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Population dynamics, reproduction, and diet of the lesser long-nosed bat (*Leptonycteris curasoae*) in Jalisco, Mexico: implications for conservation

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Abstract. We estimate fluctuations in population size and sex ratio, document breeding behavior and reproduction, and determine the diet of a population of the lesser long-nosed bat, *Leptonycteris curasoae*, in an island cave in Chamela Bay, Jalisco, Mexico, with monthly sampling during an annual cycle (October 1999–October 2000). Based on the area of the cave's ceiling and wall covered with *L. curasoae* in relation to the potential roost area without them, in 1999 the abundance increased from 80% in October to 100% in November and December. In 2000 the population decreased to 80% in January, 50% in February, 30% in March, 20% in April, 10% in May, 5% in June and July, and less than 1% in August. The population rapidly increased to 60% in September and to 80% in October. Throughout the year there were significantly more males than females; however, there was significant heterogeneity over months. In September–November there were more females, but in December–August there were more males present. The majority of pregnant and lactating females were observed from December to March and in July, while males were reproductive from September–January and in May–June. Breeding activity was observed in the cave in November–December. Twenty-six species of plants were consumed during the year, based on pollen identification from fecal samples. Bombacaceous species were the most important component of the diet from January to May and Cactaceae were most important in June–September. Peak abundance and reproductive activity coincided with peak flower resource availability, which occurred between October and January and in June–July. The year-round presence and reproductive activity of *L. curasoae* at this site throughout the year demonstrate that many individuals are annual residents in this area and indicate the importance of this roosting site. In order to develop a successful conservation program for *L. curasoae*, in addition to protecting migratory corridors and northern maternity roosts, it is equally important to identify and protect areas that function as breeding colonies and year-round sanctuaries for resident populations in the south.

Introduction

Conservation efforts for North American migratory bats have been focused on protecting migratory corridors and northern maternity roosts, but little is known about southern resident populations. *Leptonycteris curasoae* is considered an endangered species in the United States (Shull 1988) and is included in the Red List of threatened species in Mexico (SEDESOL (Secretaria de Desarrollo Social) 1994) and throughout its distribution in Central America (Unión Mundial para la Naturaleza 1999). This large nectarivore has been described as making annual migrations in the spring from Mexico to southwestern USA, where large maternity colonies are formed; a few months later these populations migrate back to Mexico (Hayward and Cockrum 1971; Arita 1991; Cockrum 1991; Cockrum and Petryszyn 1991; Wilkinson and Fleming 1996). These migrations follow the sequential flowering of several key species that they feed upon from the families Cactaceae and Agavaceae (Howell 1979; Cockrum 1991; Fleming et al. 1993). Recently, however, it has been proposed that populations that reside below 21° N latitude are residents within the area that undergo only short-distance elevational migrations, and only those populations above 23° N latitude migrate latitudinally (Rojas-Martínez et al. 1999). The resident populations of south-central Mexico (Puebla-Oaxaca region) are known to consume pollen from 23 species within the dry tropical forest and thorn forest habitats (Rojas-Martínez et al. 1999) and are thought to be one of the most important nocturnal pollinators for many of these species (Valiente-Banuet et al. 1996, 1997a, b).

Little information exists, however, about the resident populations of *L. curasoae* in Jalisco, Mexico. As this region is geographically intermediate between the southern non-migratory populations and the more northern migratory populations, it is critical to our understanding of the ecology and conservation issues of this endangered species. The objectives of our study include the following: (1) determine the abundance and population structure of *L. curasoae* within a cave that is inhabited throughout the year in the area of Chamela, Jalisco; (2) characterize the reproductive patterns of the resident population in the cave; (3) identify the resources used by resident populations in this area; and (4) determine if population abundance and reproduction are related to availability of resources in this area. Finally, based on this information we make recommendations about the conservation of this endangered species.

Methods

Study species

The lesser long-nosed bat, *L. curasoae*, has a large discontinuous distribution from southwestern USA to El Salvador and in northern Colombia and Venezuela and the adjacent islands (Koopman 1993). This is the second largest New World nectarivorous bat, with adults weighing from 18 to 30 g and with a forearm length of 46–57 mm (Nowak 1994). Long-nosed bats are specialist nectarivores consuming both nectar and pollen, but also have been documented as consuming fruits and insects (presumed to be accidental ingestion; Álvarez and González-Quintero 1970; Howell 1979; Quiroz et al. 1983; Nowak 1994). This species may travel as much as 5 h during the night, moving more than 100 km (Horner et al. 1998). Some authors have described their reproductive pattern as bimodal polyestry with one young per birth (Sánchez and Romero 1995; Rojas-Martínez 1996), whereas others suggested that it is monoestrous (Hayward and Cockrum 1971; Sánchez et al. 1996; Ceballos et al. 1997).

