

# REPRODUCTION, GROWTH, AND DEVELOPMENT IN *MYOTIS THYSANODES* AND *M. LUCIFUGUS* (CHIROPTERA: VESPERTILIONIDAE)<sup>1</sup>

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**Abstract.** Studies of reproduction and pre- and postnatal growth and development in *Myotis thysanodes* and *M. lucifugus* showed that female *M. lucifugus* copulated in the fall prior to their exodus from the summer roost while *M. thysanodes* copulated sometime after leaving the summer roost but before their spring return. Ovulation, fertilization, and implantation occurred during the first 2 weeks of May for both species. Gestation has been calculated as 50–60 days for both species.

Parturition in *M. thysanodes* is synchronous with nearly all births within a 2-week period at the end of June and beginning of July. *Myotis lucifugus*, however, gave birth over a period from June through August.

Logarithmic regression lines were calculated for daily prenatal weight increase for both species. *Myotis lucifugus* grow more rapidly and weigh significantly less than *M. thysanodes*. Regression equations for daily postnatal weight, forearm length, wing span, and fifth-finger length increase in *M. thysanodes* were calculated and found to be good criteria for estimating age to about 21 days, after which this species has attained adult size.

Estimated neonate mortality was low, about 1% for *M. thysanodes* and 2% for *M. lucifugus*.

*Myotis thysanodes* was capable of limited flight by 16.5 days of age and of adultlike flight by 20.5 days of age. *Myotis lucifugus* parallels this attainment of flight quite closely. Wing loading for both species increases slightly from birth to 6 days, followed by a decline to half the birth value at day 20. Aspect ratio for both species increases at a steady rate from birth to about 16 days, when it decreases slightly to the adult value.

There was no relation of fat index to age in either species, but significant decreases in water index were found with increasing age. Both species demonstrated significant decreases in percentage water and increases in percentage organic and mineral content with increasing age of juveniles. *Myotis lucifugus* exhibited a significant decrease in spleen weight with age, whereas *M. thysanodes* showed no such trend. Neither species showed trends in adrenal weights through the growth period.

Several guardian *M. thysanodes* females stayed with the young during the night. They nursed, retrieved, and in general protected the young throughout the night. *Myotis lucifugus* did not exhibit this behavior, but large groups of adults would return periodically throughout the night to nurse the young.

While *M. lucifugus* juveniles exhibited practice flight behavior at night, *M. thysanodes* juveniles were never observed performing this learning process.

## INTRODUCTION

Wimsatt (1960) and Orr (1970) have presented good reviews of the reproductive and developmental biology of bats. There are numerous articles dealing with the biology of bats in which the authors deal only briefly with growth and development (e.g., Herreid 1959, Sluiter and Van Heerd 1966, Fenton 1970, Hayward 1970). Several papers deal extensively with growth and development in captive bats (Orr 1954, Jones 1967, Kleiman 1969). Jones (1967) pointed out that growth rates in captive bats are possibly retarded and slower than in bats under natural conditions. Due to the secretive habits of bats and problems encountered in working with large colonies of bats, very little is known of the growth and development of these animals under natural conditions (Pearson, Koford, and Pearson 1952, Davis, Barbour, and Hassell 1968, Davis 1969a).

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Other aspects of postnatal development, such as organ weights, fat content, and gross body composition are inadequately covered (Christian 1956, Herreid 1959, Short 1961, Rudd and Beck 1969).

For the past several years an intensive study has been conducted on the biology of *Myotis thysanodes* and *M. lucifugus occultus*. Except for isolated, general reports on these bats, little is known concerning their ecology. This study is an attempt to describe in detail the ontogeny and behavior during this period of these two species.

## DESCRIPTION OF STUDY AREA

The primary study area was Montezuma Seminary, Montezuma, San Miguel Co., New Mexico. The seminary is on the south-facing slope, at the edge of the pinyon-juniper and short-grass prairie communities, at the lower end of Gallinas Canyon. The Gallinas River flows about 400 m south and southeast of the main building.

Figure 1 is a schematic illustration of the attic complex which contains bats. Roost site locations of

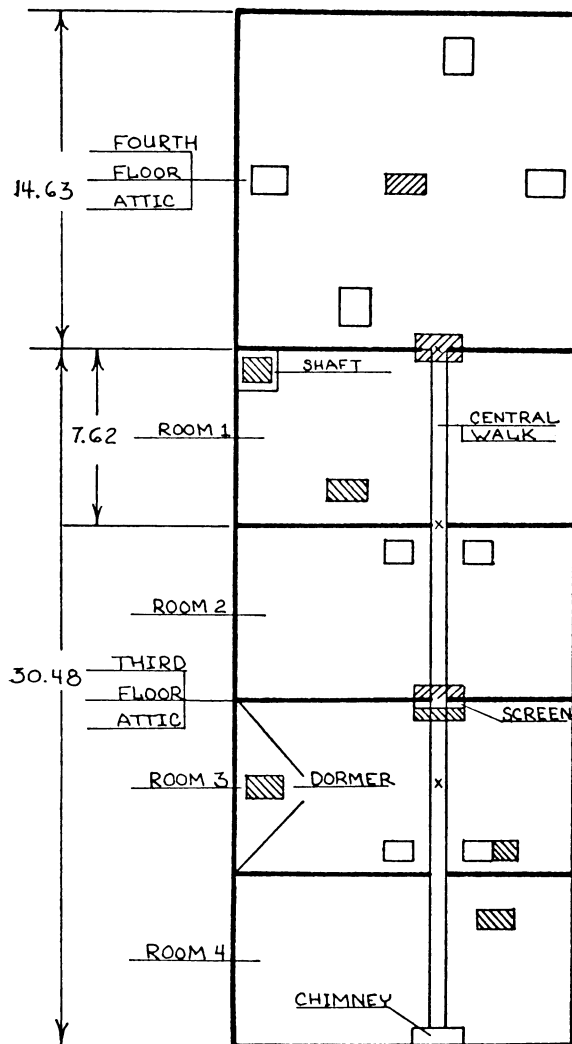


FIG. 1. Schematic drawing of the third- and fourth-floor attics of the east wing of Montezuma Seminary. All dimensions are in meters.  $\square$  = light well;  $////$  = roost of *Myotis lucifugus*;  $|||||$  = roost of *Myotis thysanodes*;  $\times$  = vent.

*Myotis lucifugus* contain large deposits of crystallized urine. Deep depressions and passageways in these deposits form numerous hiding places. The area of the shaft in room 1, next to the light well, and the dormer in room 3 were alternate roost sites for *M. thysanodes*.

A secondary study area was the attic of a three-story house on the southwest corner of Washington and 6th streets, Las Vegas, San Miguel Co., New Mexico. The attic housed several thousand *M. lucifugus* and was sampled for young bats once in June 1970.

#### MATERIALS AND METHODS

*Myotis thysanodes*, the fringe-tailed bat, and *M. lucifugus occultus* (= *M. occultus*, Findley and

Jones 1967), the little brown bat, were the two species examined in this study. Usually, six animals of each species were collected at weekly intervals from 19 April to 25 September 1970 for *M. thysanodes* and from 1 May to 6 September 1970 for *M. lucifugus*.

Reproductive tracts were removed and fixed in AFA. Serial sections at  $10\ \mu$  were stained with hematoxylin and eosin y. When placentae and embryos were visible, they were removed and weighed to the nearest 0.1 mg and crown-rump and forearm lengths to the nearest 0.1 mm were taken on embryos. These specimens were variously preserved for future study.

