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OBSERVATIONS ON SIX SPECIES OF FREE-TAILED BATS (MOLOSSIDAE) FROM YUCATAN, MEXICO

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ABSTRACT—Of the six species of free-tailed bats from selected sites in northwestern Yucatan, *Molossus sinaloae* was taken most frequently, followed in order by *Eumops glaucinus, Molossus ater, Eumops bonariensis, Promops centralis*, and *Tadarida laticaudata*. Tile roof roost data for *M. ater, M. sinaloae*, and *E. bonariensis* showed some aggregation and, for the latter two, some roost fidelity.

Although six species of free-tailed bats (family Molossidae) are known from northwestern Yucatan, most regional data have been gathered during short forays to scattered localities (e.g., Bowles, 1973; Jones et al., 1973; Birney et al., 1974). Our study extended over 11 field-seasons (March to May 1971, 1973, 1975; June 1978; May to August 1979; September to November 1976, 1977, 1979, 1983; December to January 1979 and 1980; October to November 1983) and included all six molossid species recorded from the Yucatan Peninsula. Although we worked at several places in northern Yucatan, our efforts were concentrated at three sites in or near Merida. In this paper, we focus on reproduction and relative abundance of *Eumops bonariensis, Eumops glaucinus, Molossus ater, Molossus sinaloae, Promops centralis*, and *Tadarida laticaudata*.

MATERIALS AND METHODS—Our three major Merida sites were: 1) a small shallow man-made pond at the Country Club Campestre (Campestre); 2) the swimming pool of the Colegio Peninsular (Colegio); and 3) a large, clay-tiled, suburban dwelling used by Central College (La Casa) where *M. ater, M. sinaloae*, and *E. bonariensis* roosted in roof crevices. We also netted across a cenote surrounded by thornforest located 2.5 km NW of Dzitya (Dzitya), the grounds (including pond and cave) of the Hacienda Zodzil (Zodzil) 1 km N of Merida, along the edge of the cenote at Dzibichaltun (Dzibichaltun), across the doorway of a Mayan ruin (Governor's Palace) at Uxmal (Uxmal), a coconut palm groove 12 km E of Progreso (Progreso), and a hacienda near Kinchil (Kinchil). See Birney et al. (1974) for detailed descriptions of Campestre, Colegio, and Dzitya.

We captured bats using mist nets and either tattooed them for short-term recognition (Bonaccorso and Smythe, 1972) or tagged them with numbered, color-coded plastic wing bands. For each capture we recorded capture time, band or tatoo number, sex, age (subadult if epiphyses visibly unfused), forearm length (recorded once per year per individual), weight, size (enlarged or small) and condition of male gular gland (enlarged and secreting, enlarged, small), teat size (enlarged or small) and lactational status (females), and presence or absence of embryos (detectable by palpation only during late gestation). In a few cases, we noted right or left uterine position of embryos. Rough estimates of lactation periods were made using the time from which at least 50% of adult females were lactating until at least 50% were no longer lactating. Beginning in 1979, we recorded the presence or absence of wounds and scentmarks. Using the method of Farney and Fleharty (1969), we made wing, uropatagium, and body outlines of a series of live bats to calculate aspect ratio (wingspan^2 ÷ wing surface area) and wing-loading (weight ÷ wing and uropatagium surface area). For La Casa, we noted the exact capture location (roof sections and tile numbers) from which we observed bats exit, including those mist-netted. Ultrasonic detectors (QMC or Techsonics models) were used to monitor general activity near the La Casa roosts and Campestre pond, including eight all-night sessions.

Voucher specimens taken during the study were deposited in the Biology Department, Central College, Pella, Iowa; The Museum of Natural History, The University of Iowa, Iowa City, Iowa; The Museum, Texas Tech University, Lubbock, Texas; and Departamento de Conservacion, Mexico D.F., Mexico. Six-

TABLE 1—Total number of individual bats captured at seven collecting sites in northern Yucatan, Mexico, from 1971 to 1983 (includes data from Bowles, 1973, and Birney et al., 1974).