Study area

The study was conducted in central coastal Mexico on a population of *L. curasoae* in a sea cave located on Don Panchito Island near Chamela, Jalisco. Don Panchito Island is one of 12 small islands located in Chamela Bay (ca. 19°30′ N, 105°03″ W, Figure 1). The island is approximately 10 ha in size and is located approximately 1 km from the mainland and approximately 2 km from the 13 000 ha Chamela-Cuixmala Biosphere Reserve. The dominant plants on the islands in this area include several species of cactus (*Cephalocereus purpusii*, *Pachycererus pecten-aborignum*, *Stenocereus chrysocarpus* and *S. standleyii*), *Ceiba grandiflora*, and *Amphipterygium adstringens*. The predominant vegetation type on the mainland in this area is tropical dry forest, which is characterized by a rainy season from the middle of June through October, and an extended dry season from November through May. Average annual rainfall is 750 mm and average temperature is 24.9 °C (Bullock 1995).

Mist net sampling and bat captures

We visited the island first on June 17, 1999 to evaluate the possibilities of studying *L. curasoae* and capturing them from the cave with mist nets set on the island. The cave contained primarily *Pteronotus parnellii*, but some *L. curasoae* were observed. Three mist nets of lengths 12, 9 and 6 m were opened for 2 h beginning at dusk. One *L. curasoae* and 225 female *P. parnellii* (pregnant and lactating females) were captured. We returned to the island on 17 October 1999 and observed the ceiling and walls of the cave approximately 80% occupied with *L. curasoae*. We began monthly mist net sampling, collection of feces for dietary analysis, and estimation of abundance of the population in the cave systematically in November 1999 and continued sampling through October 2000.

One 12 m mist net was placed in the same position each time, and depending on the density of bats in the cave we placed one or two additional 9 m mist nets. In order to avoid capturing other species of bats exiting the cave (primarily insectivores that flew out immediately after dusk) the nets were opened 20 min after sunset and remained open for 3 h. The mist net area was on the highest part of the island above one of the main cave exits, in an area where we initially observed many bats flying towards the mainland. Bats captured were held temporarily in soft cotton bags and the following data were collected: mass, forearm length, age-class, sex, and reproductive condition. Length and width of males' testes also were measured when possible and adults were marked with permanent plastic numbered collars (modified from Gannon 1993). Age-class (adult, young adult, or subadult) was distinguished by illuminating the dorsal surface of the extended wing and examining the epiphyseal–diaphyseal fusion of the fourth metacarpal–phalangeal joint on the ventral surface (Anthony 1988). Bats with open joints were considered subadults and bats

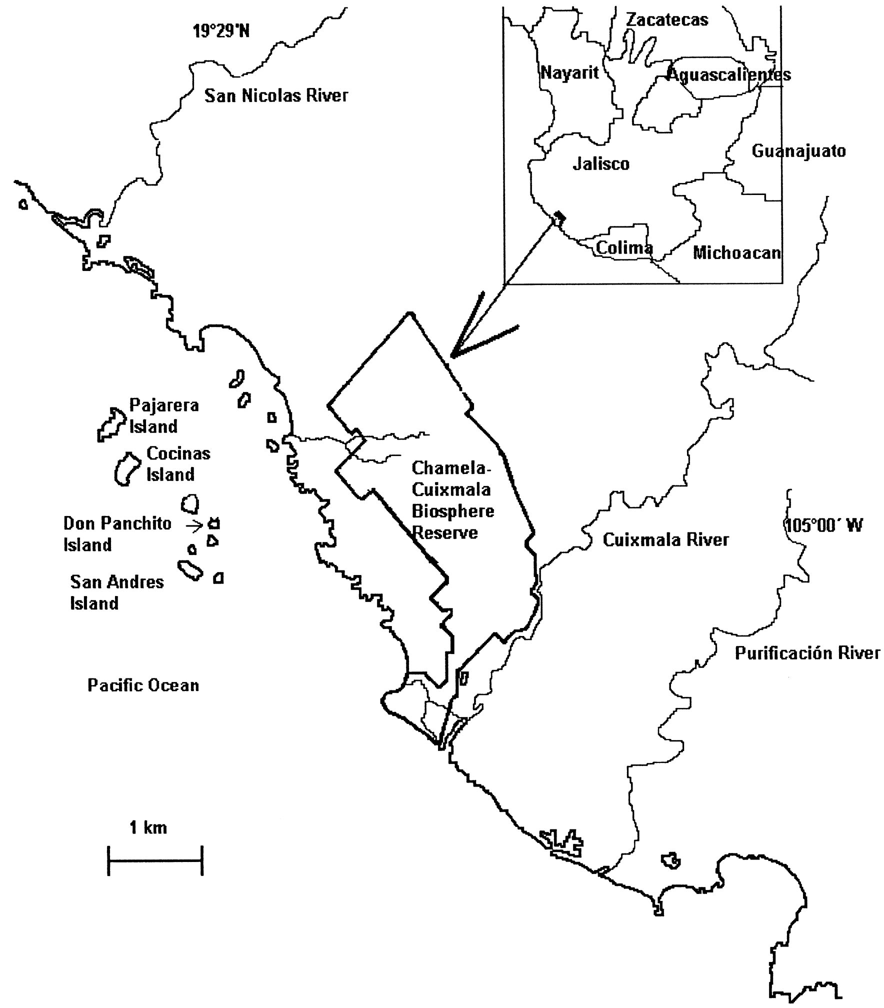

Figure 1. Study site in the state of Jalisco in west-central Mexico. The enlarged map shows the location of the cave on Don Panchito Island in relation to other islands in the area and the Chamela-Cuixmala Biosphere Reserve.

showing recently fused joints with characteristic pelage of young individuals were classified as young adults. Adults were recognized when epiphyses were completely fused with no remnant shadows of recent fusion and when the hair color was dark. Reproductive condition of adult females was determined by abdominal palpation and examination of teats (Racey 1988). The following categories were recognized: (1) not reproductive; (2) palpably pregnant; and (3) lactating. Males were recognized as reproductive when they were scrotal with testes (length × width) greater than 32 mm^2 (Ceballos et al. 1997). To detect changes in population structure, each month the numbers of males and females were compared using a *G*-test of heterogeneity (Sokal and Rohlf 1995).

