (personal communication) Chiricahua Mountain findings (Appendix, locality 12e) of bats using up to two gallons per night translates into approximately 375 bats; the 307 ounces per night at Mile Hi in the Huachuca Mountains reported by Wilson (1985*b*) would result in an estimate of about 435 bats. Carroll Peabody (personal com-

TABLE 3.—*Estimates of numbers of* Leptonycteris curasoae yerbabuenae *in various roosts (see text for discussion and appendix for details of localities). Abbreviations are: M, maternity colony; R, night roost; T, transient roost; ?, not known.*

Date		Site no.	Locality	Roost type	Estimate
1950	August	13d.	Bldg., Cochise Co., Arizona	R	100
1954	May 8	9b.	Cave, Pima Co., Arizona	M	10
	June 7	9b.	Cave, Pima Co., Arizona	M	133+
	July 14	12a.	Cave, Cochise Co., Arizona	T	1000+
	July 21	9b.	Cave, Pima Co., Arizona	M	506+
1955	August 14	12d.	Mine, Cochise Co., Arizona	T	150
	August 16	12a.	Cave, Cochise Co., Arizona	T	1500±
1956	May 26	9b.	Cave, Pima Co., Arizona	M	300+
	May 27	9b.	Cave, Pima Co., Arizona	M	700+
	May 28	9b.	Cave, Pima Co., Arizona	M	1000+
1958	April 11	22.	Cave, Sonora	M/T	100+
	July 8	9b.	Cave, Pima Co., Arizona	M	102+
	August 3	12d.	Mine, Cochise Co., Arizona	T	35±
	August 31	12d.	Mine, Cochise Co., Arizona	T	200±
	September 2	12a.	Cave, Cochise Co., Arizona	T	500-600
	September 13	12d.	Mine, Cochise Co., Arizona	T	6
	November 30	22.	Cave, Sonora	T	5
1959	March 29	27b.	Mine, Sonora	?	1000±
	April 18	22.	Cave, Sonora	T	100
	November 6	22.	Cave, Sonora	T	
1960	April 8	22.	Cave, Sonora	T	200
	May 11	9a.	Crevice, Pima Co. Arizona	M	35±
	May 23	9b.	Cave, Pima Co., Arizona	M	1000+
	June 6	9b.	Cave, Pima Co., Arizona	M	1000+
	July 18	22.	Cave, Sonora	?	30
	August 29	14.	Cave, Santa Cruz Co., Arizona	T	"many"
1962	May 26	22.	Cave, Sonora	M	6000
1963	April 26	22.	Cave, Sonora	?	100
	May 20	22.	Cave, Sonora	M	20
	June 28	18.	Mine, Sonora	M	5000
	August 30	18.	Mine, Sonora	M	10,000
1964	Jan 27	27a.	Mine, Sonora	?	50
	Feb 29	27a.	Mine, Sonora	?	50
	April 16	27a.	Mine, Sonora	?	100
	May 22	9b.	Cave, Pima Co., Arizona	M	300
	May 31	27a.	Mine, Sonora	?	100
	June 29	27a.	Mine, Sonora	M	1000
	August 7	27a.	Mine, Sonora	?	100
	November 24	27a.	Mine, Sonora	?	present
1965	September 1	14.	Cave, Santa Cruz Co., Arizona	T	200-250

TABLE 3.—*Continued.*

Date		Site no.	Locality	Roost type	Estimate
1966	May 12	9a.	Crevice, Pima Co., Arizona	M	211+
	June 21	22.	Cave, Sonora	M	5000
1970	September 18	6a.	Mine, Pima Co., Arizona	T?	250
1976	?	15c.	Cave, Santa Cruz Co. Arizona	T	200
1980	April 13	22.	Cave, Sonora	M	1000±
1983	August	27b.	Mine, Sonora	?	1000+
1985	July 10-25	15c.	Cave, Santa Cruz Co., Arizona	T	500
1986	April 13	22.	Cave, Sonora	?	2000±
	May 13	22.	Cave, Sonora	M	500-1000
	May 14	9a.	Crevice, Pima Co. Arizona	?	50±
	August 5	12d.	Mine, Cochise Co. Arizona	T	13
	September 1	12c .	Mine, Cochise Co., Arizona	T	3000
1987	April 25	6b.	Mine, Pima Co. Arizona	M	50
	September 9	14.	Cave, Santa Cruz Co., Arizona	T	500
	September 24	14.	Cave, Santa Cruz Co., Arizona	T	50
1988	August	27b.	Mine, Sonora	?	1000+
	September 9	14.	Cave, Santa Cruz Co., Arizona	T	170
	September 10	14.	Cave, Santa Cruz Co., Arizona	T	150
	September 17	14.	Cave, Santa Cruz Co., Arizona	T.	25-30
	September 17	15c.	Cave, Santa Cruz Co., Arizona	T	300
1989	April 29	8f.	Mine, Pima Co., Arizona	M	3000+
	May 22	6c.	Mine, Pima Co., Arizona	M	3000±
	May 22	8f.	Mine, Pima Co., Arizona	M	7000-9000
	June 10	8f.	Mine, Pima Co., Arizona	M	12,000
	June 18	3a.	Mine, Pinal Co., Arizona	M	3000-5000
	June 24	8f.	Mine, Pinal Co., Arizona	M	11,000
	July 6	3a.	Mine, Pinal Co., Arizona	M	6000
	July 15	15d.	Cave, Santa Cruz Co., Arizona	T	1000-2000
	July 31	3a.	Mine, Pinal Co., Arizona	M	500±
	August 20	15d.	Cave, Santa Cruz Co., Arizona	T	14,000
	August 30	15d.	Cave, Santa Cruz Co., Arizona	T	6000-8000

munication), the former owner of Mile Hi (Appendix, locality 13e) reported that between 1971 and 1982 about 660 ounces was consumed by 10:30 PM each night during a period of six to seven weeks from early August to mid-September, giving an estimate of about 924 bats. Peabody also took hummingbird feeders on short trips to Pinery Canyon, on the west slope of the Chiricahua Mountains, and reported that nectar-feeding bats emptied feeders there from the first night the feeders were present. Numbers of feeders and dates were not available. Nectar-feeding bats also have been present in numbers at feeders in the Santa Rita Mountains since prior to 1974, taking as much as 336 ounces