Taxon	Collecting site								
	Campestre	Colegio	La Casa	Dzitya	Zodzil	Dzibichaltun	Uxmal	Progreso	Kinchil
Molossidae									
Eumops bonariensis	144	18	23	2					
Eumops glaucinus	262	1							3
Molossus ater	79	85	76			3		3	
Molossus sinaloae	956	220	157	4					2
Promops centralis	59	8	1						
Tadarida laticaudata	1						15		
Other families									
Artibeus jamaicensis	66	46	63	41	4	5			
Centurio senax[1]					1				
Desmodus rotundus	5			36	3				
Diphylla ecaudata	1	1			9				
Eptesicus furinalis	3	1		19	3	1			
Glossophaga soricina	50	5	11	10	5	2			
Lasiurus ega	8			6					
Lasiurus intermedius	55	1		1					
Mimon cozumelae				1	2				
Micronycteris megalotis		1	1		1				
Moormops megalophylla			1		1				
Myotis keaysi	2			9	9				
Natalus stramineus	1			4	2				
Pteronotus davyi					2	11			
Pteronotus parnellii	7			19	3				
Rhogeesa tumida	3	3	1	3					
Sturnira lilium	3	2	2	1					

[1] New record for Yucatan; specimen deposited in The Museum of Natural History, University of Iowa, Iowa City, Iowa.

teen stomachs from bats collected on 16 June 1978 at Campestre were sent to J. O. Whitaker, Indiana State University, for content analysis.

Statistical analyses were conducted using the MIDAS computer program of the University of Michigan Terminal system (Fox and Guire, 1976), the SPSS program on the PDP-11 computer of Central College, or a hand calculator. We used *t*-tests to compare male and female forearm lengths and weights; Mann-Whitney *U*-tests were used to compare male and female aspect ratios and wing-loading values. All sex ratios were compared using the binomial test (Siegel, 1956); we report only obtained significance levels for these.

RESULTS—Of the six species of free-tailed bats from selected sites in northwestern Yucatan, *M. sinaloae* was taken most frequently, followed in order by *E. glaucinus*, *M. ater*, *E. bonariensis*, *P. centralis*, and *T. laticaudata*. Table 1 gives a summary of all bats captured at the six principal sites. Parturition of all six molossid species is highly synchronous, with most young born during the last two weeks of June (Table 2). Other bats in the region (e.g., *Glossophaga soricina*, *Desmodus rotundus*, *Artibeus jamaicensis*, *Lasiurus intermedius*) do not appear to be as reproductively synchronous (Table 3).

Although *E. glaucinus* had the longest forearms, the smaller *M. ater* had higher wing-loading values due to similar weights (Table 4). *Eumops bonariensis* was the smallest and lightest of the six species, while *P. centralis* showed an aspect ratio closer to *E. glaucinus* than the similar sized *M. ater*. Except for weight differences in *E. glaucinus* and the two species of *Molossus*, we found little difference in measurements between males and females (Table 4).

Eumops bonariensis—Although first reported from Yucatan by Birney et al. (1974), this species

TABLE 2—All captures and recaptures of palpably (e.g., embryos >10 mm for *Eumops bonariensis*, >20 mm for other species) pregnant (PP), lactating (L), and not detectably reproductive females (N), and all subadults (S) of six molossids (EUBO = *E. bonariensis*, EUGL = *Eumops glaucinus*, MOAT = *Molossus ater*, MOSI = *Molossus sinaloae*, PRCE = *Promops centralis*, TALA = *Tadarida laticaudata*) taken in Yucatan, Mexico, during 10 seasons from 1971 to 1983 (includes Bowles, 1973, and Birney et al., 1974). Each month is divided in half (1 = days 1 to 15, 2 = days 16+); "A" following a number indicates that at least some females were autopsied and embryos measured.