Abundance estimation

Due to the high density of bats and irregular surface area within the cave it was impossible to accurately count the number of bats, even within areas of 1 m^2 as used in a previous study (Ceballos et al. 1997). Furthermore, since this species never left the cave until after dark and there were several different exits from the cave, all surrounded by water, it was not possible to estimate the abundance during departure from the cave. Because of these reasons, the relative monthly abundance of *L. curasoae* in the cave was calculated by estimating the area with this species roosting compared to the potential roosting area in the cave without them. Potential roost area included all of the ceiling space within the cave and suitable wall areas that were not perpendicular to the floor (completely perpendicular walls could not be used for roosting, as the angle was not appropriate). Four principal chambers were recognized in the cave and each chamber was assigned a percentage of the total cave area based on its size. The following approximate dimensions (length × width × height) and percentage of cave area were calculated for the four chambers: 5 × 0.8 × 4.0 m (5%); 10 × 2.5 × 9.0 m (70%); 7.0 × 1.0 × 7.0 m (15%); and 8.0 × 0.7 × 3.0 m (10%). Each month the percentage of the cave covered with *L. curasoae* within each chamber was calculated and summed, with 100% indicating that all potential roost space within the ceiling and walls contained *L. curasoae*.

Feces and pollen collection

Feces for dietary analysis were collected once a month by placing a plastic sheet (2 × 6 m^2) on the cave floor below an area where *L. curasoae* roosted. Samples were collected for 1 h after placing the sheet and each fecal pellet that was at least 10 cm from the closest neighboring pellet was considered an independent sample. Each fecal sample was mixed with 2.5 ml of 70% alcohol for suspension and slides were made with this material. Pollen was identified by using pollen keys (Lozano-García and Martínez-Hernández 1990; Roubick and Moreno 1991) and a reference collection that we developed during the study from flowers in the region that had been previously described as bat pollinated or flowers that appeared to have bat-syndrome characteristics. All species of pollen were identified for each fecal sample and the most common was considered the principal pollen for that sample. In all cases, the most common pollen accounted for more than 80% of the pollen grains in the sample. To determine if the number of pollen species used each month was different throughout the year, an ANOVA was used (Sigma Stat 1995).

Estimation of flower resources

To estimate the amount of floral resources available for *L. curasoae* during the year, phenology data and density were collected for 18 species that had been previously described as bat pollinated (Álvarez and González-Quintero 1970; Quiroz et al. 1983) or had flowers that appeared to have bat-syndrome characteristics. To estimate flower availability, 10–20 reproductive individuals were marked for each species and every 2 weeks the number of flower buds, flowers and fruits were counted. A subjective scale was used to estimate the average number of flowers per individual per month: (1) 1–99 flowers per month, (2) 100–999 flowers per month, and (3) more than 1000 flowers per month. To estimate the density of these species, surveys were conducted along the trails in the Chamela-Cuixmala Biosphere Reserve and on Don Panchito Island. A total of 16 km of trails was surveyed within these two areas. The presence of all reproductive individuals was recorded for 5 m on either side of the trail. The density of each species per ha was calculated based on the area covered. Using this information a subjective estimate of density was assigned for each species: (1) 1–20 individuals per hectare, (2) 21–99 individuals per hectare, and (3) more than 100 individuals per hectare. The flower availability index was calculated by multiplying the flower value by the density value for each species and summing these values for each month.

Results

Population dynamics and reproduction

We captured 1118 individuals of *L. curasoae* on Don Panchito Island during the 12 months of the study. This species was present year-round in the cave; however, significant differences in abundance were observed over time. The cave was approximately 80% occupied by long-nosed bats in October 1999, increasing to 100% in November and December. In January 2000, the population in the cave began to decrease with 80% cover and continued to decrease to 50% in February, 30% in March, 20% in April, 10% in May, 5% in June and July, and less than 1% in August. On 1 September 2000, the population of *L. curasoae* in the cave abruptly increased to approximately 60% and was up to 80% on 20 October 2000 during the last census.

In June, July, and August 2000, the potential roosting area in the cave was approximately 80% occupied by bats, but the majority were female *P. parnellii*, which were pregnant in June, lactating with small young in July, and lactating with juveniles in August. During these months, only one of the four chambers in the cave contained *L. curasoae*. *Leptonycteris curasoae* was found roosting in the cave with *P. parnellii* and *P. davyi* almost year-round (with the exception of December). Other species that were observed sharing this cave roost with *L. curasoae* include *P. personatus* in June, January, and August, and *Mormoops megalophylla* in January, March and April. Finally, two juvenile *Glossophaga soricina* were captured on the island in June and July and two *Centurio senex* were captured in October; however, it was not clear if they were using the cave or if they flew from the mainland to forage on the island.

