ECOLOGY OF THE MEXICAN FREETAILED BAT,

Tadarida brasiliensis mexicana,

IN OKLAHOMA AND TEXAS

By

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CHAPTER I

INTRODUCTION

The Mexican freetailed bat, *Tadarida brasiliensis mexicana*, an insectivorous member of the family Molossidae, occupies a geographic range extending from South or Central America to the southwestern region of the United States. Despite its wide geographic distribution, the freetailed bat is a colonial species which is typically concentrated in large cave-dwelling colonies throughout much of its range in this country. Small concentrations of freetailed bats occur in buildings, bridges, and mine tunnels (Krutzch, 1955; Davis, Herreid, and Short, 1962; Cockrum, 1969). Reports of banding studies in recent years (Villa-R, 1956; Glass, 1958, 1959; Villa and Cockrum, 1962) have demonstrated the migratory nature of this nonhibernating species, which during colder months of the year abandons many of its United States roost sites in favor of regions in and south of Mexico.

Cockrum (1969), using band-recovery data and published reports on population movements, divided freetailed bat populations into four geographic entities in Mexico and southwestern United States. The groups range geographically from a resident population in California and southern Oregon which undergoes limited local seasonal movements to a seasonally migratory population in eastern New Mexico, Oklahoma, and Texas that moves during winter months into Mexico. Evidence suggests that little or no intermingling of bats occurs among the four designated populations.

Experiments during the present study were conducted on the New Mexico-Oklahoma-Texas group (Fig. 1). Investigations of various populations within this group have been performed by Twente (1955, 1956); Eads, Wiseman, and Menzies (1957); Davis et al.; (1965); Perry (1965); and Constantine (1967a, 1967b). The present study involves populations of freetailed bats in eight Oklahoma and Texas caves. The principal objectives of this investigation were to 1) investigate the accuracy of eye lens weight as a criterion of age determinations, 2) investigate each cave population through age class and sex ratio analyses, and 3) compare population characteristics of bats in Oklahoma and Texas caves from 1965 through 1967.

Ecologists who have studied _Tadarida brasiliensis mexicana_ and other bats have used four methods for age determinations (Perry, 1965). One method involves tooth sectioning and "annular-ring" counting and is based on the premise that hibernation or migration sufficiently alters metabolism to result in ring formation in the dentine. Correlation of this technique with one based on tooth wear in age determination of big brown bats, _Eptesicus fuscus_, was demonstrated by Christian (1956). A second procedure, using relative degrees of maxillary canine tooth wear in designation of age classes has been used during ecological investigations of bat populations. Davis et al. (1962), Christian (1953, 1956), and Twente (1955, 1956), applying this technique to studies of bat populations in Texas, Maryland and Oklahoma, developed from three to five age classes. This method was applied to banded bats to test its validity by Twente (1955) who concluded that relative, but not absolute, ages could be determined. Twente (1956) observed more rapid tooth wear in

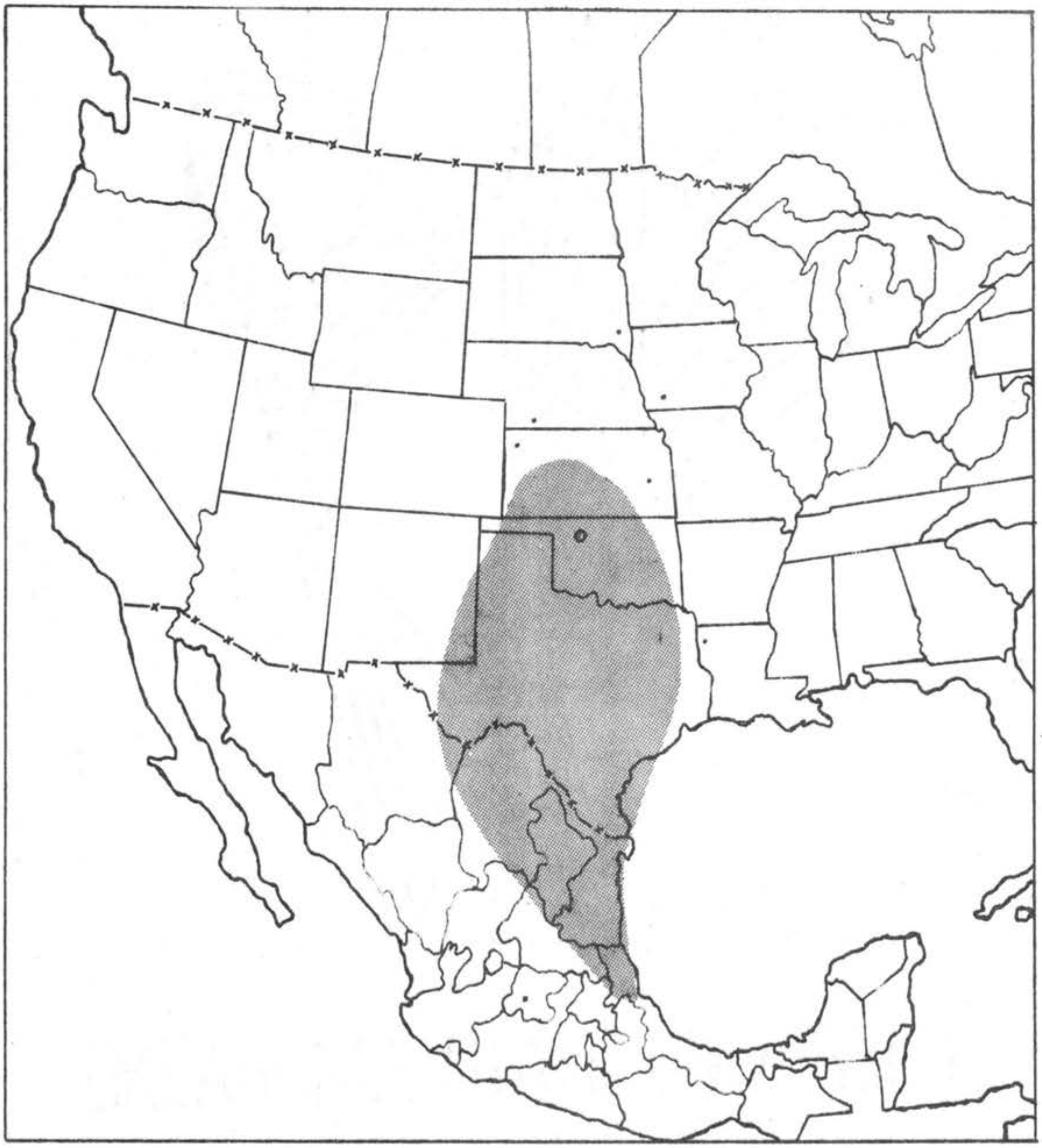

Figure 1. Distribution Records of Freetailed Bats Banded in Oklahoma Caves

female than in male <u>Myotis velifer</u>, and Herreid (1959) noted a sexual dimorphism in tooth size based on five measurements in the freetailed bat. Davis et al. (1962) postulated a more rapid rate of wear in males, whose canines were larger than those of females. My attempts to classify ages of freetailed bats using tooth wear as an aging criterion were disappointing. Maxillary canines of 100 known-age bats, banded at birth, were examined for wear with consistent assignment of specimens to incorrect age classes. Five age classes based on banded bats were possible, from specimens less than one-year old to those which were four years old. Variation in tooth wear for a given group of equal-age female bats was most evident in specimens above one year in age. This variation led to misassignment of test bats to correct age groups at least 50% of the time. Because of tooth wear variations the method was not used as an age-determining criterion during this study.

A third method of applying age-class information to population analyses involves recovery of banded bats from a colony or group of colonies. Some problems in application of this procedure are 1) difficulty in assessing mortality rates of baby bats caused by banding operations, 2) dispersal of banded survivors in a large general population of unbanded bats, which increases the difficulty of recapuring significant numbers of banded individuals, and 3) uncertainty of population homogeneity, for example in Oklahoma study caves, some of which tend to differ from others with respect to sex and age ratios (Perry, 1965).

The fourth age-classification method, introduced as a technique for study of wild animal populations by Lord (1959), is based on the premise that the human eye lens continues growing throughout the whole period of life (Smith, 1883; Collins, 1905). Later studies concerning eye development included observations that eyeball weight tripled between birth and maturity (Scammon and Wilmer, 1950), and lens weight in the human eye at age 57 was four times weight at birth (Scammon and Hesdorffer, 1937).

Hatai (1913) observed that body organ (including eyeball) weight was influenced by nutrition, age and season, sex differences, and strain of animal. Jackson (1913) found a low correlation between eyeball and body weight, suggesting that eye development may be independent of factors affecting total development of the body. However, Krause (1935) stated that normal lens growth for mammals was not continuous as had been assumed but grew toward a maximum.

Lord (1959) established accurate lens weight-age correlations up to the age of 30 months for penned specimens of cottontail rabbits. This work generated increasing investigation of this method by researchers interested in age analyses of wild animal populations. Experimental animals have ranged in size from cricetid rodents (Schwarz, 1964; Martinet, 1966) to elephants (Laws, 1967). In most instances the method has proven most satisfactory in separating juveniles from adults. Sanderson (1961) was able to determine month of birth for raccoons (*Procyon lotor*) less than 12-months old. Lens weight variations among older individuals rendered specific age determinations difficult. He thus was limited in number of attainable age groupings to adult and young-of-year animals. Beale (1962) also was limited to young and adult classes in a study of fox squirrels (*Sciurus niger*). He found the method most accurate for young up to ten weeks and possibly applicable to specimens through at least 30 months. Mead (1967) found lens weights the most useful of five indices of age which were used during a study of the spotted skunk (*Spilogale putorius*). Three classes, juvenile (less than six months), subadult (7-12 months) and adult (older than 12 months) were categorized using the lens weight method. Birney and Fleharty (1968) were unsuccessful in separating winter-trapped mink (Mustela vison) into more than two age classes. They attributed failure to achieve more accurate results to method of specimen collection.

Somewhat better accuracy has been achieved for adult animals in studies of artiodactylids. Kolenosky and Miller (1962) attempted to age pronghorn antelopes from five months to nine years and were successful with animals up to 3.5 years, beyond which lens weight overlaps reduced accuracy. Lord (1962) plotted a growth curve correlation with lens weights in white-tailed deer up to ten-years old. Longhurst (1964) found lens weight a satisfactory age indicator in Columbian blacktailed deer (Odocoileus hemionus columbianus) up to five years. Friend (1968) reported that a number of investigators found that fawns and yearlings could be separated with a high degree of accuracy, yearlings and $2\frac{1}{2}$-year olds with less certainty and thereafter year clas assignment was unreliable for individual deer.

A direct comparison of the efficacy of two age determination methods was made by Perry and Herreid (1969). Forty-eight banded freetailed bats of known age collected from Oklahoma caves were independently aged by lens-weight and tooth wear techniques. Agreement of the methods in placing bats in age classification 0-3, 4-5, and 5+ years was noted. Both methods assigned approximately 85% of the banded bats in the correct age classes. Seventy-five percent of known-age bats were placed in the same age class by both methods. However, only 49% of 482 bats of unknown age were placed in the same age class by both methods. The authors noted that the lens-weight method estimated the overall age of the unknown-age bats to be younger than the tooth wear method. Of the method, the authors concluded that:

> ". . . one is not superior to the other in accuracy. The tooth wear method of aging permits grouping of individuals into three or four categories in the field and requires little equipment. The eye lens method requires laboratory weighing, some elaborate equipment, and is more time consuming; however, it is less subjective and allows for definition of a greater number of age categories."