Postnatal development for *M. thysanodes* was determined in the following manner: On 28 June 1970, 42 neonates were collected and weighed to the nearest 0.1 g, forearms were measured to the nearest 0.1 mm, and each individual was banded with a colored celluloid ring. All banded young that could be found were collected 4, 8, 15, and 19 days later and again weighed and measured.

A weekly sample (3–6) of juveniles of both species was collected to determine wing loading and aspect ratio using the method of Farney and Fleharty (1969). However, instead of using a planimeter for determining membrane areas, wing tracings were cut out and weighed to the nearest 0.1 mg. Paper weights were multiplied by a correction factor (density of that brand of paper, in  $\text{mg}/\text{cm}^2$ ). The young were dissected and the spleen and adrenals were weighed. The bats were dried to constant weight under reduced pressure at  $40^\circ\text{C}$  and fats were then extracted with petroleum ether following the procedure of Ewing, Studier, and O'Farrell (1970). All fat-free residues were dried to constant weight and ashed at  $620^\circ\text{C}$  for 12 hr.

Organ weights are presented as g/kg body weight. Fat index (g fat/g lean dry weight), water index (g water/g lean dry weight), percentage nonfat organic and mineral content percentage ash, and percentage water were calculated for each bat.

#### RESULTS

##### Reproductive cycle

Before the bats left the attic in September 1969, copulatory behavior was noted for *M. lucifugus* but not for *M. thysanodes*. A sample of each species was examined histologically. Sperm were found in the uterus of *M. lucifugus* but not in *M. thysanodes*. Although samples were small, we believe that this is representative of what generally occurs in the fall prior to migration.

The seminary attic was examined on 10 April 1970. No bats were found. On 18 April the attic was visited again. Four *M. thysanodes*, one *M. lucifugus*, one *M. yumanensis*, and three *Eptesicus fuscus* were

found. On 19 April only one male and one female *M. thysanodes* were found. This was the only adult male of this species ever to be collected in this attic. Several *M. lucifugus* could be heard crawling above the ridge pole but none was seen.

Numbers of bats of each species did not increase until 1 May. By 8 May both species were abundant but the *M. thysanodes* appeared to have reached their peak abundance. *Myotis lucifugus*, on the other hand, kept increasing in numbers until about 11 June.

Histological examination of *M. thysanodes* upon their return to the attic in April revealed that the uterus did contain sperm; however, we have no way of knowing when copulation occurred. Females of this species were examined from 19, 22, 26, and 28 April but ovulation had not yet taken place. *Myotis thysanodes* were not collected again until 15 May when all females examined were pregnant. Therefore ovulation, fertilization, and implantation occurred within the 17 days between 18 April and 15 May.

Histological examination of *M. lucifugus* revealed that on 1 May, the first date of collection for this species, luteal tissue was present in the ovary of one female. On 5 May, three females were examined. Two had recently ovulated, probably within several hours. The third was pregnant and contained an implanted blastocyst in the right horn of the uterus.

The calculated gestation period for these two species is between 50 and 60 days.

Parturition is synchronous in *M. thysanodes* but somewhat asynchronous in *M. lucifugus*. Parturition began on 25 June and concluded about 2 weeks later, 7 July, in *M. thysanodes*. Newborn *M. lucifugus* were first observed on 23 June and pregnant females were still found a month later.

It should be noted here that on 1 June 1969, two

*M. lucifugus* gave birth to well-developed young in the laboratory. On this date a dead, fully haired juvenile was found in the attic. In early August 1969 we still found pregnant females of this species.

From visual observations on the testicular development in the juveniles of both species we conclude that the males are not reproductively active their first year of life.

#### Prenatal growth

On 17 May the first placentae were found in *M. lucifugus* and embryos by 24 May. The first visible placentae and embryos were found in *M. thysanodes* on 15 May.

Figure 2 presents logarithmic regression lines for prenatal weight increase in both species. The dashed line for *M. thysanodes* is a projection. Initial weight increase is extremely rapid beginning at approximately -60 days. However, these few days of initial growth were not included in the calculation of the regression line.

Intercepts and slopes were analyzed by means of *t*-tests to determine if the growth rates of the species were similar. Both parameters were found to be significantly different (intercepts— $t = 20.6$ ,  $N = 81$ ,  $P < 0.001$ ; slopes— $t = 19.1$ ,  $N = 81$ ,  $P < 0.001$ ), with *M. lucifugus* exhibiting more-rapid growth rate and lower birth weight.

Figure 3 gives pre- and postnatal growth, based on forearm length, for *M. thysanodes*. Prenatal forearm growth was also determined for *M. lucifugus*. There was no significant difference between forearm growth rates for the two species.

Crown-rump growth rates were determined for *M. thysanodes* and *M. lucifugus*. There was no significant difference between the growth rates for the two species. There was also no difference in accuracy of

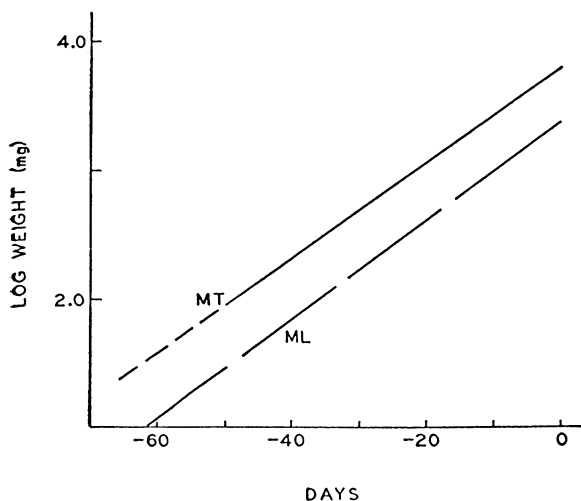


FIG. 2. Logarithmic regression lines for prenatal weight increase in *Myotis thysanodes* (MT) and *Myotis lucifugus* (ML).

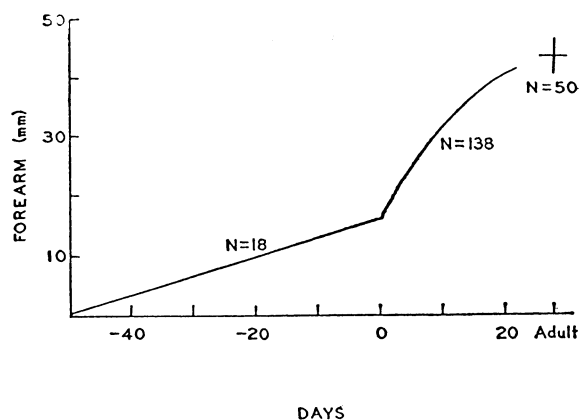


FIG. 3. Pre- and postnatal growth, based on forearm length, for *Myotis thysanodes*. Prenatal ( $N = 18$ ) is a linear regression and postnatal ( $N = 138$ ) is a curvilinear regression line. The vertical line gives the range of 50 adult forearm lengths; horizontal line represents the mean.

TABLE 1. Regression equations of selected parameters for prenatal growth in *Myotis lucifugus* and *Myotis thysanodes*

Parameter	N	Regression equation
<i>Myotis lucifugus</i>		
Weight	59	Log (wt) = 3.383 + 0.0548 (days) (0.0142) (0.000488)
Forearm	46	FA = 0.345 (days) + 16.3 (0.120) (0.393)
Crown-rump	55	CR = 0.437 (days) + 1.949 (0.0756) (0.0375)
<i>Myotis thysanodes</i>		
Weight	24	Log (wt) = 3.792 + 0.0372 (days) (0.0140) (0.000782)
Forearm	18	FA = 0.318 (days) + 15.9 (0.155) (0.358)
Crown-rump	24	CR = 0.373 (days) + 16.5 (0.109) (0.371)

NOTE: Standard error of the mean is given in parentheses. Weight is in milligrams; forearm, crown-rump length are in millimeters.

age determination for forearm length compared to crown-rump length for either species. Table 1 gives the regression equations of the above parameters for prenatal growth in both species. In our opinion, the logarithmic regression equation for weight is by far the most accurate equation for aging prenatal bats.