Of 265 adult female *L. curasoae* captured, 28 were pregnant from September to

December, in February–March, and July, and 12 were lactating from January to March (Figure 2). Males with enlarged testes were observed in September–January and May and June (Figure 3). Breeding was observed in the cave from October to December. Subadults were present in September–May, but the greatest percentage was observed in January and February (Figure 4). Young adults were observed year-round, except for August when no individuals of any age class were captured.

Overall, significantly more adult males than females were captured during the 12 months of the study ($G_{\text{pooled}} = 114$, d.f. = 1, $P < 0.001$); however, there was significant heterogeneity over months ($G_{\text{heterogeneity}} = 183$, d.f. = 11, $P < 0.001$, Figure 5). The number of males and females was not significantly different from November through February, but there were significantly more males from March through September (sex ratio was not calculated in August, as no *L. curasoae* were captured) and significantly more females in October.

Diet and resource availability

The mean number of fecal samples collected each month was 108 for a total of 1307 samples. Twenty-two species of pollen were identified and four morphospecies were recognized (Table 1). Cactaceae and Bombacaceae were the most important families consumed, accounting for the principal pollen in samples during 8 and 11 months, respectively. Bombacaceous species were the principal pollen in 67% of the total samples, being most important from January through May, while Cactaceae were the principal pollen in 18%, being most important from June through

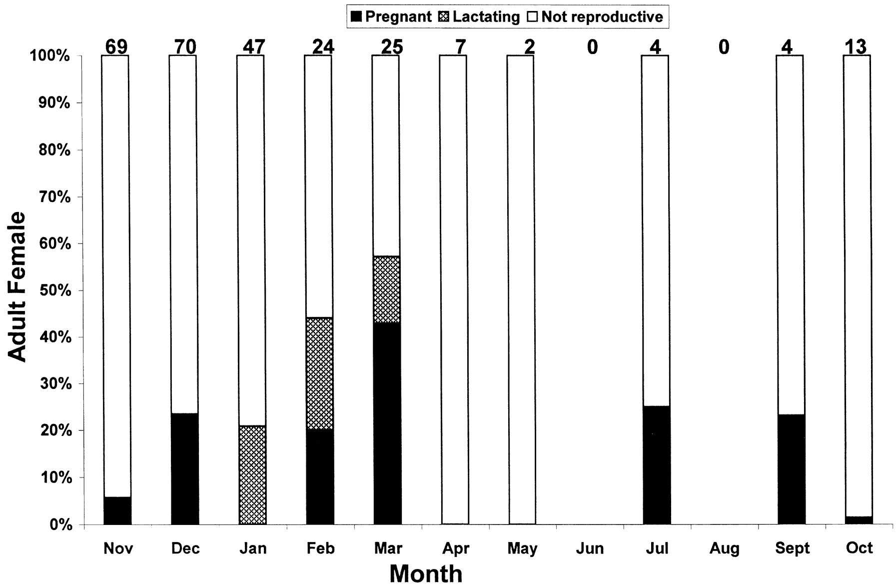

Figure 2. Reproductive condition of adult female *L. curasoae* captured on Don Panchito Island from November 1999 to October 2000. Sample sizes for each month are displayed above the bar.

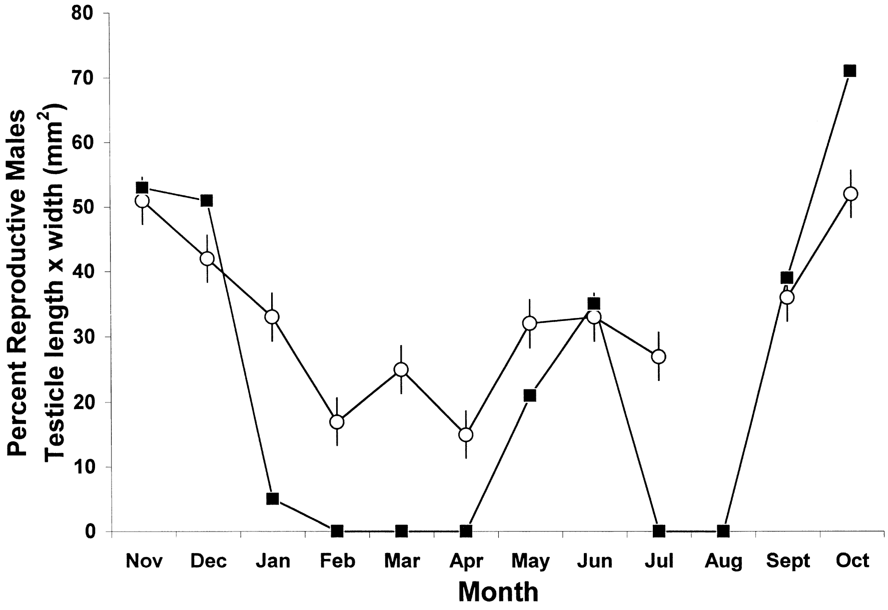

Figure 3. Percent reproductive males (squares) and average (±SE) testicle size (circles) over months of adult *L. curasoae* captured on Don Panchito Island from November 1999 to October 2000 (n = 522).