CHAPTER II

DESCRIPTION OF STUDY CAVES

Eight caves serving as natural roosting sites for freetailed bat aggregations were sampled. Included were five caves serving as nursery colonies in Oklahoma and three caves situated along the Balcones Escarpment of central Texas (Fig. 2).

The nursery caves in Oklahoma are Merrihew's Cave (Woods Co.), Selman's Cave (Woodward Co.), Vickery I Cave and Conner's Cave (Major Co.) and Reed Cave (Greer Co.). Legal descriptions of the cave locations were given by Glass and Ward (1959). Oklahoma caves, situated in gypsum formations, were formed by erosion of soil beneath gypsum crusts and, with the exception of Merrihew's Cave, front on ravines formed by collapse of the gypsum overcrust. The entrance to Merrihew's Cave is situated at the base of a small hill. Merrihew's and Vickery caves have branches of unequal length with undisturbed guano bat clusters usually confined to the deeper branch of each cave. Reed, Selman's and Conner's caves are unbranched. All Oklahoma caves studied have more than one external opening, although the freetailed bats characteristically used only one exit during evening emergence flights.

Although rains periodically cause minor flooding of the caves, only Vickery and Reed caves have fairly permanent streams throughout much of their lengths. Selman's and Merrihew's caves contain intermittent pools of water. Despite the high humidity of these caves, they are termed

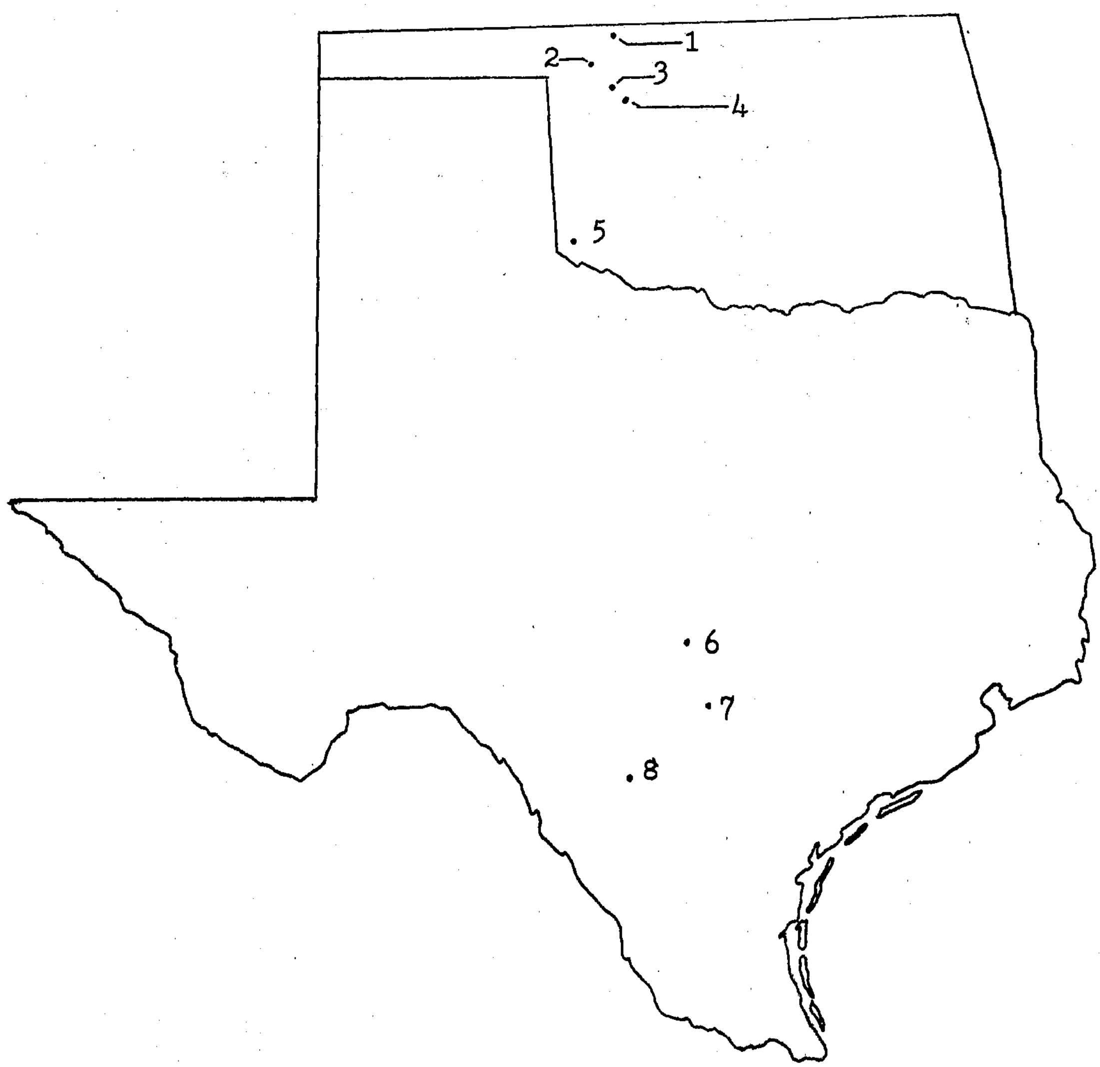

Figure 2. Locations of Freetailed Bat Caves from which Samples were Collected. No. 1 = Merrihew's Cave, 2 = Selman's Cave, 3 = Vickery Cave, 4 = Conner's Cave, 5 = Reed Cave, 6 = Davis Cave, 7 = Bracken Cave, 8 = Frio Cave

"dry" caves, since the chambers of cave areas inhabited by freetailed bats have walls which are essentially devoid of water condensate.

The smallest Oklahoma freetailed bat cave is Conner's Cave, with a southeast-facing entrance approximately 9m wide and 5m high. The cave extends northwest for approximately 60m. The entrance to Selman's Cave faces east-southeast and is approximately 12m wide and 6m high. The cave extends about 105m northwest from the opening. Vickery Cave has an opening about 15m wide and 6m high. The entrance faces south-southwest with a bifurcation located some 30m north-northeast of the opening. One passage extends about 30m northwest and the other passage approximately 90m east-southeast. The entrance to Reed Cave faces south and is about 12m wide and 5m high. This cave extends in a northerly direction for about 155m. Merrihew's Cave, mapped by Twente (1955), has a north-facing opening used by freetailed bats. The cavern bifurcates approximately 18m south-southeast of this opening. One passage, approximately 60m long, extends north-northeast, with two terminal outside openings facing northeast. The other passage, about 150m in length, extends south-southeast with a chimney-type entrance at its southernmost point. Much of this passage is congested with gypsum piles caused by partial collapse of the ceiling. Freetailed bats were usually found clustered in the longer passage.

Oklahoma caves containing freetailed bat nursery colonies frequently contained other species of bats as either residents or transients. The most notable case was Merrihew Cave, in which _Plecotus townsendii_, _Eptesicus fuscus_, _Myotis velifer_ and _Antrozous pallidus_ were observed in in addition to _Tadarida_. Vickery Cave contained _Myotis velifer_, _Eptesicus fuscus_, and rarely _Plecotus townsendii_. Small numbers of

Myotis velifer were infrequently observed to intermingle with evening emergence flights of freetailed bats from Selman's, Conner's and Reed caves.

Observations concerning Texas caves have been supplemented with information from White (1948), Eads et al. (1957) and Davis et al. (1962). Caves visited during the course of this study were Davis ("Blowout") Cave in Blanco Co., Bracken Cave in Comal Co., and Frio Cave in Uvalde Co. Unlike the Oklahoma nursery caves, these caves occur in limestone formations. Neither streams nor pools of standing water were observed in the Texas caves; although humidity is high, these caves are of the typical "dry" type colonized by freetailed bats.

Davis Cave is the smallest of the three caverns sampled. Located near the top of a low ridge, the cavern has a west-facing entrance 3m high and 12m wide. The passage is approximately 60m long and 15m wide, and is oriented in a northeasterly direction from the entrance. The north-facing entrance to Bracken Cave, at the bottom of a sinkhole, is some 5m high and 12m wide, and the cave is about 300m long. The southernmost extent of the cavern is about 37m below the surface. Frio Cave is a large cavern complex occupying much of the interior of a small hill. A map prepared by Constantine (1967b) illustrates the complexity of this cave. The two north-facing entrances open into a large antechamber supported by several limestone columns. Southwest of this area is another large chamber located at a lower level which is about 60m in width and an estimated 25m high. Three smaller chambers occur at descending levels southeast of the second chamber. Freetailed bats were usually found clustered in the second large chamber. Distance from entrance to innermost small chamber was estimated to be 370m.

Myotis velifer was frequently observed emerging from Davis and Frio caves during or following freetailed bat emergence flights. Frio Cave additionally contains *Mormoops megalophylla* during winter months (Constantine, 1967b).

CHAPTER III

MATERIALS AND METHODS

Sampling Schedule

Samples were collected in 1965, 1966, and 1967. All samples were collected with a 56cm diameter, 6mm-mesh nylon net mounted on a 5m bamboo pole. The net was found to be as efficient as, but less cumbersome than, the modified Constantine bat trap (Constantine, 1958) used by Perry (1965). Bats were sacrificed and both eyes from each bat were removed with forceps, preserved in 10% formalin, and stored in a 2-dram screw-cap vial (Curtin, 22276D).

Tables I and II include sampling dates and numbers of subsamples obtained per cave per date. Entry of (0) in a subsample column denotes that the cave was visited but either was empty or contained an insufficient number of bats for a sample. Initial samples from Oklahoma caves during 1965 were limited to collection of one sample of bats flying withing the cave from each cave per month. Results may be influenced by disturbance of bats during sampling within the caves and revised sampling procedures were initiated for Oklahoma caves in August, 1965. The revision involved collecting subsamples of 30 freetails at 30-min. intervals for the duration of the evening emergence flight. Sex ratios of bats caught in excess of the required sample size were checked prior to their release.