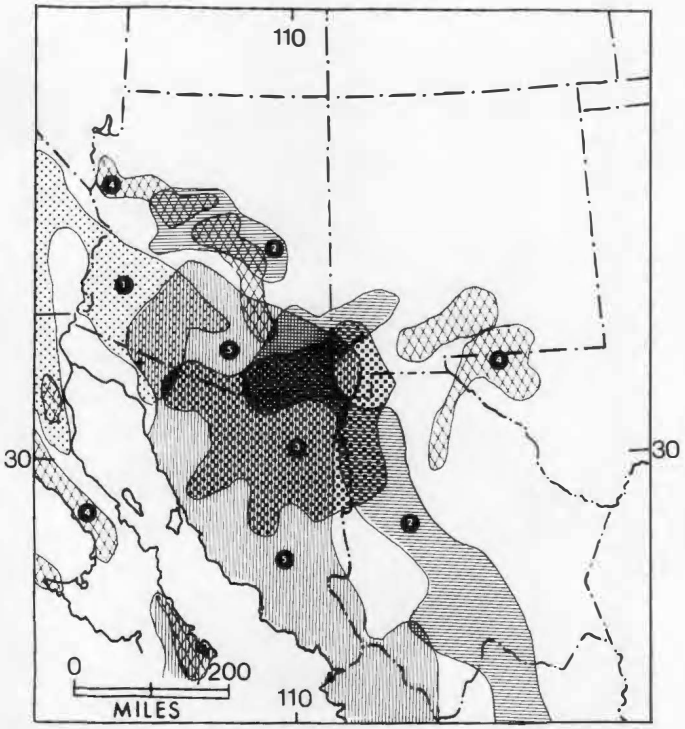

FIG. 6.—Map showing part of the geographic distribution of several species of agaves (from Gentry, 1982) superimposed over the distribution of *Leptonycteris*. Patterns show distribution of: 1, *Agave deserti*; 2, *Agave parryi*; 3, *Agave palmeri*; 4, other species of paniculate agaves; 5, *Leptonycteris*.

before 1:00 AM each night from August until early October (Appendix, locality 10b).

Reports of nectar-feeding bats at hummingbird feeders indicate presence of the bats during each of the past few years. The usage by bats of hummingbird food from feeders appears to have been relatively constant, suggesting little in the way of multiannual fluctuations in bat populations. The above estimates of numbers of *Leptonycteris* in roosts in the northwestern part of their range strongly suggest that the total population in a given roost in this area probably rarely exceeded 5000. Certainly the maximum population of *Leptonycteris* in Colossal Cave probably never has been much more than 5000 at any time since 1952—a major contrast to the 20,000 reported by Shull (1988) and others. The presence of large maternity roosts on the Organ Pipe Cactus National Monument (Table 3 and Appendix, locality 8f), Cabeza Prieta Wildlife Refuge (Table 3 and Appendix, locality 6c), and Slate Mountain (Table

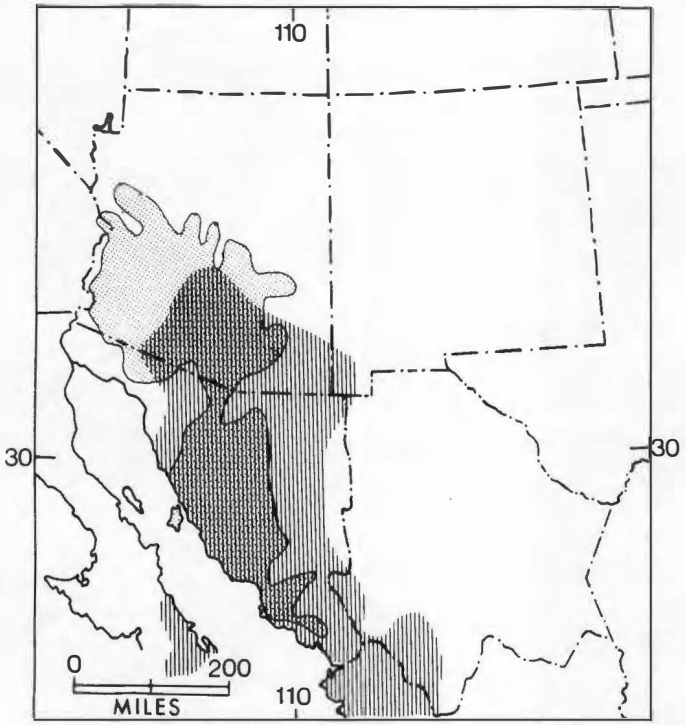

FIG. 7.—Map showing part of the geographic distribution of saguaros (dots—from Hastings *et al.*, 1972) superimposed over the distribution of *Leptonycteris* (vertical lines).

3 and Appendix, locality 3a); the known active roosts in various caves and mine tunnels in Santa Cruz and Cochise counties (Appendix, localities 12c and 15e); and the continued utilization of hummingbird feeders—all combine to strongly suggest that *Leptonycteris* was not reduced in Arizona to 500 individuals as assumed by Shull (1988) and certainly shows that the current population greatly exceeds the 1985 estimate.