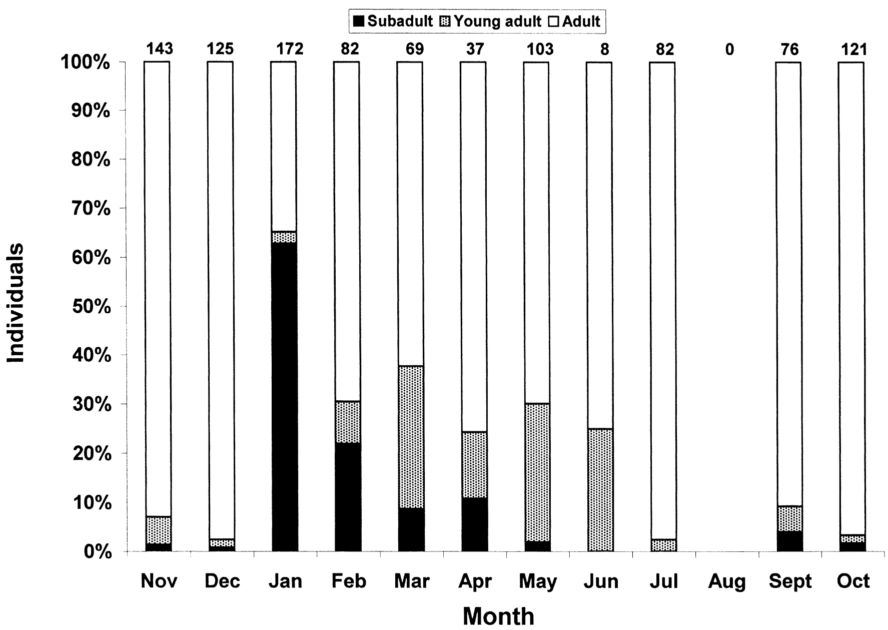

Figure 4. Percent subadults, young adults and adults captured on Don Panchito Island from November 1999 to October 2000. Sample sizes for each month are displayed above the bar.

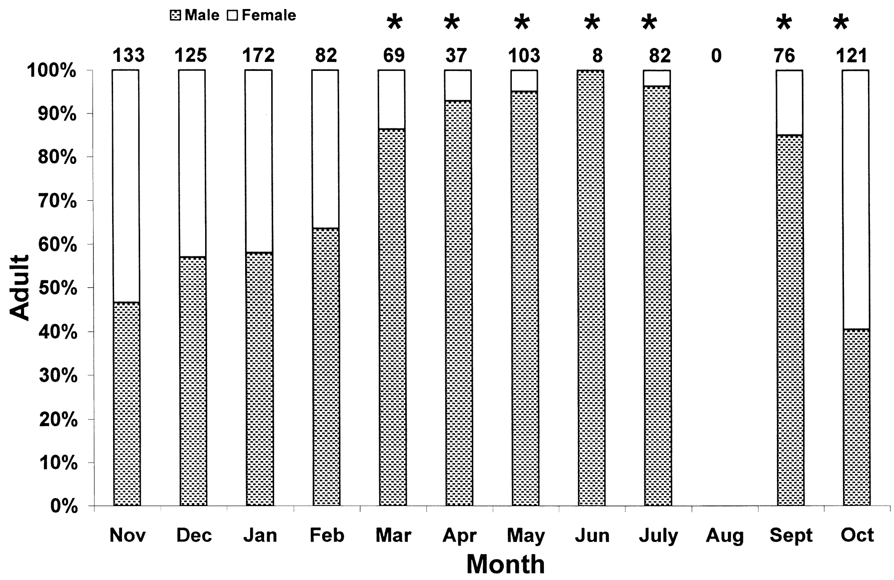

Figure 5. Percent adult male and female captured on Don Panchito Island from November 1999 to October 2000. Sample sizes for each month are displayed above the bar. Asterisks indicate significant differences with the *G* of heterogeneity test.

September. There was significant variation in the number of species of pollen consumed each month ($F_{11,\ 1296} = 193$, $P = 0.0001$, Figure 6), ranging from a low of two species in March to a high of 12 species in November.

Fruit pulp (mainly Cactaceae) was found in 12% of the samples in June, 45% in July, 40% in August, 34% in September and 2% in October. Nine percent of the fecal samples contained a very small amount of insect remains, appearing as incidental ingestion, and 2% of the samples contained sufficient quantities to suggest possible insect consumption. It is interesting to note that insect consumption occurred in April and May, when abundance of chiropterophilic flowers is low (see below).

The number of species with bat-syndrome flowers varied from a low of five species in August and September to a high of 11 species in June, July, October, and November (Table 2). The flower availability index for each month (which considered density, as well as number of flowers) showed the greatest resources available in June, July, October, November, December and January, and the lowest in February–May and August–September (Figure 7).