#### Postnatal growth and development—

##### *Myotis thysanodes*

During the week and a half prior to parturition, these bats became secretive. In general, they formed small, isolated pockets of relatively few bats per group, roosting in cracks between and behind beams. Normally they would roost in the open on the sides of beams. The cluster in room 1, which usually contained 60 or more bats, disappeared. Concomitant with this evacuation, a large cluster of *M. thysanodes* was found in the alcove of room 1, located above a 3-m shaft. Another large group of fringe-tailed bats was located in the south wall of room 3, under the screen.

Normally, this species is easily disturbed, retreating from view when a light is present. During the preparturition period, it was virtually impossible to approach these bats for they were even more easily disturbed; however, toward the end of the parturition period (7 July) one birth was observed. A female was roosting on the lower side of the screen in room 3 and appeared to be having abdominal muscle contractions. Within 15 min the baby and placenta were expelled and the placenta eaten. She spent several minutes licking her newborn and then helped it find the nipple. All this was done in the normal head-down position. After the neonate was firmly attached the female turned to a head-up position and urinated, exposing a bloody vulva. She then crawled under the screen, leaving a trail of blood. Unfortunately this

is the only observation of this behavior for *M. thysanodes*.

On 25 June 1970, the first newborn *M. thysanodes* were found in the alcove roost in room 1. Later the same day, several young were glimpsed under the screen in room 3. On 27 June a few adult *M. thysanodes* were observed on the screen in the third room. On the evening of 28 June, over 50 neonates were observed on the screen, but it was possible to capture only 42 of them. Thirteen of the 42 still had the umbilicus present and were assumed to be within a day of birth, probably only several hours old. Out of the 42 neonates 59.5% were males.

Figure 3 presents the postnatal growth curve for forearm lengths of both sexes in *M. thysanodes*. There was no significant difference in the growth rate between sexes. Growth rate in this species is quite rapid with juveniles reaching minimum adult size in 3 weeks. It can be seen from Fig. 3 that postnatal forearm growth is much more rapid than general prenatal growth.

The eyes of neonates are closed at birth but appear to open within several hours to 1 day after parturition. The pinna is folded at birth but is unfolded and held erect by the time the eyes are open. These observations are based on the presence of an attached umbilicus. It is assumed that the umbilicus is lost prior to the end of the first day due to the arid conditions in the attic. The relative humidity rarely exceeds 15%, consequently the umbilicus dries and becomes brittle and would be sloughed off

TABLE 2. Linear regression equations of selected parameters for postnatal growth in *Myotis lucifugus* and *Myotis thysanodes*

Parameter	N	Regression equation
<i>Myotis lucifugus</i>		
Wing span	49	WS = 10.2 (days) + 102.3 (0.015) (0.850)
5th-finger length	41	5FL = 1.64 (days) + 19.5 (0.040) (0.209)
<i>Myotis thysanodes</i>		
Weight	138	WT = 0.240 (days) + 2.62 (0.031) (0.052)
Forearm	102	FA = 1.31 (days) + 15.9 (0.022) (0.199)
Wing span	24	WS = 8.75 (days) + 107.0 (0.025) (1.87)
5th-finger length	24	5FL = 1.88 (days) + 19.3 (0.024) (0.395)
Total length	24	TL = 1.78 (days) + 49.3 (0.035) (0.541)
Head and body	24	HB = 0.74 (days) + 34.5 (0.056) (0.366)
Tail	24	T = 1.04 (days) + 14.9 (0.040) (0.366)
Tibia	24	TB = 0.44 (days) + 9.39 (0.029) (0.112)
Ear	24	E = 0.36 (days) + 9.62 (0.046) (0.146)

NOTE: Standard error of the mean is given in parentheses. Weight is in grams; all other measures are in millimeters.

TABLE 3. Curvilinear regression equations of selected parameters for postnatal growth in *Myotis thysanodes*

Parameter	Regression equations
Wing span	$= 0.0205 (\text{days})^2 + 8.25 (\text{days}) + 108.5$ (0.00930) (1.96)
5th-finger length	$= 0.0119 (\text{days})^2 + 1.59 (\text{days}) + 20.2$ (0.00192) (0.406)
Total length	$= -0.00173 (\text{days})^2 + 1.82 (\text{days}) + 49.2$ (0.00261) (0.552)
Head and body	$= -0.00337 (\text{days})^2 + 0.82 (\text{days}) + 34.2$ (0.00177) (0.374)
Tail	$= -0.00164 (\text{days})^2 + 0.998 (\text{days}) + 14.99$ (0.00177) (0.374)
Hind foot	$= 0.00118 (\text{days})^2 - 0.00641 (\text{days}) + 9.05$ (0.00051) (0.109)
Tibia	$= -0.00622 (\text{days})^2 + 0.286 (\text{days}) + 9.85$ (0.00049) (0.103)
Ear	$= -0.00195 (\text{days})^2 + 0.314 (\text{days}) + 9.76$ (0.00070) (0.149)

NOTE: Standard error of the mean is given in parentheses. All measures are in millimeters. Sample size equals 24 in each case.

easily. Also, no animal with a forearm length exceeding the 1-day-old range had closed eyes, folded pinnae, or an attached umbilicus.

The neonates are pink for approximately 1 week during which the skin starts to pigment. A light coat of dark gray-brown fur grows into these pigmented areas.

Tables 2 and 3 present linear and curvilinear regression equations, respectively, for selected parameters for postnatal growth in *M. thysanodes*. Linear equations are included because they are easier to use for calculating age of juveniles, but the curvilinear equations are more accurate. One could use most of these equations for aging *M. thysanodes* quite accurately.

Table 4 presents postnatal growth of selected body measures of *M. thysanodes*. The percentages of the various mean body measures of newborns as compared with mean adults values are: total length = 54.24%; head and body = 63.98%; tail = 41.13%; hind foot = 89.01%; tibia = 52.27%; ear = 54.70%; forearm = 37.22%. The mean weight of newborns is 27.01% of the mean adult female weight at this time of year.

Parturition began about 25 June. On 28 June the first neonates were found on the screen in room 3; on this evening the first weights and measures were taken. Young that were 1 day old or more could crawl quite nimbly, which accounted for the fact that only 42 of well over 50 neonates were captured. Once the bats crawled under the screen and up the inside of the wall they were impossible to capture.

The evening of 2 July, another large cluster of new babies was found on the screen, but only 15 of these had been banded. Some bands could be seen under the screen. A careful examination of room 3 then disclosed an alternate roost behind the west light well.

There were numerous babies between the rafters and roof face; 11 of these were banded young.

On the evening of 8 July, banded young were again taken off the screen but many banded and unbanded young were found in another alternate roost sites in the side room on the east side of room 3. The evening of 13 July, juveniles were found roosting in the same two areas.

Wherever the young were roosting, they usually stayed in a cluster. Contrary to adult behavior, they were never observed squabbling with each other.

During the day, adults could be found in the group of young, with a young attached to a nipple, but a large percentage of juveniles usually roosted separately. Females from time to time would nurse a young, but then would fly off and roost with other adults or solitarily, leaving the young in the original cluster. When an occasional baby fell from the roost it would immediately start squeaking an apparent distress call. Within minutes a female would fly down, land next to the baby, spread her wing over it letting it attach, and then return the baby to the cluster. We do not believe that the female was the mother. Juveniles over 2 weeks of age would generally climb the wall, quite quickly, and return to the screen. There were, however, several instances where these juveniles were picked up by a female.