Little evidence exists to document a "long-term decline" in *Leptonycteris* populations of Arizona, New Mexico, and Sonora. The various recent reports of disappearance appear to be, at least in part, the result of not looking in the right places at the right times.

Although *Leptonycteris* is an important pollinator of paniculate agaves and various columnar cacti in this part of the range of the species, its absence certainly does not prevent these plants from reproducing. Figure 6 shows the distribution of paniculate agaves; Figure 7 shows the distribution of saguaros with the range of *Leptonycteris* superimposed. Note the extensive areas of both paniculate agaves and

saguaros that are outside areas where nectar-feeding bats of either species ever have been recorded. This suggests that even if *Leptonycteris* were to be eliminated, "concern for the future of the entire southwestern desert ecosystems" (Shull, 1988) is an overstatement. Unfortunately the popular press has taken some of the above material out of context and has been reporting that lack of long-nosed bats for pollination is causing a reduction of Saguaro cactus populations, and the degradation of the Sonoran Desert ecosystem.

Conclusions

It appears that limited parts of the available data were used when the Fish and Wildlife Service ruled that the long-nosed bat, *Leptonycteris curasoae yerbabuenae*, was endangered. The data used appear to be a combination of over-optimistic estimates of past population sizes and overly pessimistic estimates of current numbers, both poorly documented. No place can we find support of the statement that the population in Colossal Cave was in the 20,000 range. Certainly the earliest records available to us—in the 1950s—were much nearer 5000. Even the highest of past estimates placed the maximum in a maternity roost in Arizona at about 14,000, and this was in 1989 after *Leptonycteris* had been ruled endangered.

Analysis of the limited records of occurrence and population size and composition suggests that most observers have not understood the seasonal cycle of movements within the northern part of the range. This has resulted in reports of disappearances of populations that are rarely, if ever, present at the time that the observer visited the roost.

The questionable hypothesis that various agaves and columnar cacti are dependent upon nectar-feeding bats for adequate pollination to insure species survival apparently also influenced the ruling of Endangered Species status for *Leptonycteris curasoae yerbabuenae*. The fact that much of the range of the saguaro and that of several agaves are in areas where no nectar-feeding bats have been recorded in historic times seems not to have been noticed by the United States Fish and Wildlife decision makers.

Certainly *Leptonycteris* no longer occurs at the Colossal Cave maternity roost. Certainly additional observations by trained bat biologists aware of the life habits of this species are necessary. But it appears probable that current populations in the northwestern part of the range of the species are little, if any, decreased from those of a quarter century ago. It even has been suggested that populations have increased in the

past century because of more suitable roosts being available as the result of mining activity in the area.

ACKNOWLEDGMENTS

Many of the banding data and field observations reported here were the results of activities of a number of former students and assistants of Cockrum. Editorial comments and critical reviews of the manuscript were provided by David Dalton, Virginia Dalton, and Ronnie Sidner. Especially useful were the editorial efforts of Thomas Huels and J. Knox Jones, Jr. To all, named and unnamed, our thanks for making this report possible.

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APPENDIX

This appendix lists all of the records of occurrence of *Leptonycteris* that we have been able to find for the northwestern portion of its range in southern Arizona, southwestern New Mexico, Sonora, and Chihuahua. The records are of four types:

(A) Specimens examined by Cockrum followed by citations to literature in which the same specimens were reported. Abbreviations include: KU (University of Kansas, Lawrence), LACM (Los Angeles County Museum), MSB (Museum of Southwestern Biology, University of New Mexico, Albuquerque), MV (Museum of Vertebrate Zoology, University of California, Berkeley), TCWC (Texas Cooperative Wildlife Collections, Texas A & M University, College Station), UA (University of Arizona, Tucson), UI (University of Illinois, Urbana), UM (University of Michigan, Ann Arbor), USNM (National Museum of Natural History), USBS (United States Biological Survey).

(B) Literature. References to published reports of specimens and observations.

(C) Banding records and associated notes. These are the notes and records compiled by Cockrum and students and currently housed in Cockrum's office at the University of Arizona.

(D) Notes, personal communications, and other records from the sources indicated.

Arizona

Maricopa County

1a. (A). Glendale, 16 September 1963, 1 immature ♀, UA (Constantine, 1966:126; Hall, 1981:133; Hoffmeister, 1986:66).

1b. (A). Phoenix, 30 August 1963, 1 immature ♀, UA (Constantine, 1966:126; Hall, 1981:133; Hoffmeister, 1986:66).

Pinal County

2. (A). Drive-in Mine, Picacho Peak, 45 mi. N Tucson [± 2000 ft.], 13 May 1960, 1 ♀, UA (Hoffmeister, 1986:66). [=? Picacho Peak, mine tunnel, 25 August 1955, 1 ♂, UA.] (C). = Picacho Peak, Drive-in [= mine tunnel, E end of S slope of Picacho Peak], 21 May 1960, 1 ♀.

3a. (B). Old Mammon Mine, W base Slate Mountains, approx. 27 mi. SW Casa Grande [± 1800 ft.], unspecified date [20 July 1957 from field notes], "Some of the adult females were pregnant; others had associated young that were capable of flight .... There were at least 300 *Leptonycteris* in one cluster ... there was an immense colony of between one and two thousand newborn and nursing *Leptonycteris* just inside the mine entrance .... On this day, young 'Leptos' were of two sizes, one almost entirely hairless and a larger size that was nearly fully-haired," Hoffmeister (1959:15). [= 27 mi. SW Casa Grande, 6, UI,

Hoffmeister (1986:66).] (D). Old Mammon Mine, W base Slate Mountains, about 27 mi. SW Casa Grande [±1800 ft.]. 18 June 1989, 3000 to 5000 in evening flight (9 netted: 2 lactating ♀♀, 6 post-lactating ♀♀, 1 juvenile), Petryszyn notes. 6 July 1989, 6000± in evening flight (examined and released adult ♀♀ and juveniles of both sexes), Petryszyn notes. 31 July 1989, 500+ (examined and released 2 adult ♀♀, numerous juveniles), V. Dalton notes.