Discussion

Population dynamics and resource availability

The abundance of *L. curasoae* was greatest from October to January, coinciding

Table 1. Species consumed by *L. curasoae* in the Chamela Bay region in Jalisco, Mexico (identified from fecal samples).

Family and species	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct
Agavaceae												
A. colimana	9	25	2									
Agave angustifolia												13
Amaranthaceae												
Species 1									4			
Bignoniaceae												
Crescentia alata								1	1		22	
Bombacaceae												
C. aesculifolia						3	99	22	13	5		
C. grandiflora	10	47	4	*	*	83	*	2				1
C. pentandra			75									
Pseudobombax ellipticum			21	75	190	1						
Cactaceae[a]	4			1	4	4		70	55	69	28	
Caesalpiniaceae												
Bauhinia pauletia	78	4							*		35	75
B. ungulata	1	11	13	1								
Combretaceae												
Combretum sp.			1			*						
Convolvulaceae												
Ipomea ampullacea	1	12	9			2						2
Cucurbitaceae												
Cucurbita argyrosperma	6											
Mimosaceae												
Albizia occidentalis						1						
Calliandra formosa	2											1
Inga vera					4							
Moraceae												
Brosimum alicastrum	2											
Sterculiaceae												
Helicteres baruensis	11	1	*								7	16
Unidentified pollen[b]	1				1		2	3	17	22	3	2
Insects						*	*					
Fruit pulp									10	21	3	2
Number of samples	125	99	125	77	199	94	101	96	90	96	95	110

[a]Principally *Cephalocereus purpusii* and *Stenocereus standleyi* in June; *C. purpusii*, *Pachycereus pecten-aboriginum* and *S. chrysocarpus* in July; *S. chrysocarpus* in November; *P. pecten-aboriginum* in January–March; and *P. pecten-aboriginum* and *C. purpusii* in April and May. [b]Morphospecies 1: March–May, morphospecies 2: June–July, morphospecies 3: August–September, and morphospecies 4: October–November. Numbers indicate the quantity of samples with that species as the most common pollen each month. Asterisks indicate other months during which each species was consumed.

with one of the two peaks in flower resource availability; however, it should be noted that the population had already increased to 60% by September, while resources were still relatively low in the study area. One possible explanation for this observation is that, since *L. curasoae* may move up to 100 km in a night of foraging (Horner et al. 1998), they can use resources that are further away from their daytime roosting site. Since the flower availability index was calculated with

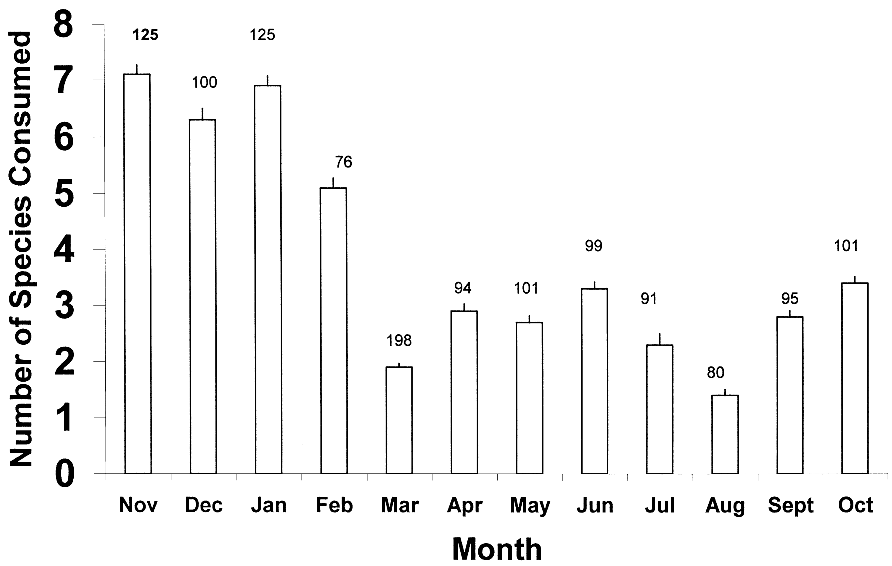

Figure 6. Average number of species consumed each month based on identification of pollen in fecal samples (±SE). Sample sizes for each month are displayed above the bar.

phenology and density data collected within the Chamela-Cuixmala Biosphere Reserve and on Don Panchito Island, this does not necessarily reflect availability of flower resources within the entire region. Another possibility is that resources are not a limiting factor for the population at this site. It has been postulated that the 'carrying capacity' of the forest in the Chamela region for *L. curasoae* is much lower in the dry season than in the wet season and for this reason the majority of individuals leave this site in December (Ceballos et al. 1997). Our data do not agree with this conclusion, but rather indicate that chiropterophilic resources are abundant year-round with two peaks, one from October to January and the other in June–July.

The greatest abundance of *L. curasoae* during our study, observed in November and December, and the gradual decline over the next several months, do not concur with that reported for 1992–1993 in this same cave; the population was at a peak in November and rapidly decreased by more than 75% in December (Ceballos et al. 1997). In addition, Ceballos et al. (1997) estimated that the cave contains more than 70 000 individuals of *L. curasoae* when the cave is completely occupied.