TABLE I

COLLECTING DATES AND NUMBER OF SUBSAMPLES
FOR OKLAHOMA CAVE SAMPLES

Year	Cave				
	Merrihew	Selman's	Vickery	Conner's	Reed
1965	20 Apr (0)	20 Apr (0)	20 Apr (1)	20 Apr (1)	--
1966	29 Apr (0)	29 Apr (0)	30 Apr (0)	30 Apr (1)	--
1967	--	--	--	--	--
1965	20 May (1)	20 May (1)	21 May (1)	21 May (1)	--
1966	30 May (1)	30 May (1)	31 May (1)	31 May (0)	--
1967	25 May (1)	25 May (1)	24 May (1)	24 May (1)	--
1965	22 Jun (1)	22 Jun (1)	21 Jun (1)	21 Jun (1)	17 Jun (4)
1966	30 Jun (1)	29 Jun (2)	28 Jun (2)	27 Jun (3)	26 Jun (4)
1967	27 Jun (1)	26 Jun (2)	25 Jun (2)	24 Jun (2)	23 Jun (3)
1965	21 Jul (1)	21 Jul (1)	20 Jul (1)	20 Jul (1)	22 Jul (1)
1966	29 Jul (0)	28 Jul (3)	27 Jul (3)	26 Jul (2)	25 Jul (3)
1967	25 Jul (0)	24 Jul (2)	26 Jul (2)	23 Jul (2)	22 Jul (3)
1965	26 Aug (2)	27 Aug (2)	25 Aug (3)	24 Aug (3)	28 Aug (3)
1966	26 Aug (2)	25 Aug (2)	23 Aug (1)	24 Aug (2)	27 Aug (1)
1967	27 Aug (2)	25 Aug (2)	26 Aug (2)	24 Aug (2)	23 Aug (2)
1965	6 Sep (1)	6 Sep (1)	7 Sep (1)	7 Sep (1)	--
1966	25 Sep (0)	25 Sep (1)	24 Sep (1)	24 Sep (0)	--
1967	23 Sep (0)	23 Sep (1)	22 Sep (1)	22 Sep (0)	--
1965	10 Oct (0)	10 Oct (1)	11 Oct (1)	11 Oct (0)	--
1966	25 Oct (0)	25 Oct (0)	26 Oct (0)	26 Oct (0)	--
1967	--	--	--	--	--

(n) = number of subsamples in the sample
(0) = cave visited but empty

TABLE II

COLLECTING DATES AND NUMBER OF SUBSAMPLES FOR TEXAS CAVE SAMPLES

Year	Cave		
	Davis	Bracken	Frio
1965	13 Jun (5)	14 Jun (1)	16 Jun (6)
1966	21 Jun (3)	22 Jun (2)	23 Jun (4)
1967	8 Jun (1)	9 Jun (2)	10 Jun (2)
1965	2 Sep (3)	4 Sep (3)	3 Sep (3)
1966	12 Sep (3)	13 Sep (3)	14 Sep (2)
1967	6 Sep (3)	7 Sep (3)	8 Sep (2)

(n) = number of subsamples in the sample

Limited time for field collections from Oklahoma caves during April, May, September, and October necessitated collection of one sample of 50 bats per cave per month. Caves were visited on weekends, and collections of bats from inside each cave rather than from the evening emergence flight permitted visits to two caves daily. Reed Cave, because of its distance from other Oklahoma caves, was sampled only during June, July, and August.

Texas caves were visited twice annually (Table II). June samples were collected prior to or during parturition periods, while September collections contained young-of-year bats. As with Oklahoma samples, collections of subsamples were at 30-min. intervals. An exception to this schedule was the Bracken Cave sample of 14 June 1965, when available time did not permit sampling of the evening emergence flight. Initial subsamples from Texas caves consisted of 30 bats; this number was increased to 50 bats per subsample in June, 1966 and subsequent Texas collections.

Collection of Known-Age Bats

A group of known-age bats was produced by banding 110,000 neonatal bats from 1962 through 1967. Ten thousand young, including 5000 females, were banded by A. E. Perry and Gordon Beckett in Selman's Cave during summer, 1962. A total of 20,000 neonatal bats from Selman's and Conner's caves was banded in 1963, of which 18,000 were females. Of the 20,000 banded in 1964, 14,000 were females. From 1965 through 1967 equal numbers of male and female young were banded at the rate of 20,000 bats per year. Banding was conducted at night to minimize disturbance of adults in the nursery caves.

In all cases bands used were of the number two size provided by the United States Fish and Wildlife Service. This size caused a minimum of irritation to wing membranes when applied to the young bat's forearm. Color-coding of bands each year through anodizing facilitated recognition of given-age bats. Anodization with bright red, green, yellow, and blue was satisfactory for approximately two years, after which time abrasion and staining of bands negated the advantage of color-coding. The aluminum bands were anodized by Mac's Plating Works, 2138 South West Boulevard, Tulsa, Oklahoma.

Known-age bats were collected during summer, 1967. The relatively small number of young banded in 1962 and the large numbers removed from the population by Perry to establish a growth curve for neonatal bats, resulted in scarcity of 1962-banded freetails in the caves by 1967. Consequently, the number of five-year-old bats collected was insufficient to use in establishing a growth curve. Approximately 250 bats banded in 1963 and subsequent years were collected in 1967. Both eyes from a freshly-killed banded bat were preserved and stored in vials containing 10% formalin.

Removal and Drying of Lenses

The procedure followed in excision and preparation of lenses for weighing was essentially the same as that used by Kirkpatrick (1964) and Perry (1965). After being stored in formalin for at least two weeks, one of the two eyes collected from each bat was removed from the storage vial, placed in a Bureau of Plant Industry watch glass and soaked in distilled water for ten minutes to remove preservative. The remaining eye was retained in preservative for use in case of mechanical damage to the first lens.

The cornea was ruptured with a knife-needle and the lens forced from the eyeball. Each lens was examined with a binocular dissecting microscope for damage or presence of extraneous matter. The latter was removed under water with a camels-hair brush. If damage was detected the lens was discarded and the remaining lens analyzed.

The excised and cleaned lens was transferred to a watch glass containing 95% isopropyl alcohol, which partially dehydrated the lens and prevented adhesion of lens to container. After ten minutes in alcohol the lens was transferred to a watch glass for initial air drying, then placed in a 0.5 dram screw-cap vial for further air drying and storage. Preliminary air drying in a watch glass minimized lens adhesion to the storage vial.

Both lens and storage vial, less cap, was placed in a 300 watt Boekel oven for final drying. The lens was dried at 70°C for 48 hr., then removed for weighing.

Weighing

Lenses were weighed within 15 min. of removal from the drying oven. To test hygroscopicity of the dried lenses, two sets of lenses were oven-dried for 48 hr. at 70°C. Lenses from Set I were weighed immediately; corresponding lenses from Set II were weighed 20 min. after removal from the oven. Comparisons of weights showed differences not exceeding 4μg in lenses of the two sets. Because of this minute change in weight due to lens exposure to air moisture, the dehumidified weighing chamber used by Perry (1965) was not used. The supposedly high hygroscopic nature of the lens evidently was not significant enough to cause marked changes in weights of lenses exposed to about 30% relative humidity over a short period of time. This is in agreement with results obtained by Friend (1967b) who found:

> ". . . that the dried lens is not hygroscopic as others have believed. However, the glass vials in which lenses were dried were found to lose weight during the drying process and then to regain the loss as they cooled . . . ."

Initially lens weights were determined with the aid of a Sartorius Precision Micro Torque Balance, which had a range of 1mg and sensitivity of 2μg per scale division. Mechanical difficulties necessitated use of a Brinkman Series DG Micro Torque Balance with a range of 1 mg and sensitivity of 1μg per scale division.

The Brinkman balance, which had a digital read-out scale, proved to be somewhat less precise than the Sartorius balance, which had a dial and pointer read-out scheme. Reweighings of lenses with the Sartorius balance resulted in variations of 2 to 4μg, while reweighings with the Brinkman balance produced variations of up to 20μg.

Accuracy of Laboratory Procedure

Data in Table III indicate significant disparity between Perry's (1965) and the present study's known-age lens weights. In all cases, mean lens weights for comparable classes of known-age bats were significantly lower in Perry's data. Less difference occurred among standard deviations expecially in the case of two-year-olds.

Several factors could have accounted for the differences of lens weight means for the two studies. As previously mentioned, the dehumidified weighing chamber used by Perry was not used during the present study. The chamber was used to prevent lens weight increase through uptake of moisture from the air. Friend's (1967b) comments concerning this point and tests by the present investigator demonstrated that hygroscopicity was an insignificant factor considering the short period of time each oven-dried lens was exposed to air prior to weighing. With the exception of the weighing chamber, procedures used by Perry during lens processing were followed in the present investigation.

Because of the nature of the fixation process, different periods of eyeball fixation could have contributed to differences in lens weights. Friend (1968) noted that lens weights increased during the first 30 days of fixation, due to the formaldehyde-amino acid bonding nature of the process. He found no increase in weight beyond 30 days until the 300th day of fixation, after which time weight increase again was evident. Total fixation time was not noted by Perry (1965), except for the state-ment that lenses were fixed for at least two weeks. In the present study, some lenses were in fixative for up to 180 days, but lenses from known-age bats were processed within 30 days. In both studies formalin-fixed eyes were soaked in water for 10 min. prior to removal and drying of lenses. Water soaking serves to break formaldehyde-amino acid bonds and remove formalin from the tissue (Friend, 1968). Therefore, differential degrees of formaldehyde bonding due to different fixation periods was minimized by the water-soaking step in the lens removal process.

TABLE III

COMPARISON OF MEAN LENS WEIGHTS AND STANDARD DEVIATIONS FROM KNOWN-AGE BATS WITH RESULTS OF A PREVIOUS STUDY (PERRY, 1965)

Age in	Mean Lens Weight (μg)			Standard Deviation	
Years	Present Study	Perry	Difference	Present Study	Perry
0-1	579 (51)	530 (21)	49	49.21	45.38
1	735 (52)	660 (31)	75	51.82	63.89
2	782 (48)	704 (25)	78	54.49	55.69
3	801 (49)	733 (3)	68	67.05	51.95
4	815 (47)	781 (4)	34	59.01	12.68

Values in parentheses denote sample size.

Perry (1965) weighed all lenses on a Sartorius Precision Micro-Torque Balance, while most lenses including those of know-age were weighed on a Brinkman Series DG Micro Torque Balance in the present study. The latter has been mentioned to be a less precise instrument but its degree of error was felt to be insufficient to account for the magnitude of discrepency in question.

The small number of known-age bats available to Perry could have resulted in inaccurate lens weight means, especially for 3- and 4-year old bats which were represented by three and four specimens, respectively. However, comparison of lens weight means for 3- and 4-year bats indicate no greater degrees of difference than in younger bats. The disagreemnt of means regardless of age-class sample size indicates that the latter was not the source of the problem.

The reason for the differences evident in Table III is unknown, but the fact remains that a lens weight would be assigned to two different age classes depending on which lens weight data were used. This leads to the conclusion that incorporation of eye lens weights from the two studies in an effort to present a continual analysis of Oklahoma populations from 1963 to 1968 would be misleading and invalid. Subsequent discussions concerning guano bat populations in terms of age classification are limited to eye lens data from the present study only.

CHAPTER IV

DEVELOPMENT OF AGE CLASSES

Variation in lens weights of known-age bats complicated determining age classes of guano bats. Perry (1965) pointed out that ranges of lens weights for a given class were so great that overlaps of weights between successive classes were common. In the present study, a given lens from a known-age bat could often be assigned to any of the five ages represented in the reservoir of specimens for which true ages were known. Much of the problem was due to a slow rate of increase in lens weights of bats over one-year old, combined with a wide range of lens weights within known-age groups. This is illustrated by the relatively narrow interval between mean lens weights of 2-, 3-, and 4-year-olds, each of which had a high standard deviation within its age class (Table IV).

Results of eye lens studies have frequently included statistical treatments of lens weight data to minimize fluctuations in variances within age classes. Examples of these statistical treatments include data transformation aimed at stablizing variances (Dudzinski and Mykytowycz, 1961; Connolly et al., 1968) and formulation of regression models intending to accurately establish age classes (Perry, 1965). Kirkpatrick (1964) established a growth curve for captive *Sigmodon hispidus* by passing a curve through the means lens weight value for each age class. Mead (1967) divided specimens of *Spilogale putorius* into juveniles, subadults, and adults using five indices of age, including eye lens weight. During the summer of 1968, 246 banded bats were recaptured from guano bats in the Oklahoma caves. (No bats were banded or recaptured in Texas caves visited in this study.) The age classes represented in these recaptured bats were young-of-year (50 specimens), one-year-olds (52), two-year-olds (48), three-year-olds (49) and four-year-olds (47).

TABLE IV

MEAN LENS WEIGHTS FOR KNOWN-AGE FREETAILED BATS

	Under One Year	One Year	Two Years	Three Years	Four Years
Set I					
Mean Lens Weight (μg)	578.84	734.69	782.85	801.08	815.00
	(50)	(52)	(48)	(49)	(46)
Standard Deviation	49.21	51.82	54.49	67.05	59.01
Set II					
Mean Lens Weight (μg)	575.69	737.82	784.61	798.78	816.09
	(50)	(52)	(47)	(47)	(47)
Standard Deviation	46.59	56.87	52.74	74.07	57.56

Values in parentheses indicate sample size.