At night after the main colony had left the attic, there would be from two to 10 adults remaining with the young. They would either be on or next to the cluster with a young attached to a nipple or would roost singly in the proximity of the young. When the young were being handled during the data collection process they maintained a constant distress call. At this time the females would fly around the balance, land on the holding container, and frequently land on the hand that was holding a baby, but they never tried to bite. Such behavior demonstrated that this species is capable of hovering and of very agile flight. By the time the banded juveniles were between 10 and 15 days old the females stopped this behavior even though the distress call was given constantly.

While the females were nursing at night it was possible to approach them with a light and even touch them without causing them to fly. It was a complete reversal from the shy behavior exhibited prior to parturition.

At 16.5 days of age *M. thysanodes* young were capable of limited flight. That is, they were able to fly in a straight line for at least several feet but could not gain altitude. Before 20 days of age they were capable of agile flight, negotiating turns and gaining altitude. By 20.5 days of age they were capable of flight indistinguishable from that of adults.

Figure 4 presents the change in aspect ratio from newborn to adult size in *M. thysanodes*. At birth the wings were relatively short and broad, which was

TABLE 4. Postnatal growth of selected body measures and other parameters related to postnatal growth in *Myotis thysanodes*

Age (day)	N	TL	T	HF	TB	E	FA	5FL
Newborn	2	49.5 (49-50)	16.0	8.5 (8-9)	10.0	10.0	16.3 (16.0-16.6)	20.5 (20-21)
2	3	53.3, 1.5 (51-56)	16.7, 1.3 (14-18)	9.3, 0.3 (9-10)	10.7, 0.3 (10-11)	10.8, 0.2 (10.5-11)	20.1, 0.1 (19.9-20.3)	25.0, 0.6 (24-26)
4	3	59.0, 0.6 (58-60)	20.7, 0.3 (20-21)	9.3, 0.3 (9-10)	11.0, 0.0 (10-12)	11.0, 0.6 (10-12)	23.4, 0.1 (23.2-23.6)	27.3, 0.3 (27-28)
6	2	61.0	20.5 (20-21)	9.0	12.5 (12-13)	11.5 (11-12)	26.0 (25.9-26.1)	31.0
9	1	66.0	25.0	9.0	13.0	13.0	30.7	37.0
15	1	75.0	31.0	9.0	16.0	15.0	37.6	48.0
16	1	79.0	32.0	9.0	16.0	16.0	38.4	50.0
19	1	89.0	38.0	9.0	18.0	18.0	41.1	59.0
20	2	81.0 (79-83)	34.0 (33-35)	9.0	17.5 (17-18)	16.5 (16-17)	41.2	52.5 (52-53)
22	8	88.5, 1.0 (83-92)	37.8, 0.7 (35-42)	9.6, 0.2 (9-10)	19.3, 0.2 (19-20)	17.5, 0.3 (16-18)	44.0, 0.3 (42.6-45.0)	61.4, 0.6 (58-64)
Adult	100	91.3, 0.3 (84-98)	38.9, 0.2 (34-44)	9.5, 0.06 (8-11)	19.1, 0.06 (18-20)	18.3, 0.06 (17-20)	43.8, 0.01 (40.0-47.0)	61.4, 0.2 (56-67)

Wing loading								
Age	N	Span	Aspect ratio	Max	Min	Mean	Fat index	Water index
Newborn	2	115.0 (111-119)	5.41 (5.17-5.66)			0.083 (0.078-0.088)	0.08 (0.06-0.10)	3.94 (3.94-3.95)
2	3	129.0, 2.0 (126-133)	5.13, 0.08 (4.98-5.23)			0.086, 0.001 (0.084-0.087)	0.13, 0.05 (0.08-0.23)	3.97, 0.15 (3.82-4.26)
4	3	143.0, 1.5 (140-145)	5.59, 0.09 (5.42-5.71)	0.099	0.092	0.095, 0.002 (0.092-0.097)	0.22, 0.01 (0.20-0.25)	2.91, 0.81 (1.29-3.77)
6	2	163.5 (162-165)	5.84 (5.50-6.18)	0.094	0.085	0.089 (0.088-0.091)	0.20 (0.19-0.20)	3.39 (3.31-3.46)
9	1	196.0	6.10	0.078	0.072	0.075	0.21	3.10
15	1	243.0	6.62	0.066	0.061	0.064	0.15	2.65
16	1	259.0	6.40	0.058	0.053	0.055	0.30	2.64
19	1	289.0	5.89	0.043	0.041	0.042	0.14	2.29
20	2	261.0 (253-269)	6.19 (5.99-6.39)	0.061	0.055	0.058 (0.056-0.060)	0.24 (0.19-0.29)	2.50 (2.41-2.60)
22	8	302.0, 1.9 (293-310)	6.30, 0.07 (6.02-6.63)	0.052	0.046	0.049, 0.001 (0.045-0.051)	0.29, 0.07 (0.12-0.65)	2.58, 0.11 (2.30-3.21)
Adult	100	299.0, 0.8 (274-318)	6.01, 0.03 (5.30-7.44)					

Age	N	% Water	% Organic	% Mineral	Spleen	L. adrenal	R. adrenal
Newborn	2	79.8 (79.7-79.8)	17.3	3.0 (2.9-3.0)		0.14 <sup>a</sup>	0.04 (0.00-0.08)
2	3	79.8, 0.6 (79.3-81.0)	18.1, 1.0 (16.5-19.9)	2.7, 0.1 (2.5-2.8)		0.06, 0.02 (0.03-0.09)	0.13, 0.03 (0.09-0.19)
4	2	78.8 (78.6-79.0)	18.2 (18.0-18.4)	3.0 (3.0-3.1)	4.71 <sup>a</sup>	0.11, 0.04 <sup>b</sup> (0.03-0.18)	0.11 (0.05-0.17)
6	2	77.2 (76.8-77.6)	19.8 (19.5-20.2)	3.0 (2.9-3.0)	5.61 (5.03-6.20)	0.14 (0.09-0.19)	0.25 (0.11-0.38)
9	1	75.6	21.4	3.0	6.34	0.14	0.10
15	1	72.6	24.0	3.4	5.06	0.14	0.08
16	1	72.6	24.0	3.5	4.50	0.05	0.05
19	1	69.6	28.2	2.1	2.76	0.08	0.06
20	2	72.2 <sup>a</sup>	24.1 <sup>a</sup>	3.6 <sup>a</sup>	5.68 (4.69-6.68)	0.08 (0.03-0.12)	0.10 (0.08-0.13)
22	8	71.9, 0.8 (70.2-76.3)	22.6, 0.8 (18.6-25.1)	5.5, 0.6 (3.8-8.8)	4.40, 0.59 (1.83-7.70)	0.09, 0.01 (0.03-0.14)	0.08, 0.02 (0.03-0.18)

<sup>a</sup>N = 1.<sup>b</sup>N = 3.

NOTE: TL, total length; T, tail; HF, hind foot; TB, tibia; E, ear; FA, forearm; 5FL, fifth-finger length; and wing span in millimeters. Aspect ratio is span squared divided by wing area. Wing loading is in grams/square centimeter of wing area. Fat index is grams of fat/gram lean dry weight; water index is grams of water/gram lean dry weight. Spleen and adrenal measures are expressed as grams/kilogram fat-free live weight. Numbers are arithmetic mean; standard error of the mean and range are in parentheses.