3b. (B). 28 mi. SW Casa Grande, 8, UI, "maternity colonies are known in Arizona at two places in the Slate Mountains, 27 and 28 miles SW Casa Grande [mine shafts]," Hoffmeister (1986:66).

3c. (B). 27–28 mi. SW Casa Grande [= 3a and 3b?], 14, UI, Davis and Carter (1962:197).

Graham County

4a. (A). Gillespie Wash, 0.25 mi. N Highway 266 (Stockton Pass Road), 20 September 1986, 1 juvenile , UA. [= Gillespie Wash, 1321 m, in Stockton Pass, S end Graham Mountain, Pinaleño Mountains, Sidner and Davis, 1988:494).]

4b. (B). Muleshoe Preserve [=? 22 mi. NW Willcox on Greenlee-Cochise county line, ±5000 ft.], "small colony," date not given [personal communication—"5 to 7 seen a couple of times in September, 1988"], Howell (1988:9).

Pima County

5. (C). Mist net, pool, Sabino Canyon. Nets in place at least 40 evenings between 21 July 1958 and 24 August 1962—one ♀ *Leptonycteris* taken 24 June 1961.

6a. (B). Blue Bird Mine, 2 mi. NW Growler Mine, just outside Organ Pipe Cactus National Monument, September 1970, 250, (OPCNM records), Cockrum (1981:2) and Cockrum and Petryszyn (1986:8).

6b. (B). Mine tunnel, Growler Mountains, Cabeza Prieta National Wildlife Refuge, "approximately 50 . . . including many pregnant females," 25 April 1987, Sidner and Davis (1988:494).

6c. (D). Mine adit, Growler Mountains, Cabeza Prieta National Wildlife Refuge [= 6b?]. 22 May 1989, 3000± (all examined were gravid ♀♀ or ♀♀ with young), Petryszyn notes.

7a. (A). Mist net, Agua Dulce Pass, Agua Dulce Mountains, Cabeza Prieta Game Range. 29 July 1968, 1 ♀, UA (Hoffmeister, 1986:66).

7b. (D). Cowboy Mine, Agua Dulce Mountains. 5 June 1989, Ten dead (1 adult, 9 young), Petryszyn notes.

7c. (D). Papago Mine, Agua Dulce Mountains. 6 June 1989, 20 adults, Petryszyn notes.

7d. (A). Mist net, Pozo Nuevo, Organ Pipe Cactus National Monument, 29 July 1979, 1 ♀, UA (Cockrum and Petryszyn, 1986:8).

8a. (A). Mist net, Alamo Wells, T. 12 S, R. 4 W, Organ Pipe Cactus National Monument, 8–9 July 1979, 2 ♀♀, UA (Cockrum and Petryszyn, 1986:8).

8b. (D). Mist net, water trough, Alamo Canyon, 26 June 1977 (OPCNM records, Cockrum, 1981:2).

8c. (C). Mist nets at scattered pools, Alamo Canyon, 29 May 1979, 1; 9–10 July 1979, 16 (♂♂, ♀♀, juveniles) (Cockrum, 1981:5).

8d. (A). 30 mi. SE Ajo, 3 (2 ♂♂, 1 ♀), 14 May 1953, LACM; = Tonoga, 30 mi. SE Ajo, 8, LACM (Constantine, 1961:405 and Hoffmeister, 1986:66; =? Natural cave, 2 mi. W Tonoga Well, E slope Ajo Mountains, 1 May 1943, "a group" including 1 ♀, Constantine, 1961:404 and Hall, 1981:134).

8e. (D). South entrance of Copper Mountain Mine [Organ Pipe Cactus National Monument], 1 June 1977, 10 netted (OPCNM records); 27 July 1979, used as a day roost, Cockrum (1981:2) and Cockrum and Petryszyn (1986:8).

8f. (D). Mine tunnel, NE corner Organ Pipe Cactus National Monument [=? 8e]. 29 April 1989, 3000+ (many pregnant), Petryszyn notes. 22 May 1989, 7000 to 9000 (both pregnant females and females with young), Petryszyn notes. 10 June 1989, 12000± (more than 2000 nonvolant young), Petryszyn notes. 24 June 1989, 7000 to 11000 in evening flight, Petryszyn notes.

8g. (A). Bull Pasture Springs, Organ Pipe Cactus National Monument [mist net], 23 April 1982, 1 gravid ♀, UA (Cockrum and Petryszyn, 1986:8).

8h. (A). Dripping Springs, Organ Pipe Cactus National Monument [mist net], 28 July 1979, 1 ♀, UA (Cockrum and Petryszyn, 1986:8).

9a. (A). Box Canyon Crevice [± 3500 ft.], Saguaro National Monument, 24 August 1960, 2 ♂♂, UA (= Box Canyon Crevasse, Hoffmeister, 1986:66). = Saguaro National Monument, Rockslide, N side Sentinel Butte, 12 May 1967, 5 ♀♀, UA (Hoffmeister, 1986:66--see Sidner and Davis, 1988:494, for comments about this locality). B). = Saguaro National Monument, rock crevice near south boundary, June 1969, 2 ♂♂, 5 ♀♀ removed, Howell (1972:5). [= Box Canyon Crevice (Saguaro National Monument), 14 May 1986, "about 50," and 24 July 1986, 5, Sidner and Davis (1988:494).] (C). 11 May 1960, 1 banded ♀ recovered of 35±; 24 August 1960, 2 subadults; [= Saguaro National Monument, Rock slide on N side of Sentinel Butte, 12 May 1967, 189 ♀♀ banded, 11 ♀♀ recovered, 9 ♀♀ retained].