Since lens weights from the recaptured known-age bats formed the basis for determination of age-class criteria which would be applied to analyses of the freetailed bat populations, both eye lenses from each banded bat were weighted. Eyes from each bat were separated, marked for reference purposes, and compiled into two groups. Each group was processed in turn, from excision of the lens to final weighing. This procedure was thought to give the most accurate determination of lens weight of each known-age bat and also determined the precision of the lens preparation and weighing process. Data in Table IV summarize the data for each age group of banded bats. Mean lens weights for the two sets of lenses from each age group differed by no more than approximately 3μg and standard deviations for each group were fairly consistent.

Thirty lens weights were randomly selected from each group of known-age bats. The selected lens weights for each group were averaged to obtain a mean lens weight (Table V). The mid-point in weight between successive group means was selected as the dividing point between age classes. All lens weights which fell between any two successive dividing points were considered to be of the age class defined by these points. For example, the mid-point between banded bats having a mean lens weight of 737μg and those having a mean weight of 784μg was 760μg, and the mid-point between the means of 784μg and 796μg was 790μg. So all lens weights between 760μg and 790μg were considered to represent bats of the two-year-old class. The range of lens weights for each age class, as determined by this procedure, are listed in Table V.

The accuracy of this age classification procedure was tested by construction of a two-way table in which lens weights of those banded bats not used in designation of each lens weight range were classified as defined by the appropriate range (Table VI). In this table, five age classes were used, from young-of-year (Class 0) to bats at least four-years old (Class IV). Each column in the table under CLASSIFIED AGE represents an age class determined by the lens weights range listed in Table V. Lens weights from each successive group of known-age bats

(ACTUAL AGE) were then placed into the table according to their positions in the CLASSIFIED AGE Column. Thus, of the twenty lenses from bats known to be young-of-year, sixteen were correctly placed in the appropriate CLASSIFIED AGE column, and four were incorrectly designated one-year-olds. The q-values listed to the right of the table list the number of correct placements of known-age lenses in the classification scheme.

TABLE V

AGE CLASS SCHEMES BASED ON RANGES OF LENS WEIGHTS FROM KNOWN-AGE BATS

Age Class	Mean Lens Weight (μg)	Weight Range for Each Class (μg)
0 - (less than 1 year)	575	less than 656
I - (1 year old)	737	656 to 760
II - (2 years old)	784	760 to 790
III - (3 years old)	796	790 to 806
IV - (4 years old)	816	more than 806
0 - (less than 1 year)	575	less than 656
I - (1 year old	737	656 to 768
II - (2 years and older)	799	more than 768

Only lenses from young-of-year bats were consistently placed in the correct age class using the lens weight criterion. Some success was evident in placement of lenses from one- and four-year olds, and little success was evident for two- and three-year olds. The explanation for this lies in the growth rates of lenses throughout the life of the guano bat. Rapid initial growth in young bats resulted in a large number of

TABLE VI

COMPARISON OF ACCURACY OF FIVE-CLASS AND THREE-CLASS SCHEMES

ACTUAL AGE \ CLASSIFIED AGE	0	I	II	III	IV	
0	16	4	0	0	0	q_1 = 16/20 (80%)
1	3	12	5	1	1	q_2 = 12/22 (54%)
2	0	6	4	4	4	q_3 = 4/18 (22%)
3	0	3	3	1	12	q_4 = 1/19 (5%)
4	0	2	1	5	9	q_5 = 9/17 (53%)

ACTUAL AGE \ CLASSIFIED AGE	0	I	II	
0	16	4	0	q_1 = 16/20 (80%)
1	3	15	4	q_2 = 15/22 (68%)
2	0	13	41	q_3 = 41/54 (76%)

q_i = number of correct placements of lens weights eye lens weights that correctly fitted the classified age scheme for young bats. A decrease in lens growth rate of bats 1-year old and older resulted in narrower weight ranges for subsequent age classes, with an increased risk of misclassification. This is well illustrated in 3-year-old bats. The lens weight range for this group was only 16μg as opposed to 104μg for one-year-olds. The chances of correctly placing bats in an age group of such limited weight range were minimal.

The inaccuracies apparent in Table V in sorting lenses into five weight and age classes prompted a revision of the classification procedure. Number of weight and age classes was reduced to the following three classes: 0 (less than 1 year), I (1 year), and II (2 years and older). Using the two-way table as a test of correct classification (Table VI), it is apparent that much greater success was attained with reference to inclusion of lens weights in the appropriate classified age interval. Because only higher age classes were grouped, accuracy for young bats as indicated by q-values was unchanged. But wider weight intervals for classes I and II resulted in greater chances of placement of given lenses in these classes.

Although the sensitivity of the method was reduced by inclusion of 2-, 3-, and 4-year-old bats in one class, the increased probabilities of correctly placing a given lens in the right age class increased the confidence with which unknown-age guano bats could be discussed in population analyses.

CHAPTER V

RESULTS

Age Class Structure of Cave Populations

Results in the following section are based on consolidation of lens weights into three age classifications; young-of-year, 1-year-olds, and bats 2-years and older. Data are presented by cave in order of latitude. Data for the northernmost cave (Merrihew's) is discussed first, the southernmost (Frio) treated last. Population data were presented without regard to sex of the bats. The paucity of male bats in most caves (see sex-ratio data, Tables VIII - X) precluded meaningful analysis of age class data for members of this sex.

Merrihew's cave was visited from April through October in the three years of the study, but was consistently empty of guano bats in April and October. In 1966 and 1967 bats were also absent in September, and were present in July in such low numbers that samples were impossible to obtain. Samples were collected from May through September, 1965, and data concerning population structure are presented in Fig. 3. From May through August, 1-year-old bats were the dominant age group. Young-of-year bats gradually increased in percentage of the total colony until they comprised over 50% of the cave population in September. During this time, 1-year-old bats were decreasing from 75% of the population in May to less than 30% in September. The proportion of bats more than

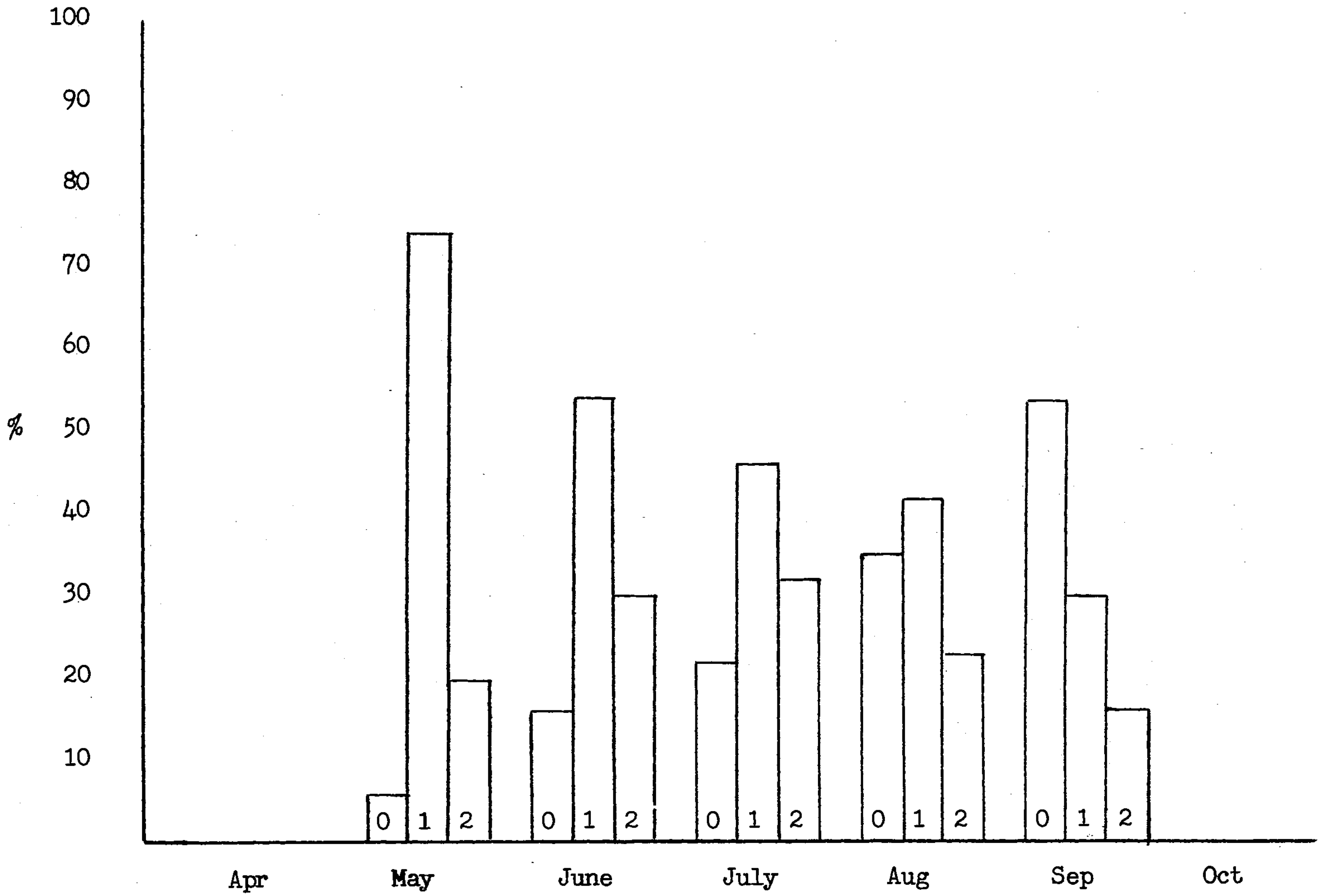

Figure 3. Age Structure of Freetailed Bats in Merrihew Cave–1965. Age Class 0 = Less than One Year Old, 1= One Year, 2= Two Years and Older

1-year old remained between 15% and 30% from May through September.

In 1966, 1-year-old bats comprised about 55% of the total in May and June, and declined to approximately 25% in August, while young bats increased from less than 10% of the total in May and June to over 70% in August (Fig. 4). Bats more than 2-years old declined from approximately 30% of the total in May and June to near 5% in August. The same pattern was apparent in 1967 (Fig. 5), although during June young-of-year comprised less than 5% of the population while the ratio of 1-year olds increased to nearly 70%.

Data for Selman's Cave during 1965 illustrated age composition for May through October (Fig. 6). No sample was collected in April due to a low population level. One-year-olds and older constituted between 85% and 90% of the total cave population from May through July, but the ratio of young-of-year to older bats changed drastically in August when 85% of the freetailed bats were less than 1-year old. Young bats declined in proportion of the population to 60% in September and October.

Age class ratios in 1966 reflected those of 1965 until July, when young nearly equaled one-year-olds in number (Fig. 7). August figures for the two years were similar, but September samples indicated nearly equal populations of young and year-old bats. The cave was nearly empty of guano bats in October.

The significant aspect of the 1967 Selman Cave samples was the predominance of young bats in the July sample (Fig. 8). This predominance was evident in August, as was the case in the previous two years, but the September sample displayed a trend toward more equal numbers of bats from the three age classes. As in 1966, only a small cluster was found in a crevice near the cave entrance in October.