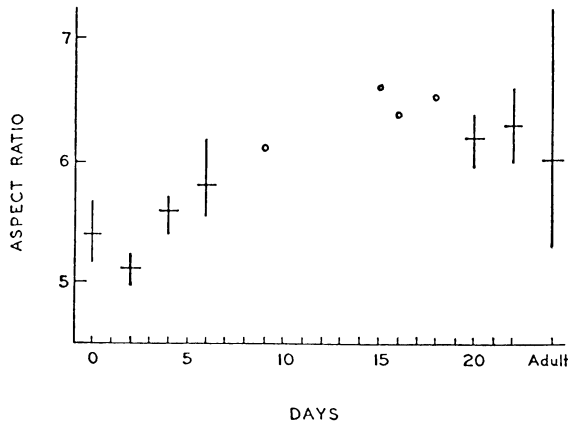


FIG. 4. The change in aspect ratio ( $\text{span}^2/\text{wing area}$ ) from newborn to adult size in *Myotis thysanodes*. Vertical line = range; horizontal line = mean; circle = one animal.

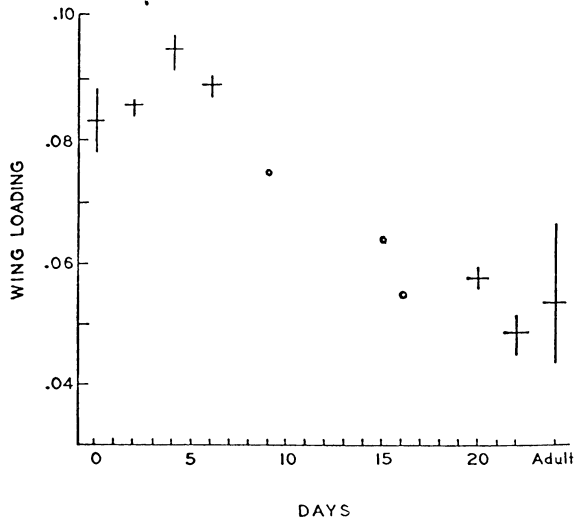


FIG. 5. The change in mean wing loading (mean body wt/total area) from newborn to adult size in *Myotis thysanodes*.

emphasized even more by the third day. After the third day the length of the wings increased more rapidly than width, resulting in a marked increase in aspect ratio. By day 15, growth in width surpassed growth in length resulting in a slight decrease in aspect ratio, approaching average adult values.

Figure 5 presents the change in wing loading from newborn to adult size in *M. thysanodes*. Weight of neonates increased more rapidly than wing area, which caused an increase in wing loading up to the fourth day. After this time, increase in wing area surpassed increase in body weight, which caused a decrease in wing loading down to the minimum range of adults.

Table 4 gives postnatal changes in fifth-finger length, span, and aspect ratio, and changes in maximum, minimum, and mean wing loading in *M. thy-*

*sanodes*. Additionally, Table 4 gives postnatal changes in fat and water indices for *M. thysanodes*. There appears to be a trend in the water index to decrease as the animals approach adult size. This relationship was tested by analysis of variance, and water index was found to decrease significantly ( $F = 4.62$ ,  $df = 22$  and  $2$ ,  $P < 0.05$ ) and no significance was found in fat index.

Postnatal changes in gross body composition in *M. thysanodes* (Table 4) were also tested by analysis of variance. Percentage water decreased significantly from newborn to adult-sized juveniles ( $F = 52.33$ ,  $df = 20$  and  $2$ ,  $P < 0.001$ ). On the other hand, percentage organic content increased significantly from newborn to adult-sized juveniles ( $F = 16.40$ ,  $df = 19$  and  $2$ ,  $P < 0.001$ ). Similarly, there was a significant increase of percentage mineral content from newborn to adult-sized juveniles ( $F = 8.08$ ,  $df = 19$  and  $2$ ,  $P < 0.01$ ).

Table 4 gives postnatal changes in spleen and adrenal weights in *M. thysanodes*. The data were tested by analysis of variance with no significant trends occurring in any of the organ weights in relationship to age of young. Left and right adrenal weights were analyzed, when possible, by *t*-tests to determine if there was a difference between weights, but no significant differences were found.

#### Postnatal growth and development—

##### *Myotis lucifugus*

The behavior of adult females of this species does not vary from behavior that is considered normal at other times of the year within the maternity roost. There was no extraordinary shyness exhibited in prepartum behavior. Parturition was not observed in this species because the large and deep formations of urine at the major roost sites provided a ready hiding place for animals seeking solitude.

*Myotis lucifugus* presented many problems in determining postnatal growth and development. This was by far the most abundant species in the attic, but they roosted in the honeycomblike maze of crystallized urine. Their time of parturition is spread out over more than a month, which made it impossible to obtain a reasonable sample of known-age neonates. We believe that the postnatal growth rate (Fig. 6) is quite similar if not identical to *M. thysanodes*.

The first babies were observed on 23 June. From observations of neonates in the roost, with the umbilicus still attached, and from several babies born in captivity, the appearance of newborns has been determined. They are pink for the first few days, then they start to pigment. The eyes are closed and the pinnae folded at parturition, but eyes are open and pinnae unfolded within several hours after birth. Their ability to crawl is quite good from the first day.

TABLE 5. Postnatal growth of selected body measures and other parameters related to postnatal growth in *Myotis lucifugus* (for further explanation see Table 4)