	Portion of	EUBO				EUGL				MOAT				MOSI				PRCE				TALA			
Month	month	PP	L	N	S	PP	L	N	S	PP	L	N	S	PP	L	N	S	PP	L	N	S	PP	L	N	S
March	1									2A		4		1A		19									
	2	2A		2				4				15		2A		74				1					
April	1			3				1		3A		2		6A		18									
	2			4		2A		2		2		5		9A		9		3A							
May	1	11A				7A				5		1		2A		29				1					
	2	1				13A		2		10		10		18		1									
June	1	11	16	1		8				19	4	1		24	3	7									
	2	8A	56	16		35	44	17		3	32	17		38A	353	6		5	9	2		15			
July	1		1	1			8	1			3				76	2			4						
	2		3	1			11	5			4				62	4	2		2				1		
August	1										3				24	1	4		1						
	2																								
September	1			2								1	1			10	1								
	2															7	3								
October	1			2												9	1								
	2			2	2							22	9			103	1								
November	1			3								13	4			29	3								
	2											2				13	1								
December	1																2								
	2															11									
January	1															15									

TABLE 3—All captures and recaptures of palpably pregnant (PP), lactating (L), and not detectably reproductive females (N) and all subadults (S) or juveniles (J) of four non-molossid species of bats (GLSO = *Glossophaga soricina,* DERO = *Desmodus rotundus,* ARJA = *Artebius jamaicensis,* LAIN = *Lasiurus intermedius*) captured in Yucatan, Mexico, during 10 seasons from 1971 to 1983 (includes Bowles, 1973, and Birney et al., 1974). Each month is divided in half (1 = days 1 to 15, 2 = days 16+); "A" following a number indicates that at least some females were autopsied and small embryos measured.

	Portion of	GLSO				DERO				ARJA				LAIN			
Month	month	PP	L	N	J	PP	L	N	J	PP	L	N	J	PP	L	N	J
March	1	2		1						1							
	2			2						6A	2	7					
April	1			1						4A		5					
	2			5	1	2A	1			4A		18	1	1			
May	1											5		2A		1	
	2	1										1					
June	1	5		2				2		7		2		9	6	1	
	2			4						2	1	6			15	5	
July	1														2		
	2															4	2
August	1													2	1		
	2																
September	1																
	2																
October	1										2	6	1				
	2			1		1		2	1								
November	1			5			1	3				10					
	2																
December	1																
	2																
January	1																

was collected earlier but erroneously identified as *T. laticaudata* (Bowles, 1973); we captured 187 individuals (Table 1). At Campestre and La Casa, the adult sex ratios favored females (113:31 and 16:7; $P < 0.001$ and $0.1 > P > 0.05$, respectively). At Colegio, the reverse was true (5:13; $0.1 > P > 0.05$).

Pregnant females were taken from late March to late June with parturition synchronous in mid to late June; lactating females were captured over 7 weeks (early June to late July) and we estimate a 6- to 8-week lactation period (Table 2). Five autopsied pregnant females had single embryos (crown–rump length in millimeters and right or left uterine position if recorded): 28 March, 8 mm; 30 March, 9 mm; 8 May, 2 mm; 15 May, 2 mm (right) and 16 mm; 16 June, 15 mm. Four subadults were taken at La Casa on 12 July (2) and 25 and 29 October. The six adult male specimens from March to May had testes 3 to 5 mm in length, those from two in September and October were 4 mm. Most males (23 of 24) had enlarged or secreting throat glands in May and June, whereas, in July, six of seven had small glands (G-test; Fox and Guire, 1976; $G = 19.06$; $d.f. = 1$; $P < 0.0001$). Content analysis of stomachs of four adult females yielded Lepidoptera (55% volume), Coleoptera (mostly Carabidae, 23.4%), Hemiptera (probably Lygaeidae, 15%), Scarabidae (3.8%), and unidentified insect (2.5%).