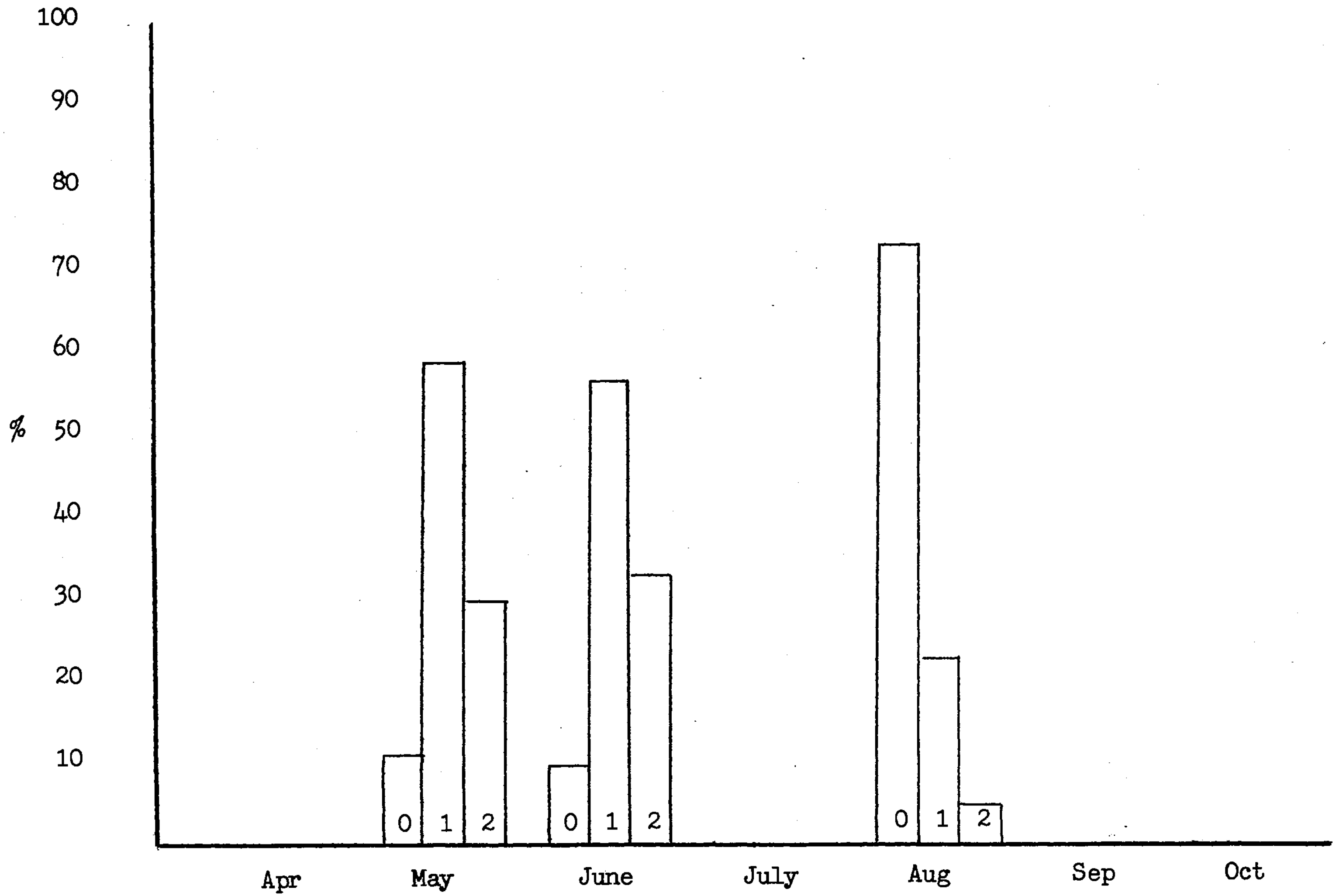

Figure 4. Age Structure of Freetailed Bats in Merrihew Cave - 1966. Age Class 0 = Less than One Year Old, 1 = One Year, 2 = Two Years and Older

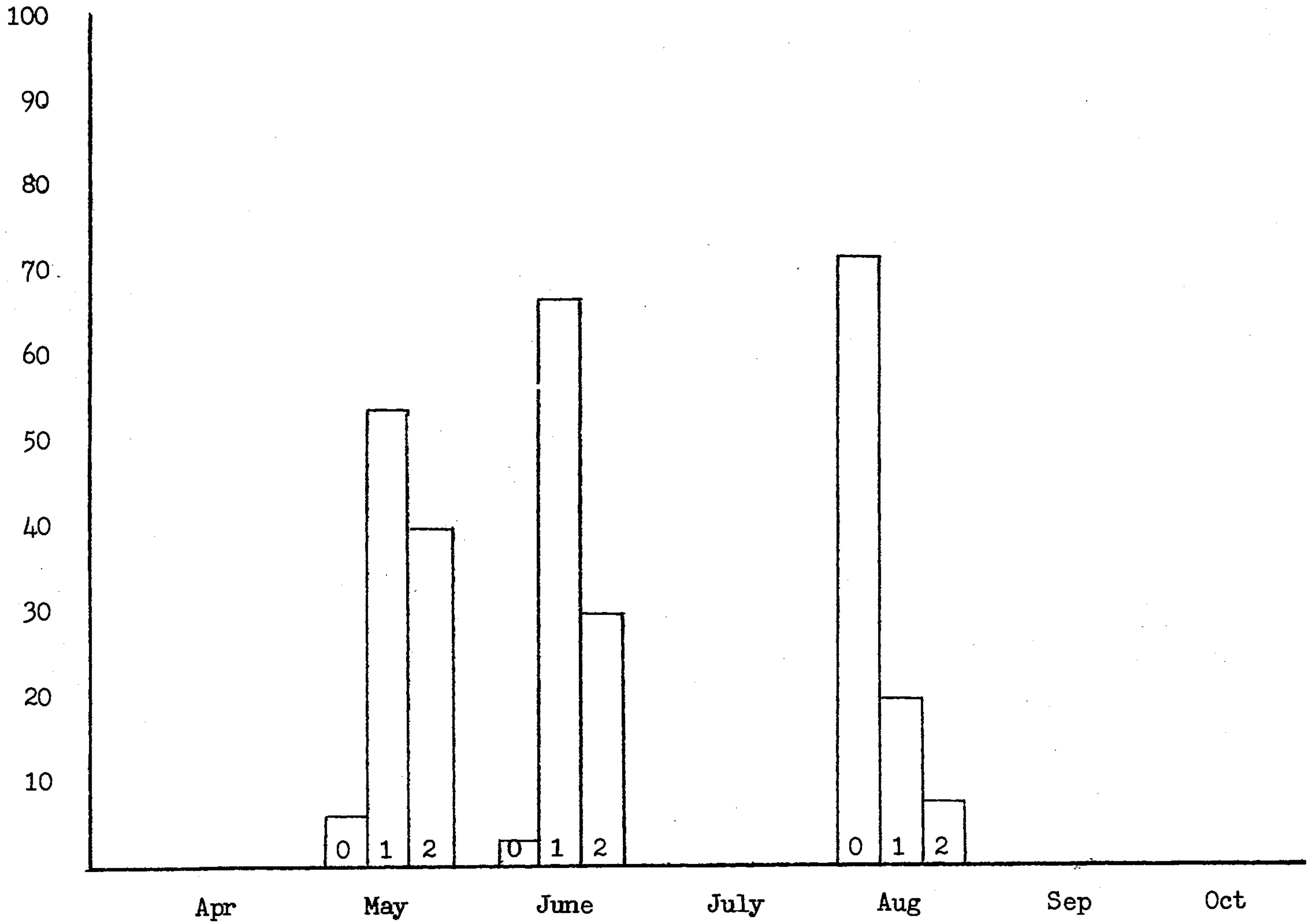

Figure 5. Age Structure of Freetailed Bats in Merrihew Cave - 1967. Age Class 0 = Less than One Year Old, 1 = One Year, 2 = Two Years and Older

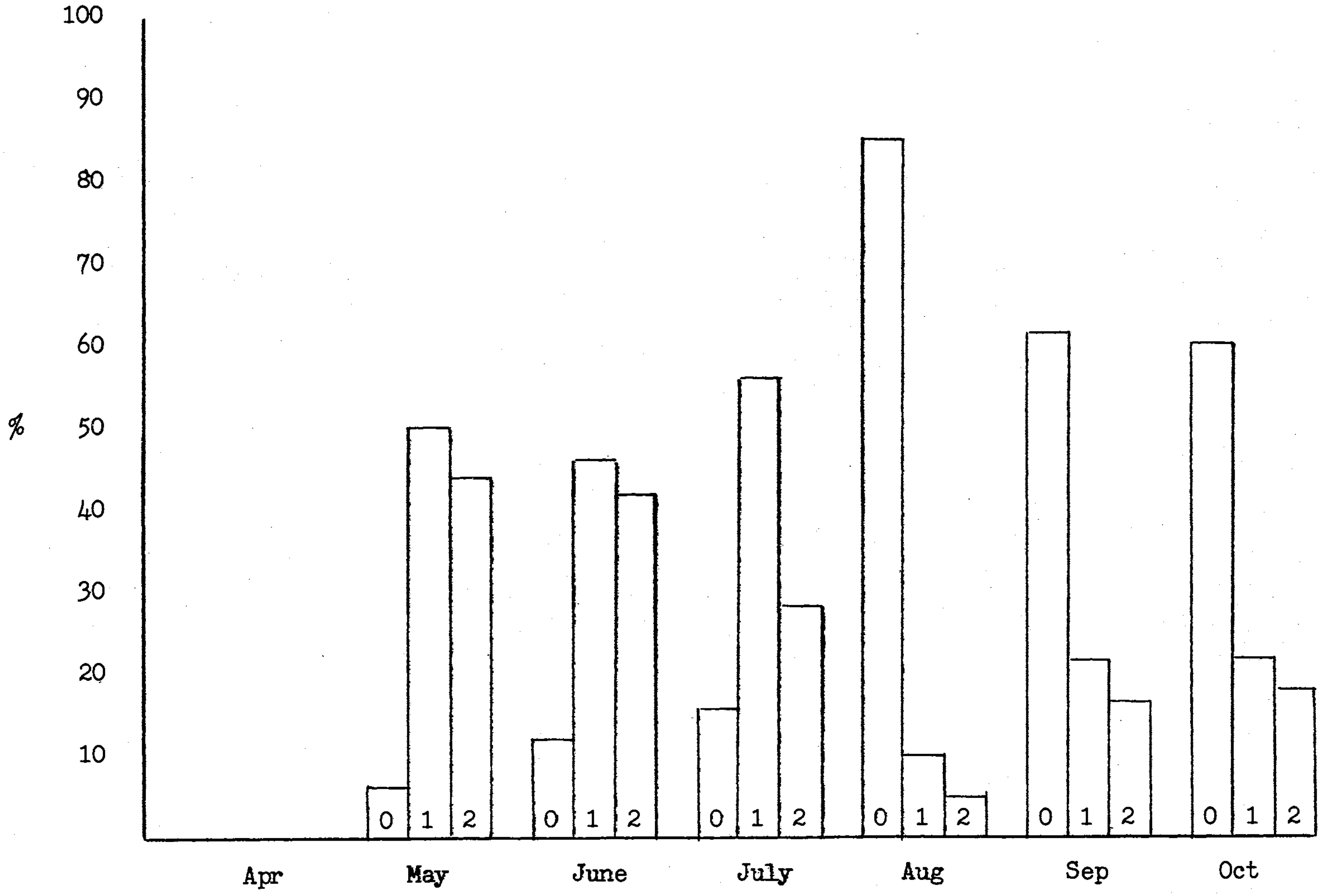

Figure 6. Age Structure of Freetailed Bats in Selman's Cave - 1965. Age Class 0 = Less than One Year Old, 1 = One Year, 2 = Two Years and Older