Age (day)	N	TL	T	HF	TB	E	FA	SFL	SPAN	Aspect ratio	Wing loading		
											Max	Min	Mean
Newborn	18	48.1, 0.7 (39-52)	15.9, 0.3 (14-18)	8.2, 0.1 (8-9)	9.1, 0.1 (8-10)	7.9, 0.1 (7-9)	15.7, 0.3 (12.5-17.3)	19.7, 0.4 (14-23)	104.6, 1.9 (79-117)	5.21, 0.17 (3.97-6.77)	0.092 <sup>a</sup>	0.085 <sup>a</sup>	0.098, 0.005 (0.078-0.168)
1	4	53.5, 0.9 (52-56)	18.3, 0.5 (17-19)	8.5, 0.3 (8-9)	10.0, 0.0 (8-9)	8.8, 0.3 (8-9)	18.1, 0.2 (17.8-18.5)	22.0, 0.4 (21-23)	117.0, 1.4 (115-121)	5.38, 0.19 (5.07-5.90)			0.098, 0.003 (0.093-0.108)
2	1	52.0	18.0	8.0	12.0	9.0	19.9	24.0	126.0	5.58			0.089
3	3	58.3, 0.7 (57-59)	19.7, 0.3 (19-20)	9.0, 0.0	10.7, 0.3 (10-11)	9.3, 0.3 (9-10)	21.6, 0.3 (21.1-22.1)	24.0, 0.6 (23-25)	138.0, 3.1 (134-144)	5.88, 0.32 (5.42-6.50)			0.101, 0.004 (0.094-0.109)
4	4	60.5, 1.0 (59-63)	21.0, 0.7 (19-22)	8.5, 0.3 (8-9)	12.0, 0.0 (10-11)	10.5, 0.3 (10-11)	23.9, 0.1 (23.7-24.0)	27.5, 0.3 (27-28)	147.0, 1.1 (145-150)	6.06, 0.17 (5.61-6.43)	0.102 <sup>b</sup>	0.093 <sup>b</sup>	0.092, 0.010 (0.066-0.109)
5	4	61.0, 0.6 (60-62)	21.0, 0.0	8.9, 0.1 (8.5-9)	13.9, 1.4 (11-16.5)	9.8, 0.5 (9-11)	24.8, 0.2 (24.3-25.4)	27.8, 0.5 (27-29)	153.5, 1.3 (150-156)	6.03, 0.19 (5.52-6.40)			0.096, 0.004 (0.088-0.103)
6	1	57.0	22.0	9.0	17.0	10.0	26.0	28.0	158.0	6.05			0.092
7	3	64.6, 1.9 (61-67)	24.3, 0.9 (23-26)	9.0, 0.6 (8-10)	12.8, 0.2 (12.5-13)	11.3, 0.7 (10-12)	27.9, 0.1 (27.7-28.0)	32.3, 0.9 (31-34)	171.7, 3.4 (165-176)	6.03, 0.21 (5.78-6.45)	0.091 <sup>b</sup>	0.082 <sup>b</sup>	0.086, 0.005 (0.078-0.095)
8	1	68.0	21.0	9.0	13.0	12.0	29.5	34.0	185.0	5.95			0.128
9	2	68.5	29.0	8.0	13.5	13.0	30.8	35.0	192.5	6.23	0.078	0.070	0.074
14	2	82.5 (81-84)	34.5 (34-35)	9.0	17.0	14.5 (14-15)	30.5-31.0 (37.0-37.5)	50.5 (50-51)	254.0 (253-255)	6.19-6.27 (6.37-6.46)	0.053	0.047	0.073-0.075 (0.045-0.055)
15	4	90.3, 1.8 (85-93)	40.3, 1.0 (38-43)	9.5, 0.7 (8-11)	17.5, 0.5 (16-18)	14.5, 0.5 (13-15)	38.4, 0.1 (38.0-38.5)	53.0, 1.1 (51-56)	266.0, 1.9 (262-271)	6.52, 0.11 (6.21-6.67)	0.056	0.049	0.054, 0.002 (0.049-0.058)
16	2	88.5 (87-90)	40.0 (38-42)	9.5 (9-10)	17.5 (17-18)	15.0 (14-17)	39.0	51.0 (50-53)	273.5 (273-274)	6.29 (6.09-6.48)	0.055	0.049	0.052 (0.050-0.054)
17	2	88.5 (85-92)	40.0 (39-41)	9.5 (9-10)	18.0 (17-18)	14.5 (14-15)	40.0	52.5 (51-54)	271.5 (264-279)	6.60 (6.57-6.63)	0.058	0.051	0.054 (0.053-0.056)
18	1	85.0	37.0	10.0	18.0	14.0	40.5	51.0	267.0	6.38			0.048
>20	6	88.8, 1.0 (85-92)	38.5, 0.4 (37-40)	9.3, 0.2 (9-10)	17.2, 0.3 (16-18)	14.7, 0.2 (14-15)	38.3, 0.2 (38.0-39.0)	52.8, 0.6 (51-55)	266.5, 2.3 (262-277)	6.06, 0.08 (5.81-6.25)	0.050	0.046	0.053, 0.002 (0.048-0.061)
Adult	100	92.7, 0.3 (81-99)	40.0, 0.3 (28-48)	9.3, 0.1 (8-10)	18.0, 0.1 (16-19)	15.3, 0.1 (14-17)	39.5, 0.1 (37-41)	54.3, 0.2 (50-59)	273.7, 0.7 (255-290)	6.17, 0.03 (5.10-6.96)	0.056	0.050	

<sup>a</sup>N = 1.  
<sup>b</sup>N = 2.



Table 2 presents linear regression equations for growth of wing span and fifth-finger length. Since the aging is only an approximation, equations for other parameters were not computed.

Table 5 presents postnatal growth of selected body measures of *M. lucifugus*. The percentages of the various mean body measures of newborns as compared with mean adult values are: total length = 51.89%; head and body = 60.99%; tail = 39.86%; hindfoot = 88.42%; tibia = 50.75%; ear = 51.89%; forearm = 39.69%. Mean weight of newborns is 28.26% of mean adult female weight at this time of year.

Occasionally a neonate would fall from the roost, but this was not common during the day. Immediately after hitting the floor the young bat would start squeaking (distress call) and would start crawling up the wall or nearest vertical object. Within minutes a female would fly down, let the baby attach, and then return to the roost site.

As the *M. lucifugus* began their evening emergence from room 1, many young were observed falling to the floor. This is the only room in which this happened in large numbers. In all the rooms with large roost sites for this species, young bats could be heard squeaking. The distress calls were constant for about an hour until the females began their return. After this time, there was a constant flight of adults in and out of the attic. This continued for about 5 hours when the majority of adults returned; this happened at about 1½ hr prior to sunrise. During the night females would periodically return to suckle their young and then leave to forage again.

The juveniles obtained their immature pelage between about 4 days and 2 weeks. The fur was a dark gray-brown, quite distinguishable from the rich brown color of adults. Provided the age estimates were correct, the juveniles were able to fly at 14–15 days of age.

At this time, juveniles were observed flying at night in rooms 1 and 2 in what appeared to be practice or exercise flight. They constantly circled the room in large swarms. There appeared to be no purpose in their flight. Frequently, individuals would land on the sloping rafters, the floor, even on the observer. For awhile they would crawl around and squeak, then would take flight again. This flight behavior appears to be associated with the act of learning to fly in this species. It should be stressed that this behavior only occurred at night after the adults had left for the evening.

Figure 6 presents the change in aspect ratio from newborn to adult size in *M. lucifugus*. Wing length increased more rapidly than did wing width for the first 4–5 days, but it increased more slowly up to about 17 days. The width of the wings increased

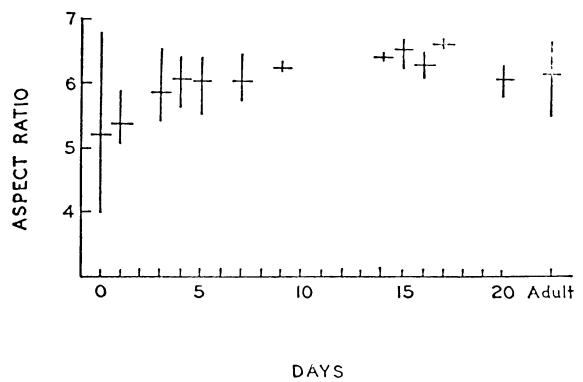


FIG. 6. The change in aspect ratio ( $\text{span}^2/\text{wing area}$ ) from newborn to adult size in *Myotis lucifugus*. Vertical line = range; horizontal line = mean.

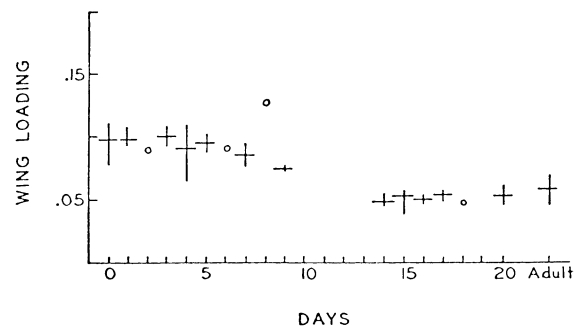


FIG. 7. The change in mean wing loading (mean body wt/total area) from newborn to adult size in *Myotis lucifugus*.

rapidly then, with the mean adult value reached by day 20.

Figure 7 presents the change in wing loading from new born to adult size in *M. lucifugus*. The increases in weight and wing area were similar for the first 5–6 days. After this time, the increase in wing area surpassed the increase in body weight which caused a decrease in wing loading; the mean adult value was reached by day 20.

Table 5 also gives postnatal changes in fifth-finger length, span, aspect ratio, and changes in maximum, minimum, and mean wing loading in *M. lucifugus*.