La Casa capture-recapture data (24 banded, 14 recaptured at least once) suggest some roost fidelity by both sexes. One male used the same tile but with different pairs of females on three successive years, 1977 through 1979. Another female captured exiting the same roost in 1977 and 1978 was 20 tiles away on the same roof in 1979, after a banana tree had blocked the entrance of

TABLE 4—Forearm length, weight, aspect ratio (wingspan^2 ÷ surface area of wings), and wing-loading (weight ÷ surface area of wings plus uropatagium) values (±1 *SD*) for six species of molossids from Merida. Abbreviations for species are defined in Table 2. Sample sizes are given in parentheses. Non-pregnant individuals were used for female weights except in calculations of wing-loading for MOAT and MOSI. In comparisons of females and males, *t*-tests were used for forearm length and weight, and Mann-Whitney *U*-tests were used for aspect ratio and wing-loading.

		Variable			
Species	Sex	Forearm length[1] (mm)	Weight[2] (g)	Aspect ratio	Wing-loading (g/cm^2)
EUBO	Female	39.3 ± 1.23 (54)	12.4 ± 2.18 (91)	8.87 ± 0.62 (6)	0.14 ± 0.01 (7)
	Male	39.9 ± 1.24 (28)	11.4 ± 2.15 (32)	8.88 ± 0.37 (6)	0.15 ± 0.02 (6)
EUGL	Female	58.9 ± 1.49 (31)	34.4 ± 3.05 (84)	9.23 ± 0.28 (2)	0.20 ± 0.04 (2)
	Male	59.4 ± 1.23 (34)	35.9 ± 2.92 (82)	10.00 ± 1.51 (8)	0.21 ± 0.05 (7)
MOAT	Female	51.7 ± 1.39 (7)	33.4 ± 4.81 (72)	8.92 ± 0.98 (6)	0.30 ± 0.03 (6)
	Male	52.6 ± 1.25 (70)	39.6 ± 4.22 (59)	9.11 ± 0.37 (6)	0.30 ± 0.02 (6)
MOSI	Female	46.2 ± 1.21 (227)	21.8 ± 2.42 (436)	8.38 ± 0.50 (6)	0.23 ± 0.01 (6)
	Male	46.8 ± 1.14 (193)	25.5 ± 2.62 (329)	8.10 ± 0.74 (6)	0.27 ± 0.03 (6)
PRCE	Female	52.7 ± 1.00 (11)	29.7 ± 3.37 (19)	9.34 ± 0.72 (8)	0.21 ± 0.02 (8)
	Male	52.9 ± 1.08 (18)	29.3 ± 3.40 (35)	9.50 ± 0.52 (4)	0.23 ± 0.02 (4)
TALA	Female	43.1 ± 0.64 (8)	12.5 (1)		
	Male	43.8 ± 0.75 (6)	12.9 ± 0.67 (8)		

[1] Females significantly ($P \leq 0.05$) different from males for EUBO, MOAT, and MOSI.
[2] Females significantly ($P \leq 0.05$) different from males for EUBO, EUGL, MOAT, and MOSI.

the first roost. While individuals were captured exiting a given tile on numerous occasions (although roosting bats were often net-shy), we did note some roost aggregation, one male-one female ($n = 1$) and one male-two females ($n = 3$). On another occasion (October), we captured two females (adult and subadult) entering the same tile, nearly simultaneously. We estimate a population of about 20 used the La Casa roost tiles in summer and about 10 in fall (no data are available for winter and spring).

Eumops glaucinus—Despite recorded rareness in Yucatan (Jones et al., 1973), this was the second most abundant species at Campestre (160 females, 102 males; $P < 0.001$). Aside from the three taken near Kinchil (Birney et al., 1974), however, we took only one elsewhere (Colegio).

Pregnant females were captured from late April to late June and lactating females from mid-June to late July; parturition was synchronous in the latter half of June, with lactation lasting at least 5 or 6 weeks (Table 2). Nevertheless, embryos varied considerably in crown-rump length (in millimeters) on a given date: 19 March, 15 and 16 mm; 8 May, 6, 16, 18, 19, 23, and 30 mm; 17 May, twins, 3 (left) and 6 (right), 20, 20, 25, 27, 28, and 30 mm; 20 June, 28, 29, and 31 mm. Only one of 18 autopsied pregnant females had two embryos (Birney et al., 1974). Testes of seven adult male specimens, all from April through June, ranged from 7 to 8 mm in length. All 18 males for which we have data (all from June) had enlarged or secreting throat glands.