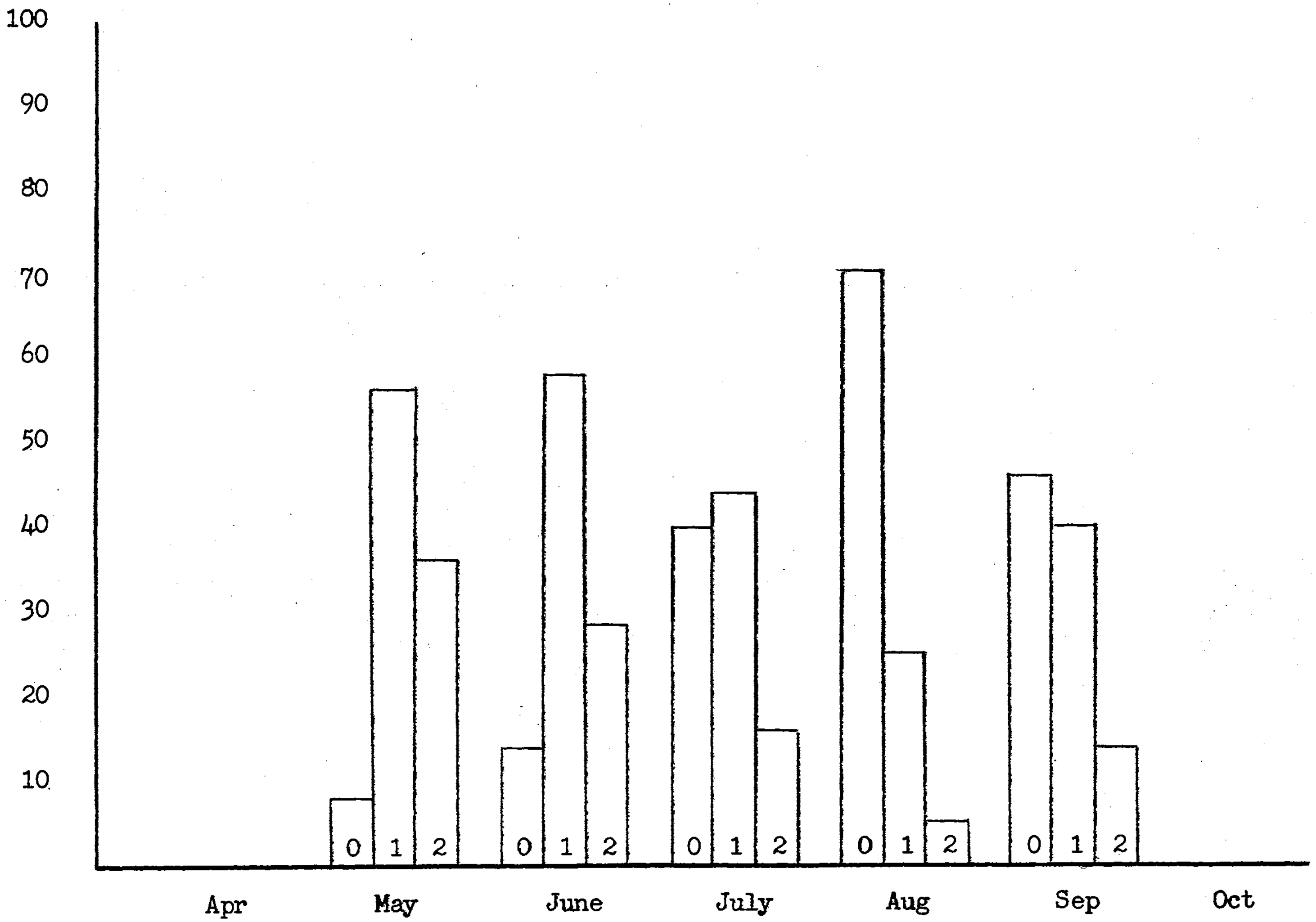

Figure 7. Age Structure of Freetailed Bats in Selman's Cave - 1966. Age Class 0 = Less than One Year Old, 1 = One Year, 2 = Two Years and Older

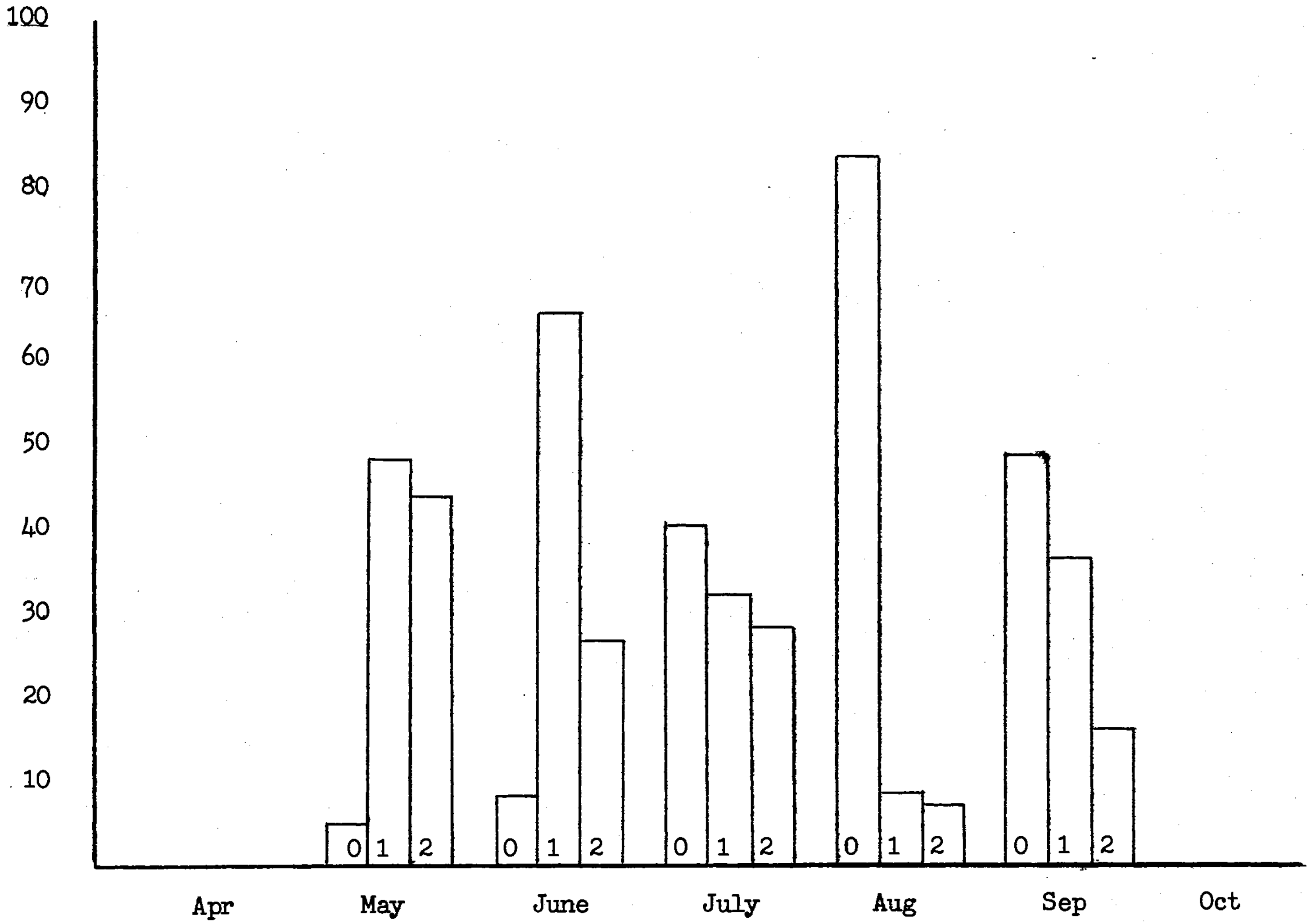

Figure 8. Age Structure of Freetailed Bats in Selman's Cave - 1967. Age Class 0 = Less than One Year Old, 1 = One Year, 2 = Two Years and Older

Data for Vickery Cave in 1965 exhibited a predominance of 1-year-old bats through July, with the ratios of the three age groups remaining fairly constant (Fig. 9). During August, young-of-year bats were most abundant. The pattern of age class ratios remained essentially unchanged through October, during which month young-of-year were about one-half the total number of bats.

The Vickery population in April 1966 was insufficient for sampling. May and June samples resembled patterns for the same months in 1965, with 1-year-old bats being the most numerous (Fig. 10). The young were the largest age group in July, but the August sample was unusual in the absence of bats over 1 year old. This class was again present in the September sample, which contained nearly equal proportions of young and 1-year-olds.

The monthly pattern of age class ratios during 1967 resembled that of 1965 with the exception of July, when young were the most abundant class (Fig. 11). September data indicated that the late summer population consisted of over 80% young and 1-year-old bats.

Connor's Cave differed from other Oklahoma caves in that the May 1965 sample (Fig. 12) contained more 2-year and older bats than 1-year-olds. The ratio was reversed in June, when 1-year-old bats again were most numerous. Young bats exceeded other age groups in August, although the sample indicated that 1-year-olds were nearly as abundant. Nearly two-thirds of the September sample were young bats. This colony in 1966 (Fig. 13) resembled 1965 during April, but bats were absent in May. The cave was filled with bats in June and the colony displayed the usual pattern of a majority of 1-year-olds. Young became most numerous in July flight samples, and predominated in August. The cave was empty of

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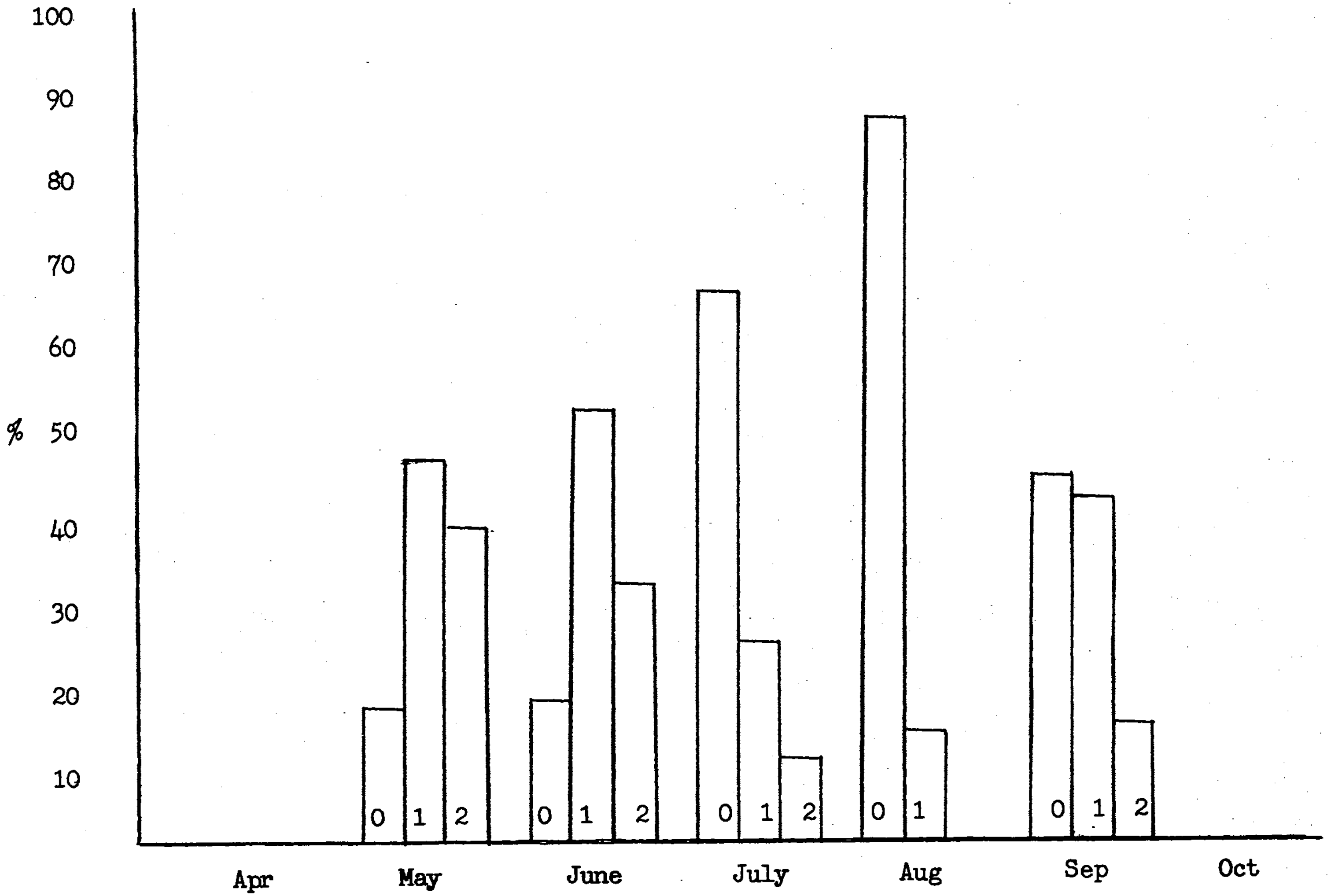