Table 6 gives postnatal changes in fat and water indices for *M. lucifugus*. There appears to be a tendency for the water index to decrease slightly with age. This was tested by analysis of variance and was found to be significant ( $F = 4.67$ ,  $df = 17$  and  $2$ ,  $P < 0.05$ ). There was no significant trend for fat index with increasing age. Table 6, additionally, gives postnatal changes in gross body composition in *M. lucifugus*. These data were also tested by analysis of variance. Percentage water decreases significantly from newborn to adult-sized juveniles ( $F = 13.61$ ,  $df = 16$  and  $2$ ,  $P < 0.001$ ). Percentage organic content increases significantly from newborn to adult-sized juveniles ( $F = 10.50$ ,  $df = 16$  and  $2$ ,  $P < 0.01$ ).

TABLE 6. Postnatal growth of selected body measures and other parameters related to postnatal growth in *Myotis lucifugus* (for further explanation see Table 4)

Age (day)	N	Fat index	Water index	% Water	% Organic	% Mineral	Spleen	L. adrenal	R. adrenal
5	1	0.10	2.91	74.5	22.3	2.7	5.69	0.08	0.00
7	2	0.17	3.35	77.0	20.1	2.9	5.88	0.06	0.08
		(0.10-0.24)	(3.34-3.35)	(77.0-77.0)	(19.9-20.3)	(2.7-3.2)	(5.54-6.21)	(0.05-0.06)	(0.05-0.11)
9	2	0.18	3.54	77.9	19.4	2.7	4.36 <sup>a</sup>	0.05	0.02 <sup>a</sup>
		(0.13-0.23)	(3.22-3.86)	(76.3-79.4)	(17.9-21.0)	(2.7-2.7)		(0.04-0.06)	
14	2	0.16	2.69	72.8	23.6	3.6	2.94 <sup>a</sup>	0.17	0.04
		(0.02-0.29)	(2.46-2.93)	(71.1-74.5)	(22.2-25.1)	(3.3-3.9)		(0.10-0.24)	(0.00-0.08)
15	3	0.17, 0.10	2.42, 0.01	70.7, 0.1	25.4, 0.1	3.9, 0.0	3.78, 0.18	0.07, 0.03	0.08, 0.02
		(0.04-0.37)	(2.40-2.44)	(70.6-70.9)	(25.2-25.5)	(3.9-4.0)	(3.42-4.04)	(0.02-0.13)	(0.05-0.11)
16	2	0.18	2.50	71.4	24.7	3.9	2.99	0.05 <sup>a</sup>	0.13
		(0.14-0.22)	(2.44-2.56)	(70.9-71.9)	(24.3-25.1)	(3.8-4.0)	(2.97-3.02)		(0.09-0.17)
17	2	0.12	2.70	72.9	23.7	3.7	3.96	0.09	0.08
		(0.07-0.16)	(2.51-2.88)	(71.5-74.2)	(22.3-24.6)	(3.5-3.9)	(3.83-4.10)	(0.09-0.10)	(0.08-0.09)
18	1	0.13	2.45	71.0	25.4	3.6	4.60		0.00
20	5	0.21, 0.02	2.66, 0.26	70.1, 1.1	25.3, 0.7	4.6, 0.4	3.76, 0.34	0.07, 0.01	0.08, 0.02
		(0.14-0.23)	(2.09-3.62)	(66.9-72.0)	(23.9-27.3)	(4.1-5.7)	(2.53-4.58)	(0.04-0.09)	(0.03-0.13)

<sup>a</sup>N = 1.

Similarly, there is a significant increase of percentage mineral content from newborn to adult-sized juveniles ( $F = 17.42$ ,  $df = 16$  and  $2$ ,  $P < 0.001$ ). Finally, Table 6 gives postnatal changes in spleen and adrenal weights in *M. lucifugus*. No weights were obtained for animals from parturition to 4 days old. The data were tested by analysis of variance with no significant trends occurring in adrenal weights in relation to age. However, spleen weight decreased significantly as the animals became older ( $F = 12.13$ ,  $df = 15$  and  $2$ ,  $P < 0.01$ ). Left and right adrenals were tested, when possible, by *t*-tests to determine if there was a difference between weights but no significant differences were found.

#### Comparative development—*Eptesicus fuscus*

In room 4 there was a small maternity group of about 50 *Eptesicus fuscus*. The first babies were found on 24 June. The period of parturition lasted for about a week. The young would also issue a distress call after falling from the roost site, upon which a female would retrieve the baby. The young were also left behind at night and would squeak constantly while the females were gone. The juveniles were flying by 13 July. They seemed to exhibit the type of practice flight behavior similar to *M. lucifugus*; however, *E. fuscus* were notably more clumsy when learning to fly. They would even run into objects while in flight.

#### DISCUSSION

Copulation was known to have occurred in *M. lucifugus* prior to departure from the attic in the fall. It appeared, however, that *M. thysanodes* had not copulated during this time. Within 2 weeks of their return to the attic, *M. lucifugus* females had ovulated and fertilization had occurred. *Myotis thysanodes* females, however, contained sperm in the uterus but did not ovulate until a month after their

return. It is possible that this species copulated during the winter or upon its return in the spring. Further work will be required to verify this.

Gestation period is highly variable in microchiropterans. There are not only differences from year to year in colonies, there can also be individual variations. Within a species gestation differences can usually be correlated with geographic area or with environmental temperatures to which the bats have been exposed (Orr 1970).

Gestation for the two species of *Myotis* dealt with in the present study has been calculated to be between 50 and 60 days long. This estimate agrees with that given for *M. lucifugus* (Wimsatt 1945). Kunz (1971) estimated the gestation period for *M. velifer* to be between 60 and 70 days. Pearson, Koford, and Pearson (1952) estimated a gestation period of 56–100 days for *Plecotus townsendii*. Davis, Herreid, and Short (1962) estimated a gestation period of 90 days for *Tadarida brasiliensis*. It would appear that gestation in *Myotis* is rapid but might be subjected to geographic and climatic variation.

At the time of parturition the fetuses are extremely large in relation to the female and the birth canal. Term fetuses of both *Myotis* were about 50% of the adult total length and 25% of the adult weight. The birth canal is roughly an ellipse, 2 by 4 mm. Obviously a fetus could not pass readily through this opening. O'Connor, Cain, and Zarrow (1966) described the separation of the pubic symphysis and an elongation of the interpubic ligament in *M. lucifugus*. They suggested that this phenomenon was under the hormonal control of estrogen and relaxin. This was also reported for *Tadarida brasiliensis* (Crellin 1969).

Wimsatt (1960) states that the most common posture for vespertilionid bats during parturition is with the head up and uropatagium cupped ventrally.

He states, however, that this parturitional posture is not essential for birth, even in vespertilionids. The duration of labor for bats may vary from 2 min to several hours. Breech presentation at birth appears to be the usual delivery procedure for many families including Vespertilionidae (Wimsatt 1960), although the head-first presentation appears normal for Phyllostomidae (Tamsitt and Valdivieso 1965, 1966). It was suggested that this occurred due to the reduction or lack of the uropatagium common in phyllostomid bats.

With only one observation of parturition in the present study, very few conclusions can be drawn. Since the posture was head down, it can be assumed that this is at least not uncommon in *M. thysanodes*. Presentation of the fetus was not seen and it is assumed that it was breech.

The placenta is usually eaten shortly after parturition except in *M. lucifugus* and *T. brasiliensis* (Wimsatt 1960). In these two instances, neonates were observed with the placenta still hanging to the umbilical cord for up to 8 hr after birth. In the seminary attic it was observed that the single *M. thysanodes* ate the placenta immediately. This species was never observed with the placenta attached to the umbilicus of free-hanging neonates. On the contrary, many *M. lucifugus* were sighted, hanging by themselves with the placenta still attached to the umbilical cord.