Molossus ater—We captured 247 *M. ater* (Table 1). At Campestre and Colegio, adult females were more numerous than males (48:31 and 57:28, respectively; $0.1 > P > 0.05$ and $P < 0.01$), whereas at La Casa the sex ratio was about equal (37 females : 39 males; not significant).

Pregnant females were captured from early March to late June and lactating females from early June to early August; parturition was synchronous in the latter half of June and the lactation period was about 6 to 8 weeks (Table 2). Seven autopsied pregnant females had single embryos (crown-rump length in millimeters): 9 March, 3 mm; 14 March, 3 mm; 4 April, 6 mm; 9 April, 3 and 20 mm; 14 April, 2 and 3 mm. We netted three subadults (5 September, male; 29 October, female; 6 November, female). Testes of five adult male specimens from March to June were 7 to 8 mm in length, whereas three of four

from October to November were 6 to 8 mm, the fourth being only 3 mm. All 34 adult males for which we have data had enlarged or secreting throat glands: May (6), June (10), July (15), August (2), October (1). Stomach content analysis of two adult females yielded Carabidae (92.5% volume), Scarabidae (5.0%), and Hemiptera (probably Lygacidae, 2.5%).

We are unable to determine roost fidelity since *M. ater* usually chewed off or made their bands illegible (90 banded; 27 recaptured at least once, but only one with a legible band in a subsequent field season). While we have counts ranging from one to seven individuals exiting the same roost tile, our capture data from selected tiles show a variable ratio of females : males (4:2, 1:2, 5:2, 2:1, 3:1, 4:2, 5:1). We estimate that a population of about 30 regularly roosted in La Casa roof tiles, and we were unable to discern any difference between fall and summer population sizes.

Molossus sinaloae—We captured 1,339 individuals (Table 1). Adult females were more numerous than males at the three major sites: Campestre (696:260; $P < 0.001$), Colegio (115:105; $P > 0.100$), and La Casa (98:59; $P < 0.010$). Of 15 juveniles captured at La Casa, five were females.

Pregnancies occurred from early March to late June with parturition synchronous in mid- to late June. Lactating females were taken from early June to early August, an estimated lactation period of 6 to 8 weeks (Table 2). Embryos varied considerably in crown-rump length (millimeters): 14 March, twins, 2 (left) and 2 (right); 18 March, 3; 30 March, 10; 3 April, 3; 9 April, 6, 7, and 11; 10 April, 4; 19 April, 13; 23 April (all right side of uterus), 3, 5, 5, 6, 9, 10, 10, 11, and 13; 14 May, 19; 15 May, 24; 19 June, 30. Only one of 20 autopsied pregnant females had twins (Birney et al., 1974). Fourteen subadults were captured over 5 months: August (3), September (4), October (2), November (4), December (1). Testes lengths of autopsied males were 4 to 8 mm in March and April ($n = 6$), 2 to 6 mm in June ($n = 11$), and 3 mm in November ($n = 2$). Most males had secreting gular glands from May through August (193 of 207), but fewer than half the glands were secretory from September through early January (12 of 25). Content analysis of 10 adult male stomachs yielded Lepidoptera (78.5% volume), Carabidae (9.0%), Hemiptera (probably Lygaeidae, 8.0%), Diptera (1.0%), Scarabidae (1.0%), and unidentified insect (1.0%).

Capture-recapture data from La Casa (112 banded, 69 recaptured at least once) showed some roost fidelity. Two females and two males were captured regularly at their respective roosts. Another female captured in 1977 was recaptured at different roosts in 1980 and 1983.

Promops centralis—Although taken less frequently than all other molossids except *T. laticaudata*, *P. centralis* was captured regularly at Campestre (33 males, 26 females; not significant) and seemed more abundant locally than previously assumed (Jones et al., 1973; Birney et al., 1974). Our only other captures, however, were six males and two females from Colegio and a single male from the La Casa roost. The latter, an emaciated individual, was taken on 29 October 1983.