There is no doubt that part of the population moves away from the cave each year, but the timing and number of individuals that migrate are variable. Based on the significant changes in sex ratio over the months (Figure 5), more females than males move away from the cave from March to September; however, it is not known where they are migrating. This time coincides with peak availability of chiropterophilic resources in other areas of Central Mexico. For example, in the Tehuacán Valley in Oaxaca and Puebla, most columnar cacti that have chiropterophilic pollination characteristics flower between March and May. Furthermore, the most abundant columnar cactus at this site, *Neobuxbaumia tetetzo*, may reach densities of

Table 2. Flower phenology of 24 chiropterophilc species in the Chamela-Cuixmala Biosphere Reserve.

Species	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Combretum fruticosum	—	—	—	—	—	—	—	—	—	—	—	—
Ceiba grandiflora	—	—	—	—	—	—	—					—
Helicteres baruensis	—	—	—					—	—	—	—	—
Ipomoea ampullacea[a]	—	—	—	—	—	—	—					—
Bahuinia ungulata	—	—	—	—	—	—						
Agave colimana	—	—	—	—	—							
Stenocereus chrysocarpus	—							—	—	—	—	—
Bahuinia pauletia	—	—	—									—
Cucurbita argirosperma[a]	—	—										—
Calliandra formosa[a]	—	—										—
Brosimum alicastrum[a]	—	—										—
Pachycereus pecten-aboriginum			—	—	—	—	—		—			
Pseudobombax ellipticum			—	—	—	—						
Ceiba pentandra			—	—	—							
Inga vera[a]					—							
Cephalocereus purpusii						—	—	—	—			
Ceiba aesculifolia						—	—	—	—			
Albizia occidentalis[a]						—	—					
Stenocereus standleyi							—	—				
Acanthocereus occidentalis								—	—			
Cleome spinosa								—	—			
Crataeva tapia								—	—			
Crescentia alata								—	—	—	—	—
Agave angustifolia										—	—	—

[a]Information obtained from the literature (Bullock and Solís-Magallanes 1990; Lott 1993) and from the herbarium at the Estación de Biología Chamela.

1200 individuals per ha and it has been demonstrated that it is a main resource for *L. curasoae* during this time (Valiente-Banuet et al. 1996).

Another possibility is that part of the bat population from the Don Panchito Cave is migrating to other areas within the state of Jalisco. One possibility is the region near the Manatlan Biosphere Reserve, which is within 100 km from the Chamela Cuixmala Biosphere Reserve and provides a different habitat with different resources available. Future studies should concentrate on estimating the abundance of *L. curasoae* and resources used by this species in different habitats within the state of Jalisco.

Reproduction

The data on reproductive events and the age-class structure of the population in the cave do not support the idea of a generalized latitudinal migration pattern in which females migrate north in the spring to form maternity colonies in southwestern USA, which has been the most commonly accepted model for long-nosed bats (Hayward and Cockrum 1971; Arita 1991; Cockrum 1991; Cockrum and Petryszyn 1991; Wilkinson and Fleming 1996). The presence of reproductive females during December–March and July and September (Figure 2) demonstrates that there are

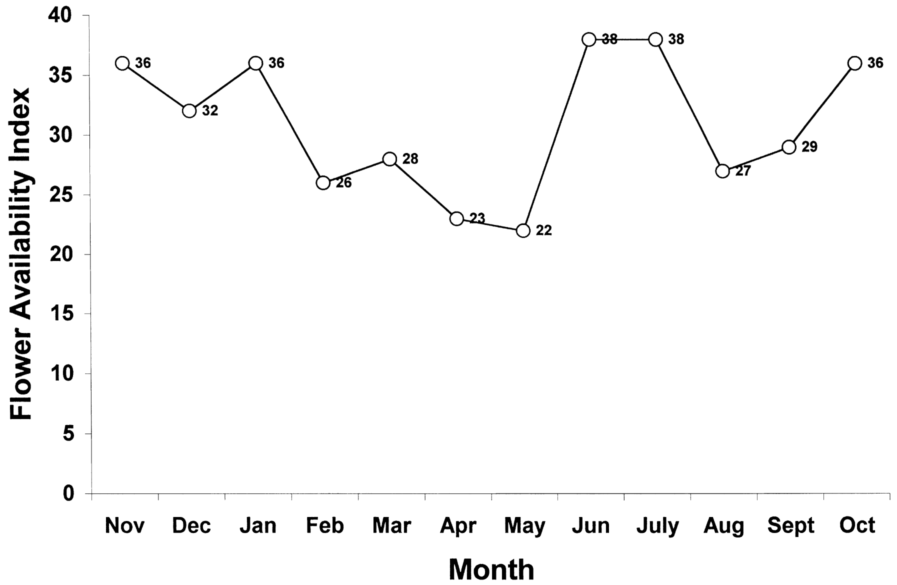

Figure 7. Flower availability index based on number of flowers and density of chiropterophilic species in the Chamela-Cuixmala Biosphere Reserve (see text for complete description).

two reproductive bouts a year for this species at this site and that many females do not migrate to northern maternity roosts. These data do not, however, indicate if individuals experience two reproductive bouts a year, since only two recaptures were made. Therefore, it is not possible to draw any conclusions about whether this species is monoesterous or polyesterous. The data for males also indicate that the male population at this site undergoes two reproductive bouts a year, one from September to December and the other in May–June (Figure 4). Both of these periods of reproductive activity at least partially coincide with peaks in availability of resources, October–January and June–July (Figure 7). Finally, the appearance of large numbers of juveniles in January (Figure 4) indicates that many females are giving birth at this site, or possibly in nearby areas. Based on the size of these juveniles (n = 59, forearm = 51.1 ± 1.2; peso = 19 ± 1.9), it is clear that the juveniles observed in January did not make a migration from southwestern USA, as they would have been too small (Hayward and Cockrum 1971).