From the available literature, the development of the fetus at birth varies, usually between families (Orr 1970). Most reports on Vespertilionidae give the time of eye opening from about 1 day (Jones 1967) to several days or more (Wimsatt 1960, Kleiman 1969, Orr 1970). Cockrum (1960) stated that the eyes of *Eumops perotis* were open within an hour of birth, while Davis et al. (1962) reported that another molossid, *T. brasiliensis*, was blind for some time after parturition. Phyllostomid bats, on the other hand, have eyes that are open anytime prior to or shortly after parturition (Orr 1970).

The development of the ear, whether flattened or erect, seems to follow the same trend as development of the eyes (Orr 1970). These factors appear to be correlated with the relative precocity of the young at birth.

*Myotis thysanodes* and *M. lucifugus* in northeastern New Mexico appear to be rather precocial for vespertilionids, since the eyes are open and pinnae erect shortly after parturition. In other respects, also, they follow closely the subsequent growth of hair in some other members of this family (Kleiman 1969) but tend to surpass hair growth in many others (Mazak 1963, Orr 1970).

The present study verified Davis's (1970) observation that the young are left in the roost and not carried during the foraging flights. The only time

TABLE 7. Calculated estimates for first 10 days of postnatal forearm growth and weight increase in various species of bats

Species	Forearm (mm/day)	Weight (g/day)	Source
<i>Eptesicus fuscus</i>	1.6	0.3-0.4	Davis et al. 1968
<i>Plecotus townsendi</i>	0.86		Pearson et al. 1952
<i>Antrozous pallidus</i>	1.5	0.3-0.4	Davis 1969a
<i>Nycticeius humeralis</i> <sup>a</sup>	0.6-0.7	0.1-0.2	Jones 1967
<i>Nyctalus noctula</i> <sup>a</sup>	1.4-1.5	ca. 0.6	Kleiman 1969
<i>Pipistrellus pipistrellus</i> <sup>a</sup>	0.7-0.8	ca. 0.4	Kleiman 1969
<i>Eptesicus serotinus</i> <sup>a</sup>	1.6	ca. 0.9	Kleiman 1969
<i>Myotis advenus</i>	0.65		Dwyer 1970
<i>Myotis velifer</i>	1.35	0.44	Kunz 1971
<i>Myotis thysanodes</i>	1.5	0.33	Present study
<i>Tadarida brasiliensis</i>	0.7	0.4	Pagels & Jones, pers. comm.

<sup>a</sup>Studies conducted on captive bats.

that young were carried by females was during disturbance and subsequent movements within the attic.

*Myotis lucifugus* left their young in the attic at night but usually had a young attached during the day. They quite possibly picked their own baby out of the mass of young at the roost site. The ability to determine the identity of their own young has been demonstrated in megachiropterans (Kulzer 1961, Nelson 1965) and in microchiroptera (Davis 1969a). Deposition of all the babies in a particular nursery site observed in *M. thysanodes* closely approximates a similar behavior in *T. brasiliensis* (Davis et al. 1962). Beck and Rudd (1960) discovered a female *Antrozous pallidus* guarding a small group of babies. This is the only report found in the literature that closely resembles the occurrence of the nocturnal guard-nurse *M. thysanodes* in Montezuma Seminary.

Davis et al. (1968) documented the retrieval of fallen neonates in *Eptesicus fuscus*. In the present study, both species of *Myotis* retrieved fallen young as did the few *E. fuscus*. This type of behavior has great postnatal survival advantage. This was evidenced when we examined the floor and guano piles below the roost sites. We estimate that only 1% of the *M. thysanodes* neonates and 2% of the *M. lucifugus* neonates died during the postnatal period. Christian (1956) estimated 7% of the postnatal *E. fuscus* died during his study. Mortality rates among young in the large colony-dwelling bats may be considerably higher due to such predators as dermestid beetles in the guano deposits.

Table 7 gives calculated estimates for the first 10 days of postnatal growth of forearms for various species of bats. Davis et al. (1968) reported an increase in forearm length of 2.6 mm in a single day for two individual young *E. fuscus*. The data for *M. thysanodes* agree well with most of the other estimates cited. It would appear that many species grow at approximately the same rate whether under captive or natural conditions. The differences under

natural conditions may be due to local climate. Under captive conditions nutrition, temperature, and amount of handling might affect growth rate significantly.

Table 7 also gives calculated estimates for the first 10 days of postnatal weight increase for various species of bats. Differences in weight increases are possibly due to the differences in relative adult weights that will be reached by these species; however, nutrition and other such factors would also significantly affect weight increase in postnatal animals.

Except for *A. pallidus* (Orr 1954, Davis 1969a) and *Nyctalus noctula* (Sluiter and Van Heerdt 1966), all bats studied have been able to fly at 3 weeks of age. *Myotis thysanodes* young, in the present study, were able to fly at 16.5 days. It is estimated from wing loading, aspect ratio, and observations that *M. lucifugus* young are able to fly at about 14–15 days.

Beck and Rudd (1960) noted practice flight of young *A. pallidus* in the roost. This is probably quite common in bats. This was described, in the present study, for *M. lucifugus* and *E. fuscus* with differences being noted as to agility of the respective young, but practice flight behavior was never observed for *M. thysanodes*.

Jones (1967) and Davis (1969b) presented wing-loading values for postnatal *Nycticeius humeralis* and *A. pallidus*, respectively. These species followed the approximate pattern of *M. thysanodes* and *M. lucifugus*, with a general decrease in wing loading with age. Wing-loading values for *A. pallidus* were much greater than those obtained for either species of *Myotis* before the attainment of flight. However, both species of *Myotis* were quite comparable in loading values obtained throughout the growth period (Fig. 5 and 7).

Water and fat indices and gross body composition have not been dealt with extensively for small mammals in the postnatal state. Sawicka-Kapusta (1970) dealt with *Microtus arvalis* with the following results: Fat content increased from 17.1 to 39.1%, water and protein content decreased with age, and ash content remained fairly constant.

Fat and water indices were comparable for both species of *Myotis* in the present study. No significant patterns were found in fat index through the growth period, but significant decreases in water indices with age were found in both species.

Both species of *Myotis* demonstrated a significant decrease in percentage water and significant increases in percentage organic and mineral content. Theoretically, postnatal animals should dehydrate with age. An increase in organic and mineral content should occur due to the growth and addition of muscle and other organic material and of bones. Obviously more work is required in this area.

Herreid (1959) obtained organ weights on a single captive-born *T. brasiliensis*, which had died after 8 days with no significant increase in body weight. We converted the adrenal and spleen weights to g/kg body weight (spleen = 3.85, left adrenal = 0.06, right adrenal = 0.06). These agree well with the values in the present study (Tables 4 and 6).

Christian (1956) found no significant variation in adrenal mass in immature *E. fuscus* throughout the summer and fall. Rudd and Beck (1969) suggested that adrenal weights of immature bats are approximately that of adults. Their animals, however, were all of sufficient age to fly. Short (1961) showed that there is an increase in adrenal weights with age until the young reach 3 weeks of age.

Both *Myotis* species from the seminary showed no significant variance in either adrenal weight throughout the postnatal period. Adrenal weights were variable, then, not only between individuals, but also between the left and right adrenals in an individual.

*Myotis thysanodes* showed no significant differences in spleen weight as a function of age, whereas *M. lucifugus* exhibited a significant decrease in spleen weight with age. While both species were capable of thermoregulation when quite young (Studier and O'Farrell 1972), there was considerable variability within individuals, adult and young, as to control of body temperature. Lidicker and Davis (1955) showed that spleen weight was increased in torpid bats, and even 5 min after removal from a refrigerator the spleen was still over twice the weight of spleens from active bats. Since thermoregulation studies were conducted on both species of *Myotis* prior to sacrificing them, it is possible that this might have affected the spleen weights.

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