Figure 10. Age Structure of Freetailed Bats in Vickery Cave - 1966. Age Class 0 = Less than One Year Old, 1 = One Year, 2 = Two Years and Older

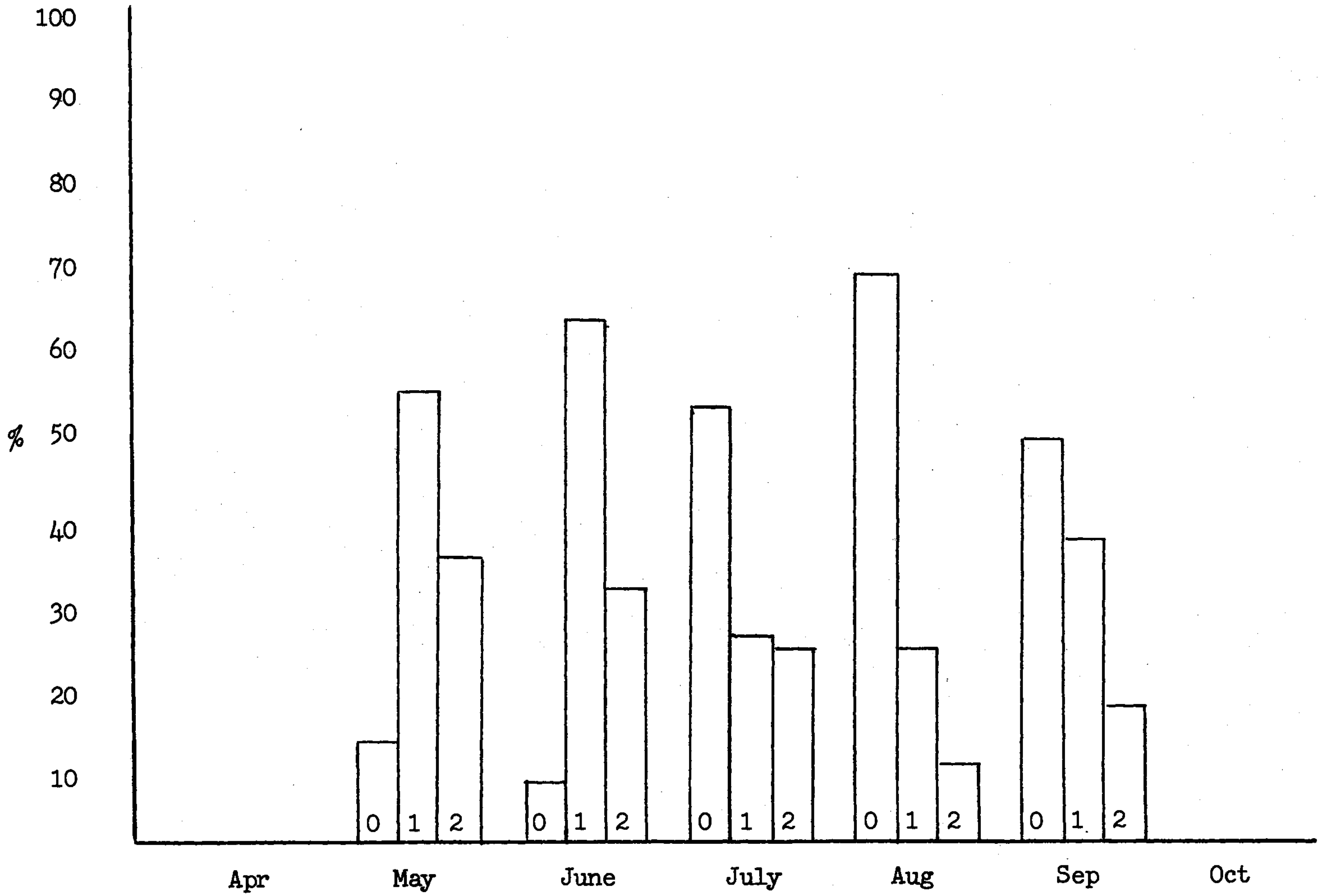

Figure 11. Age Structure of Freetailed Bats in Vickery Cave - 1967. Age Class 0 = Less than One Year Old, 1 = One Year, 2 = Two Years and Older

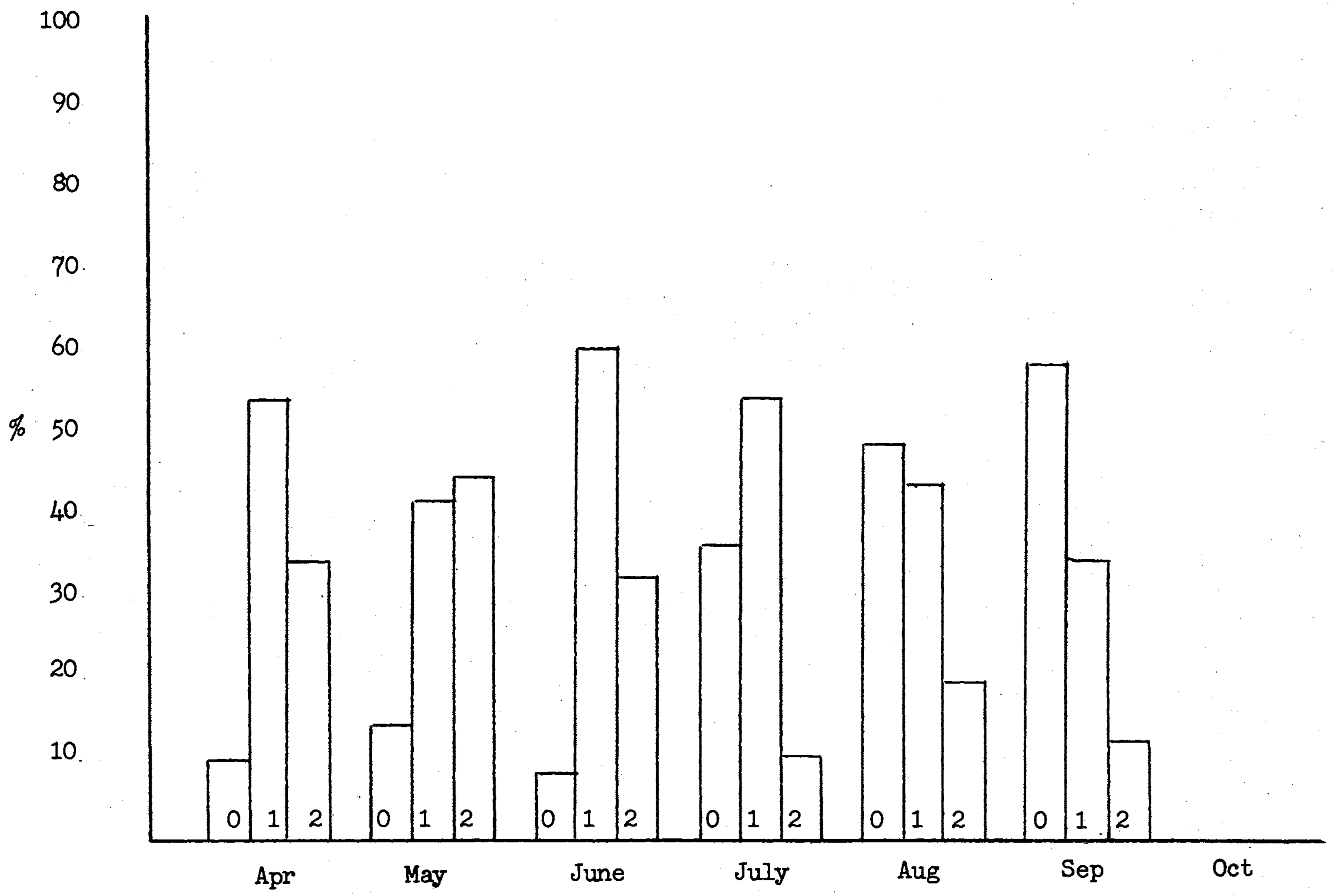

Figure 12. Age Structure of Freetailed Bats in Conner's Cave - 1965. Age Class 0 = Less than One Year, 1 = One Year, 2 = Two Years and Older