We captured pregnant females from late March to late June and those in lactation from late June to early August. Parturition appears to be synchronous in the latter half of June, and lactation appears to last at least 6 weeks (Table 2). Four autopsied females had single embryos, ranging in crown-rump length from 8 mm on 28 March to 20, 20, and 23 mm on 21 April. Testes measurements from 12 adult males taken from March to June ranged from 3 to 8 mm in length, with no apparent seasonal pattern. All 13 males for which we have data had large or secretory throat glands: June (6), July (4), August (1), September (1), October (1).

Tadarida laticaudata—We captured this species at only two localities. At Uxmal, we took 15 pregnant females (nine autopsied, all with single embryos 25 to 30 mm crown-rump length) and 15 adult males (nine autopsied, all with testes 3 mm in length) from a colony of 500 to 1,000 residing in cavities within the Mayan ruin (Governor's Palace) on 21 June 1978. Our only other record was a lactating female captured at Campestre on 26 July 1979. These data, while few, suggest that parturition is synchronous in late June. Given the reported commonness of *T. laticaudata* on the Yucatan Peninsula (Jones et al., 1973), we were surprised to capture only one in Merida.

Discussion—Natural bodies of water (e.g., cenotes and aquadas) and artificial waterholes (e.g., swimming pools and ponds) scatterd over the flat open limestone terrain of northwestern Yucatan serve as drinking and feeding sites for many species of bats (see Lee, 1980, for descrip-

tive details of Yucatan). It is noteworthy that at the artificial pond (Campestre) and swimming pool (Colegio) where we concentrated efforts in Merida, molossids were by far the most commonly captured bats (88% and 85%, respectively; Table 1). The pond was open and away from buildings and trees, allowing the long-winged *E. glaucinus* room for maneuvering, and it was the second most common species caught there. In contrast, the swimming pool was surrounded by buildings, and *E. glaucinus* was virtually absent (although the slightly smaller-winged *M. ater* with greater wingloading was abundant at both sites). The two cenotes where we netted were distant from towns and entirely (Dzitya) or partially (Dzibichaltun) surrounded by thornforest; molossids made up only 4% and 14% of the respective captures at these sites (Table 1). These data imply that molossids are associated with open areas (especially urban), although other differences among the sites may account for these trends. At the tile roost-site in La Casa, we rarely found more than one species using the same tile cavity, although all three (i.e., *E. bonariensis*, *M. sinaloae*, and *M. ater*) at times used different tiles of the same roof segment.

In three species, adult sex ratios in our samples were significantly biased at one or more sites. In *M. sinaloae*, females were more abundant; in *E. bonariensis*, females were more abundant at two sites but less so at another. In *M. ater*, females were more abundant at two sites, but the sex ratio was unbiased at a third. This implies some segregation between sexes in the use of foraging, drinking, or roosting areas. Although differences may also reflect differential mortality or differing capture probabilities, variation among sites seems more consistent with preferential use of particular sites by one sex.

Since most rain in northern Yucatan falls between May and October (Lee, 1980), parturition of all six molossid species in the last 2 weeks of June means that young are born in the middle of the rainy season. Lee (1980:5) notes, however, that "rainfall is bimodal, generally with peaks in June and September separated by a relatively dry July." Synchronous late June parturition evidently allows for 5- to 8-week lactation with young becoming volant as rainfall (and presumably insects) peaks again prior to the dry season (November to April).

All-night mist net and ultrasonic detector data from the roost-site in La Casa and the feeding-drinking site in Campestre showed considerable temporal variation of activity. A merging of all-night data for Campestre ($n = 8$) does, however, reveal a 2-h activity peak after sunset, with a slightly lower one before sunrise for *E. bonariensis*, *E. glaucinus*, and *M. sinaloae*. We rarely captured *M. ater* after midnight and *P. centralis* showed no evidence of activity peaks.

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