9b. (A). Colossal Cave, 30 mi. SE Tucson [= 23 mi. E, 10 mi. S Tucson, 3650 ft.], 13 June 1930, 1 ♀, USBS; 1 August 1953, 2 juvenile ♂♂, UA; 3 June 1966, 1♂, 1 ♀, UA; [= entrance Colossal Cave, 1953, 1 mummy, UA]; [= near Colossal Cave, 30 mi. SE Tucson, 27 May 1930, 1 ♀, USBS]. (1 UA, 2 UI, Hoffmeister, 1986:66). (B). [= Colossal Cave, 30 mi. SE Tucson, Cochise [*sic*] County], 2, USBS, Hoffmeister (1957:457); 2, UI, Davis and Carter (1962:197); May-June, 1962, 9 [or more] ♀♀ removed, Huibregtse (1963); "all" [number not given but exceeded 16] experimental animals captured Colossal Cave, Carpenter (1969:289). (C). 1 August 1953, 2 juvenile ♂♂; 8 May 1954, 8 ♀♀ banded of 10±; 31 May 1954, 9 banded; 7 June 1954, 133 banded; 18 June 1954, 9 banded; 18 July 1954, 41 banded; 20 July 1954, 10 banded; 21 July 1954, 506 banded; 16 May 1955, 3 ♀♀ banded, 3 recovered, 1 adult taken; 19 May 1956, 26 ♀♀ banded, 4 ♀♀ recovered; 26 May 1956, 42 ♀♀ banded, 3 ♀♀ recovered, 300± young hanging from ceiling; 27 May 1956, 900± young; 28 May 1956, 1000± young; 23 June 1956, 2 young ♂♂, 2 young ♀♀ banded, 4 adult ♀♀ recovered; 30 June 1956, 34 young ♂♂, 32 young ♀♀, 1 adult ♀ examined; 8 July 1958, 50 ♂♂, 52 ♀♀ banded; 14 May 1959, 30 to 40, 1 young on ceiling; 23 July 1959, 8 recoveries; 28 July 1959, 1 ♂, 1 ♀ banded "several days since large numbers of bats have been seen"; 23 May 1960, 1000±, 3 ♀♀ with young, 4 gravid, 2 barren; 6 June 1960, 1000±, many hundred young; 22 May 1964, 300; 23 May 1964, 200; 3 June 1966, 5 taken. (D). Colossal Cave. 1905, nine to 10 [13 in Beatty, 1955:14] railroad carloads of guano removed (T. J, Tichnor, 1953 personal communication). 9a or 9b?. (B). Box Canyon or Colossal Cave, June 1966, 30 ♀♀ "from a maternity colony," Carpenter and Graham (1967:710).

9c. (D). Shallow Cave "near Colossal Cave," May, 1988, some, W. D. Peachey notes.

10a. (A). 2 mi. E Helvetia, 5200 ft., T. 18 S, R. 16 E, sec. 19, 28 May 1976, 1 ♀, UA.

10b. (D). Hummingbird feeders, Madera Canyon Lodge, Santa Rita Mountains. Every summer (August to early October), starting before the Collisters arrived in 1974, bats have fed from hummingbird feeders. In 1988, there were 14 one-quart hummingbird

feeders in place. Bats usually emptied the feeders, taking about 336 ounces by 1:00 AM. (Mrs. Lyle Collister, personal communication).

10c. (D). Mist net, Empire Ranch, 14 mi. N Sonoita. 30 August 1989, 1 adult and 1 juvenile, Petryszyn notes.

Cochise County

11. (A). 1 mi. W Ft. Bowie, T. 15 S, R. 28 E, 22 September 1976, 1 ♀, UA (Roth and Cockrum, 1976:5).

12a. (A). Buckelew cave, T. 16 S, R. 30 E, sec. 24, 4800± ft., 16 mi. S, 0.3 mi. W San Simon [= 7.7 mi. N, 5.1 mi. W Portal and = Buckalew Cave, 13 mi. N Portal], 28 August 1958, 1 ♂; 27 August 1968, 1 ♂, UA (Cockrum and Ordway, 1959:9 and Hall, 1981:133; = Blue Mountain cave, 4800 ft., Baker and Cockrum, 1966:330. (B). = W end Blue Mountain, 17 mi. S San Simon, 11 August 1951, 3 ♂♂ and 6 August 1957, 2 ♂♂, UA, Hoffmeister, 1986:66.; = "Buckalew Cave, Blue Mountain, 10.5 km south of San Simon by dirt road," August 1968, 47 ♂♂, 60 ♀♀ removed, Howell (1972:5). = Buckalew Cave, August 1963, 2 ♂♂, 8 ♀♀, UM, Howell, (1972:8). =? 10 mi. NW Paradise, 4 in W. G. Frum Collection, Hoffmeister (1957:457) and Hoffmeister (1986:66). (C). Buckalew Cave. 14 July 1954, 46 adult ♂♂, 3 adult ♀♀ banded of 1000+ (Beatty, 1955:18). 26 July 1954, 46 adult ♂♂, 34 adult ♀♀, 3 juvenile ♂♂, 3 juvenile ♀♀ examined (Beatty, 1950:18). 16 August 1955, 3 ♂♂, 5 ♀♀ banded, of 1500±. 19 August 1955, 1 ♀. 28 August 1956, 1 adult ♂, 2 adult ♀♀, 1 juvenile ♂. 2 Sepember 1958, 8 ♂♂, 51 ♀♀ banded, 2 ♀♀ recovered of 500 to 600. 3 September 1958, 13 ♂♂, 31 ♀♀ banded, 2 ♀♀ recovered. 4 September 1958, 1 ♀ banded of 10±. (D). Bucklalew Cave, 9 August 1965, 29 removed, R. B. Baker notes.