Diet

Most studies have emphasized the importance of CAM plants from the families Agavaceae and Cactaceae as critical resources for *L. curasoae* and it has been postulated that the flowering phenology of these plant species facilitates the seasonal migratory behavior of this species (Cockrum 1991; Fleming et al. 1993). However, in a dietary study of this same population in 1993–1994, using carbon isotope techniques, Ceballos et al. (1997) concluded that CAM plants (Agavaceae and

Cactaceae) were never an important component of the diet of *L. curasoae* at this site. In contrast to this conclusion, our dietary analysis indicates that *Agavae* sp. was consumed from October through January and was the principal pollen in 25% of the samples collected in December. Furthermore, Cactaceae was one of the main resources consumed from June to September, accounting for the principal pollen in 74, 75, 93, and 33% of the samples, respectively (Table 1). These differences may be a result of variation in diet between years, or possibly due to the small sample sizes or irregular sampling used in the previous study (Ceballos et al. 1997). Although previous studies have identified that *L. curasoae* consumes pollen from bombacaceous species (Villa 1966; Álvarez and González-Quintero 1970; Baker et al. 1971; Eguiarte et al. 1987; Petit 1997), this is the first study that demonstrates the importance of this family as a crucial resource in the diet year-round.

Implications for conservation

Leptonycteris curasoae has long been recognized as one of the principal pollinators of saguaro and organ pipe cacti (Alcorn et al. 1961; McGregor et al. 1962) and agaves (Howell and Hodgkin 1976) and since these first descriptions many other species of cacti and agaves have been identified that are principally pollinated by this species (Howell 1979; Howell and Roth 1981; Eguiarte et al. 1987; Howell and Hartl 1989; Petit 1995; Fleming et al. 1996; Nassar et al. 1997; Casas et al. 1999). Our study demonstrates the importance of this species as a potential pollinator of several bombacaceous species and the principal pollinator of *C. grandiflora* (Stoner, unpublished data). Given the economic importance of many species of Cactaceae (for food; Casas et al. 1999), Agavaceae (for food, fiber and alcoholic beverages; Nabhan 1985), and many species of Bombacaeae (for wood; Chudnoff 1984), changes in the population of *L. curasoae* would undoubtedly have negative repercussions on the use of these plant species. It has been documented that in the absence of *L. curasoae* the seed set of *Agave palmeri* is less than 5% of its maximum potential (Howell and Roth 1981).

Suggestions for the conservation of *L. curasoae* have concentrated primarily on identifying their migratory patterns in order to protect biological corridors (Fleming et al. 1993) and identifying and protecting maternity roosts in the northern part of their range (Nabhan and Fleming 1993). Although we recognize the importance of both of these strategies, we suggest that an effort should also be made to identify and protect key roosts that house resident (non-migratory) populations and that provide areas for breeding, as observed in the cave on Don Panchito Island. In a recent review of the conservation biology of nectar-feeding bats in Mexico, four principal areas in the country were recognized as priority areas for conservation of glossophagines: (1) western Sierra Madre; (2) Balsas Basin; (3) southern Sierra Madre; and (4) the southeastern lowlands (Arita and Santos-del-Prado 1999). The area that includes the cave population of *L. curasoae* on Don Panchito Island was not considered a priority area for conservation.

Don Panchito Island is not protected, nor are any of the other small islands in the area near the Chamela-Cuixmala Biosphere Reserve. However, these islands have been recognized as important areas for the protection of biological diversity and it has been suggested that they be included in the National System of Protected Areas in Mexico (Periodico Oficial 1999). Currently, a tourist development is under construction on Cocinas Island, which is 1 km from Don Panchito Island. This development will undoubtedly have a negative impact on the population of *L. curasoae* in the cave on Don Panchito Island. The non-governmental organization Biotopía, based in Guadalajara, Mexico, is attempting to stop this tourist development by complaining to the Secretary of the Environment (Secretaria de Ambiente y Recursos Naturales de México, SEMARNAT) about the damage it will cause to the flora and fauna on the island and the surrounding islands as well as the marine habitat.

The distribution of sea caves that serve as roosts for *L. curasoae* in the region has not been evaluated and a thorough census of the area should be undertaken to document the distribution of these important roost sites. In order to develop a successful conservation program for *L. curasoae*, in addition to protecting migratory corridors and northern maternity roosts, it is equally important to identify and protect areas that function as breeding colonies and year-round sanctuaries for resident populations in the south.

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