12b. (C). Frank Nolen mine, 2 mi. ESE Buckelew Cave, 27 September 1967, 2 recovered by A. F. DiSalvo, banded in 12a.

12c. (D). Abandoned mine shaft, Whitetail Canyon. 1 September 1986, 3000± seen by A. Morgan, Petryszyn notes.

12d. (A). Mine tunnel, 1 mi. N Paradise, 5200 ft., 14 August 1955, 11 ♂♂, 3 ♀♀, 1UA (Cockrum and Ordway, 1959:9; Hall, 1981:133; and Hoffmeister, 1986:66). (B). =? Paradise Mine, August 1968, 2 ♂♂, 2 ♀♀ removed, Howell (1972:5). [=? Mine tunnel "near Paradise-Gayleville," 5 August 1986, 13, Sidner and Davis (1988:494).] (C). 14 August 1955, 16 ♂♂, 5 ♀♀ banded, 2 ♂♂, 10 ♀♀ taken of 150±; 19 August 1955, 6 ♂♂, 9 ♀♀ banded of 100±; 29 July 1956, some; 3 August 1958, 8 ♂♂, 14 ♀♀ examined of 35±; 7 August 1958, 20; 31 August 1958, 34 ♂♂, 16 ♀♀ banded of 200±; 2 September 1958, 1 ♂; 13 September 1958, 6; 14 August 1959, 4 ♂♂, 5 ♀♀.

12e. (B). Rancho-Aguila [the Spofford home on Cave Creek], Portal. 1971: Hummingbird feeders installed at Rancho-Aguila. 1979: "In late summer and early fall, our feeders are used by two species of Mexican nectar-eating bats. That is one reason why some of our neighbors take in their feeders at night." 1982: August-September, 1.5 to 2 gallons sugar water taken each night by bats, then about 1 gallon per night until they left in mid-October. Photographs taken nights of 7, 10, 20, and 24 September were of both *Choeronycteris* and *Leptonycteris*, but primarily the latter (Spofford, 1985:5–7). (D). 1979: First noticed nectar feeding bats at the hummingbird feeders (Spofford, 1982 letter). 1985: 8 August, "A few Leptos and Choeros have been showing up so our sugar supply is going down rapidly!" (Spofford, 1985, letter). 1988: Bats are still feeding at the hummingbird feeders. Some are present in June and July [a time that the Spoffords are not in residence but others keep the feeders filled] with most being present in August and September. Other people in the Portal area maintain hummingbird feeders. Some lower their feeders so that the bats cannot reach them but others let the feeders stay in place

overnight. Often the feeders are empty the next morning. (Telephone conversation, 28 December 1988, with Sally Spofford).

12f. (B). 2 mi. S Portal, 7, KU, Hoffmeister (1986:66).

13a. (A). W boundary Fort Huachuca Military Reservation, 23 August 1933, 1 ♂, CNHM [= Panama Mine, near Pyatt Ranch, Campbell, 1934:241]. (B). =? Canelo Mine, 8 mi. W Fort Huachuca, 2–27 August 1949, 6 (1 adult ♂, 1 adult ♀, 4 young), UI, Hoffmeister and Goodpaster (1954:3–54) and Hoffmeister (1957:457). [=? 8 mi. W Fort Huachuca, 1, UI, Davis and Carter (1962:197)]. [= Fort Huachuca, Panama Mine, near Pyatt Ranch—same as Canelo Mine, Hoffmeister and Goodpaster (1957:39).] [=? 8 mi. W Fort Huachuca, Miller Canyon, 6, UI, Hoffmeister (1986:66).]

13b. (B). Pyatt Cave, 5500 ft., Baker and Cockrum (1966:330). [=? "Cave inside north gate Fort Huachuca," July 1967, 4 removed, Howell (1972:6).]

13c. (A). Headquarters Building, B.L.M. San Pedro Riparian Study, T. 20 S, R. 21 E, 200 yards N highway 82, 11 June 1988, 1 mummified skeleton, UA.

13d. (B). Ranch barn, lower edge oak belt, mouth of Miller Canyon, Huachuca Mountains, below 5100 ft., 24 adult ♀♀, 12 immature ♂♂, 19 immature ♀♀, UI, of 100±, Hoffmeister and Goodpaster (1954:54–55) and Hoffmeister (1957:457). [= Miller Canyon, 10–15 mi. SE Fort Huachuca, 55, UI, Davis and Carter (1962:197).] [=? 10 mi. SSE Fort Huachuca, Miller Canyon, 51, UI, and 15 mi. S Fort Huachuca, Miller Canyon, 6, UI, Hoffmeister (1986:66).]

13e. (B). The Mile Hi, Ramsey Canyon Preserve of the Nature Conservancy, Huachuca Mountains. First noticed "about ten years ago," Warren and Howell (1988:1). "Early and late summer," 307 ounces per night from feeders in 1985, Wilson (1985*b*:18). (D). Hummingbird feeders, Mile Hi Ranch, Ramsey Canyon, Huachuca Mountains. 1956. Carroll Peabody began feeding hummingbirds at this locality. From the first, some bats utilized the feeders. Between 1971 and 1982, beginning in late July or early August and ending "Labor Day to September 15," nectar feeding bats emptied 55 to 60 hummingbird feeders by 10:30 PM if the feeders were not lowered to ground and covered with cloth. Peabody estimated that 12± ounces were taken from each feeder [= 660 oz. each night] (Peabody, personal communication). [= Mile Hi Ramsey Canyon Preserve of The Nature Conservancy, "For several years" prior to 1982 (Spofford, 1982 letter).]

13f. (D). Star of Texas Mine, Coronado National Monument, Huachuca Mountains, 14 August 1966, 1 ♂, T. Hansen notes.

Santa Cruz County

14. (B). Cave of the Bells, 5440 ft. 29 August 1960, "many bats"—Southwest Caver, 1(8), August, 1960. (D). 1 September 1965, "Approximately 200–250 bats seen in the room immediately after the entrance, hanging high on the ceiling," L. Marts notes. 6 September 1987, "cluster" just inside entrance, personal communication, J. White and R. Gruss. 9 September 1987, 500±, Petryszyn notes. 10 September 1987, cluster photographed by W. D. Peachey. 12 September 1987, 250±, W. D. Peachey and R. Gruss. 24 September 1987, 50± (4 ♂♂ examined). 25 September 1987, 1 adult ♂, 2 subadult ♂♂ examined of 11, Petryszyn notes. 9 September 1988, 170± in evening flight, personal communication, R. Gruss. 10 September 1988, 150±, personal communication, R. Sidner. 17 September 1988, 25 to 30, personal communication, R. Gruss.

15a. (A). 5 mi. N, 2 mi. W Patagonia, 4450 ft., July 1954, 3, UA (= Abandoned mine tunnel, 5 mi. N, 2 mi. W Patagonia, 5500 ft., 3 July and in August 1954, some, Beatty, 1955:13–4).

15b. (B). Patagonia, several miles west in old tunnel directly over road, 25 August 1933, 1, Campbell (1934:241).

15c. (B). 5 mi. E Patagonia, 5, UI, Davis and Carter (1962:197). =? 5 mi. E, ½ mi. S Patagonia, 5, UI, Hoffmeister (1986:66). =? "a colony of approximately 200 *L. sanborni* remained in the Patagonia area" Howell and Roth (1981:4). =? "in a very remote area on private property in the mountains near Patagonia," 500± sometime in the period of 10 to 25 July 1985, Wilson (1985*b*:15).

15d. (D). Bat cave, 5275 ft. [probably the same as 15c]. 17 September 1988, 300±, personal communication, W. D. Peachey. = Shallow cave in Patagonia area, 15 July 1989, 1000 to 2000 (more than 50 percent juveniles); 20 August 1989, 14,000± (many juveniles); 30 August 1989, 6000 to 8000 (many juveniles), Petryszyn notes.

15e. (D). Stable, Circle Z Ranch, 4.5 mi. SW Patagonia, 1988, mummy hanging "for a few months," R. Sidner notes.

15f. (C). Manzanal Mine, near White Oak Mine, Walker Canyon, 7 June 1959, 1 ♀.

New Mexico

Hidalgo County

16a. (A). Mine tunnel, Granite Pass, 17 mi. NNE Rodeo, 5 October 1958, 1 ♀, UA. (B). 4 October 1958, 4 (recovered 1 ♀ banded at 12a). (B). = Granite Gap, Peloncillo Mountains, 5 October 1958, 1 ♀, MSB, Jones and Findley (1963:174). = Mine tunnel, 17 mi. NNE Rodeo, Baker and Cockrum (1966:331), Hall (1981:133), and Findley *et al.* (1975:26).

16b. (B). T. 29 S, R. 20 W, sec. 17, 2, MSB, Findley *et al.* (1975:26).

17a. (B). OK Bar, T. 31 S, R. 19 W, sec. 24, 1, MSB, Findley *et al.* (1975:26).

17b. (B). Clayton Canyon, T. 32 S, R. 21 W, sec. 17, 1, MSB, Findley *et al.* (1975:26). =? Peloncillo Mountains, Guadalupe Canyon, 11–12 August 1962, 1 ♂, 2 ♀♀, MSB, Jones and Findley (1963:8) and 12 (11, MSB; 1, MHP), Findley *et al.* (1975:26).

17c. (B). Robertson Ranch, T. 33 S, R. 21 W, sec. 20, 3, MSB, Findley *et al.* (1975:26).

Sonora

18. (A). Mine, 1 mi. N Tajitos, 3 ♀♀, 5 October 1963, UA. (B). = Tajitos, 2500 ft., Baker and Cockrum (1966:330). July, 1969, 2 ♀♀ removed, Howell (1972:6). (C). = Mina de la Virgin and other mines in same hill, Tajitos, 28 June 1963, 5000± (including small to nearly volant young); 30 August 1963, 10,000æ; 5 October 1963, present.

19a. (A). Pilares, 30 June 1935, 1 ♂, UM (Burt, 1938:21; 8, UM, Hoffmeister, 1957:457).

19b. (A). Santa María Mine, near El Tigre, 5–6 August 1935, 5 ♀♀, 5 ♂♂, UM (= Below Santa Maria mine, near El Tigre, UM, Burt, 1938:21; = Santa María Mine, El Tigre Mountain, 3, UM, Hoffmeister, 1957:457 and Davis and Carter, 1962:197.)

20. (A). 18 mi. S Desemboque, 25 April 1970, 1 ♂, UA.

21. (B). Guirocoba, MVZ, taken between 1929 and 1934, Burt (1938:21).

22. (A). Cueva de la Tigre, 1500 ft., 14.9 mi. SSE Carbo, 11 April 1958, 3 ♀♀, UA; 7 November 1959, 1 ♂, UA (Cockrum and Bradshaw, 1963:5); 27 June 1962, 1 ♂, UA (= "Carbo, 1800 ft," Baker and Cockrum, 1966:330); 15 May 1971, 10 ♀♀, UA; 3 June 1974, 1 ♀, UA (=? 25 mi. N Hermosillo, 1500 ft., Hall, 1981:134). (B). = 25 mi. N Hermosillo, 1500 ft., 1, TCWC, Davis and Carter (1962:197); = "Cueva del tigre Carbo [*sic*]," May 1969, 1 ♂, 5 ♀♀ removed, Howell (1972:6). (C). 11 April 1958, several hundred; 30 November 1958, 5; 18 April 1959, 100±; 7 August 1959, some; 6 November 1959, 5; 8 April 1960, 200±; 18 July 1960, 30; 26 May 1962, 6000±; 11 April 1963, some; 26 April 1963, 100; 20 May 1963, 30 ♀♀ examined; 1 July 1963, 16 ♂♂; 21 June 1966, 5000. (D). 13

April 1986, 2000±, J. Brown notes; 13 April 1980, 1000± (pregnant ♀♀), Petryszyn notes; 13 May 1986, 500 to 1000—"all appeared to be gravid females," Petryszyn notes.

23a. (A). Mist nets, 2 mi. N Chueca = 18 mi. NW Bahia Kino, 19 September 1974, 2 ♀♀, UA.

23b. (D). Mist net, 4 mi. N Bahia Kino, June 1984, 5, Petryszyn notes.

24. (A). Mist nets, Bahia San Carlos, 27 March 1959, 1 ♀, UA (Cockrum and Bradshaw, 1963:5). (D). 7 May 1960, 1 ♂, A. L. Gardner notes; 21–23 July 1960, 6 (1 adult ♀, 2 juvenile ♂♂, 3 juvenile ♀♀), A. L. Gardner notes.

25a. (A). 1 mi. S, 7.6 mi. E Vicam, 25 August 1963, 31 (14 ♂♂, 17 ♀♀), UA.

25b. (D). Mist net, El Trigo, *ca.* 4 mi. NE Quiriego, 380 m. [= ± 65 km. E Ciudad Obregon], 12 April 1986, 4 (1 ♂, 3 ♀♀), R. Sidner notes.

26. (B). Tesia, 5, AMNH, Howell (1972:8).

27a. (B). Minas Armolillo, 1500 ft., 5 mi. NNW Alamos, 2 mi. S Piedras Verdes, 27 January 1964, 50±; 29 February 1964, 50±; 16 April 1964, 100±; 31 May 1964, 100±; 16 June 1964, present; 29 June 1964, 1000±; 20 July 1964, present; 7 August 1964, 100±; 24 August 1964, 10; 27 November 1964, present—Mitchell (1965:22–23).

27b. (A). ¼ mi. W Aduana, 1600 ft., 16 May 1948, 49 (7 ♂♂, 42 ♀♀), KU. [=4, KU (Davis and Carter, 1962:197; = 1 ♀, KU, Anderson, 1972:239;).] [= Mine tunnel at La Aduana, 1600 ft., 5 mi. W Alamos, 11 April 1958, 10 (2 ♂♂, 8 ♀♀), UA.] [= mine tunnel, ½ mi. N La Aduana, 22 April 1960, 1 ♀, UA (Cockrum and Bradshaw, 1963:5).] [= Minas Aduana, 5 mi. W Alamos, 25 March 1967, 2 ♀♀, UA.] [= Aduana Mine, 1/2 mi. W Minas Nuevas, 29 August 1983, 1 ♂, 1 ♀, UA.] (B). =? 1 km. SW La Aduana, 1600 ft., about 5 mi. W Alamos, 1 ♂, 1 ♀, Loomis and Davis (1965:497) and Hall (1981:133). [=? Alamos, dry stream bed below Mina de Agua, April-June 1970, 3 ♂♂ and 10 ♀♀ removed, Howell (1972:6).] (D). 29 March 1959, thousands (25 examined were gravid ♀♀), L. Commissaris notes; 29 July 1960, 1 subadult , A. L. Gardner notes; August 1983, more than 1000, personal communication, C. Schwabe; August, 1988, more than 1000, personal communication, C. Schwabe.

27c. (D). Mist nets, small arroyos near La Aduana. 31 July 1960, 1 ♂, 2 ♀♀, A. L. Gardner notes.

27d. (B). Alamos, 1000 ft., Baker and Cockrum (1966:330) and 1 ♀, Baker (1967:427).

27e. (A). 2 mi. S Aduana, 2600 ft., 18 May 1948, 22 ♂♂, KU.

27f. (D). Mist net, Rio Cuchahaque, 11.3 mi. SSE Alamos, 21 June 1966, 5, Cockrum notes.

27g. (B). Chinobampo, collected between 1929 and 1934, Burt (1938:21).

?. (B). "Mexico, Sonoran Desert, on the Gulf of California." Locality not further specified. "Tuttle [M. D. Tuttle] found only a hundred bats where several thousand had been reported in the 1960's," Anon (1988*a*:4). Not plotted.

Chihuahua

28. (A). Cave in canyon near Carimechi, 4 January 1935, 24, UM (Burt and Hooper, 1941:2 and Hall, 1981:133). = Río

Mayo, Carimechi, 24, UM, Hoffmeister (1957:457). = Carimechi, Río Mayo, 5, UM, Davis and Carter (1962:197). = "taken in a cavern in a canyon near Carimechi in January . . . adult males," Anderson (1972:239).

29. (A). Batopilas, 1 June 1937, 1 ♂, MVZ (Anderson, 1972:239; Hall, 1981:133).