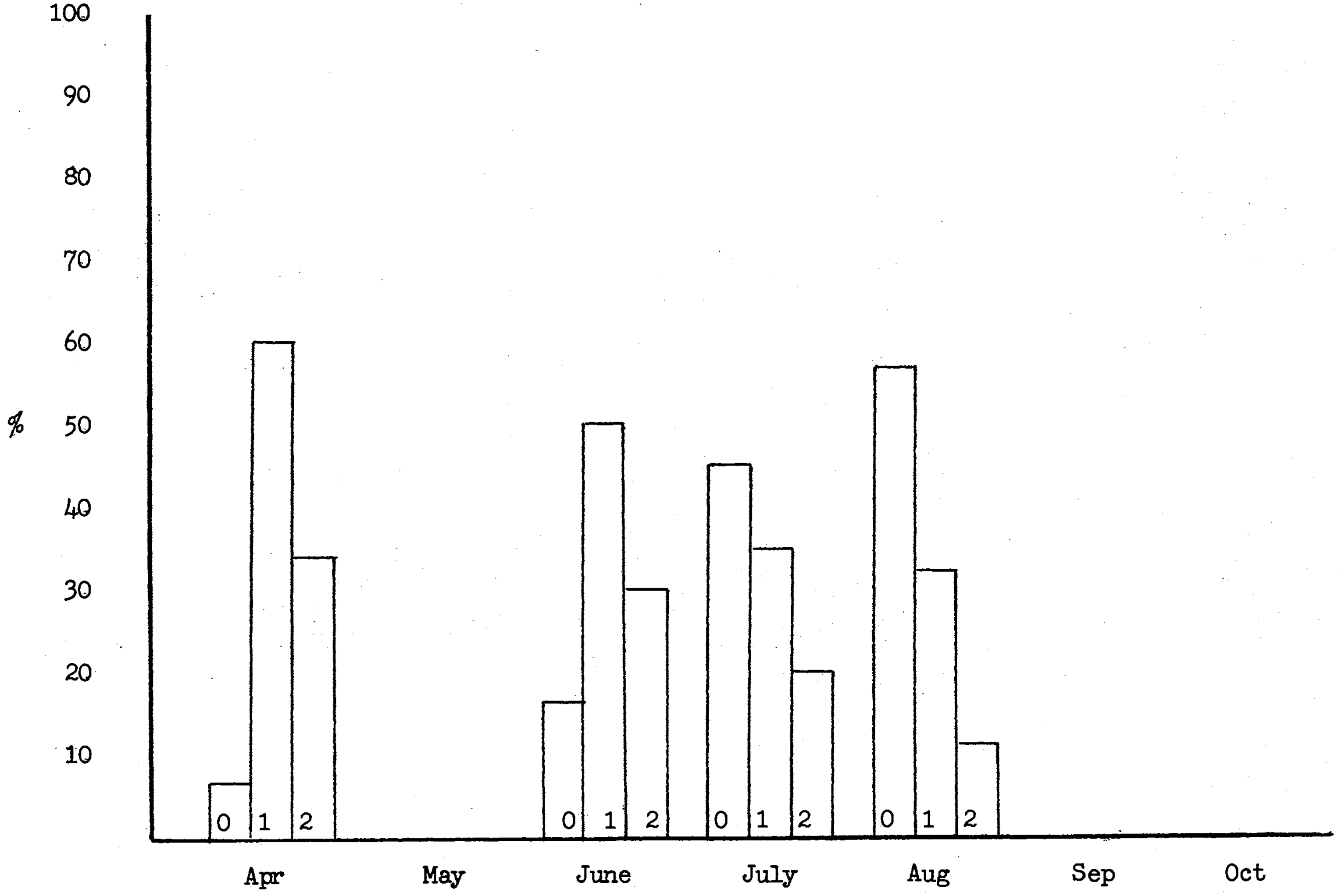

Figure 13. Age Structure of Freetailed Bats in Conner's Cave - 1966. Age Class 0 = Less than One Year Old, 1 = One Year, 2 = Two Years and Older

bats in late September and in October.

Age class data in Connor's Cave in 1967 indicated an age class pattern which resembled that for 1965 (Fig. 14). Samples were collected from May through August, after which the cave was empty. One-year-old bats were most numerous through July, although in that month only 40% of the bats belonged to the 1-year-old class. During August, young-of-year bats made up two-thirds of the cave population.

The Reed Cave population, southernmost of Oklahoma colonies, was sampled during June, July, and August. Age class patterns resembled other Oklahoma caves (Fig. 15). During 1965, 1-year-old bats predominated until August, when young-of-year comprised 60% of the sample.

As was the case in the other Oklahoma caves, young-of-year bats outnumbered 1-year-olds in July of 1966 and 1967. The August 1966 sample was over 90% young bats, a somewhat higher than usual ratio for late summer samples.

Davis Cave was sampled twice each summer, as were the other Texas caves. The first sample was collected in June, before the emergence flights contained young-of-year bats. The second sample was collected during September to study population fluctuations during migration.

Age composition of the Davis Cave colony was relatively constant during June for all three years (Fig. 16). The majority of bats were 1-year olds which were approximately twice as numerous as age class II bats in 1965 and 1966 and three times as abundant in 1967. Instability in population patterns with regard to age composition was apparent in data for September samples. The ratio of young to 1-year-old bats was nearly even in 1965, but 1-year-old bats were most abundant in 1966, while the relative number of young-of-year declined. For both years,

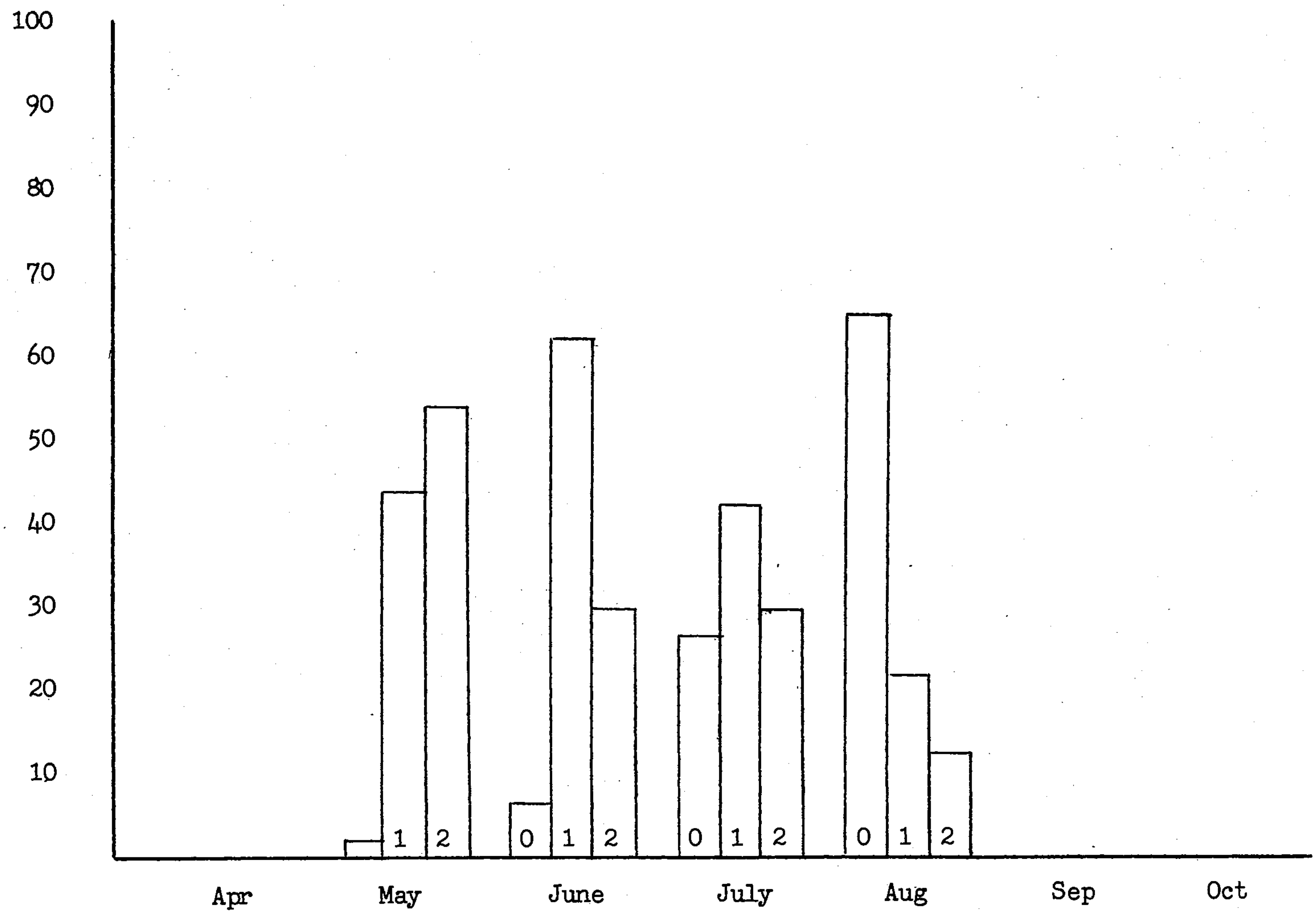

Figure 14. Age Structure of Freetailed Bats in Conner's Cave - 1967. Age Class 0 = Less than One Year Old, 1 = One Year, 2 = Two Years and Older

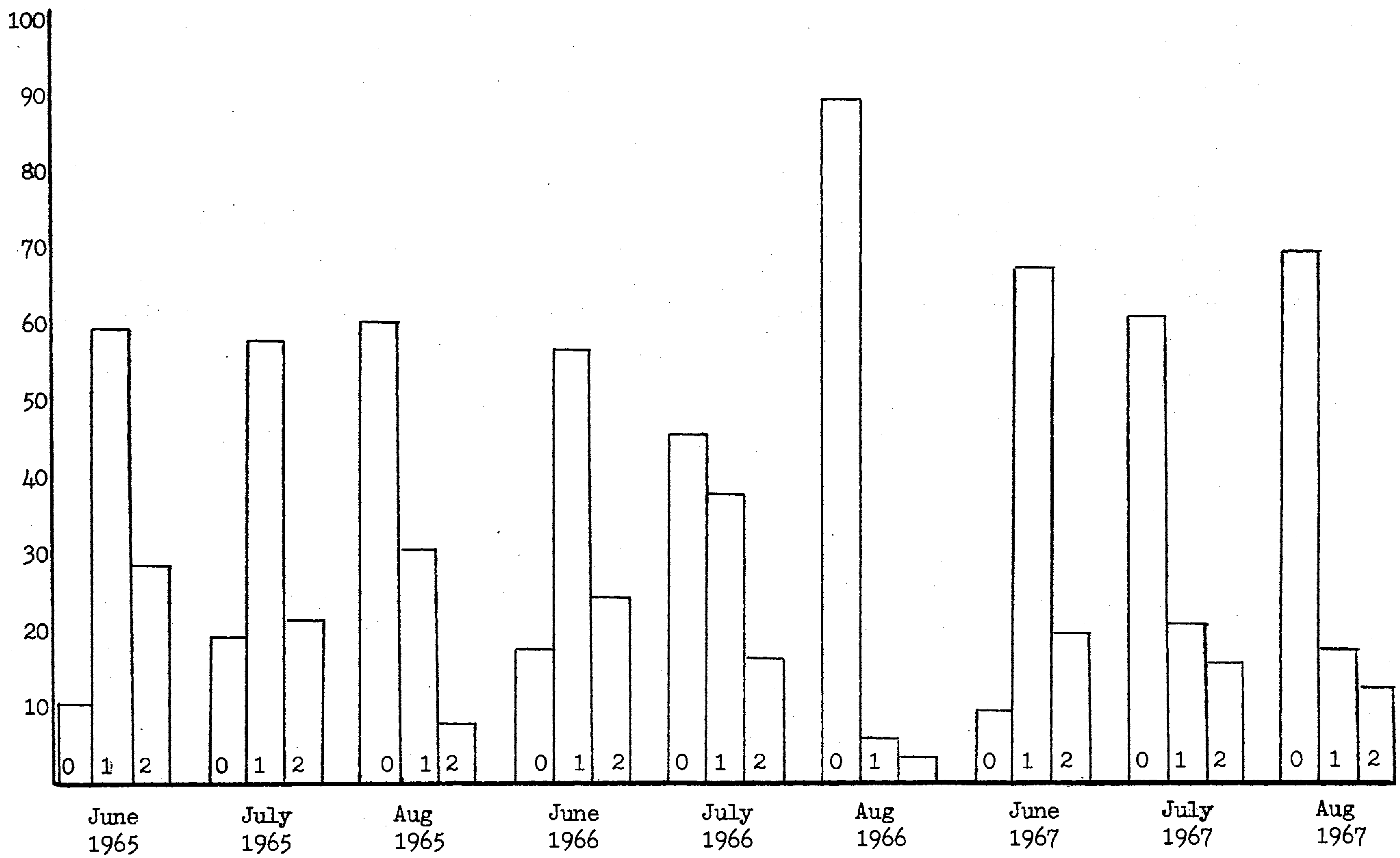

Figure 15. Age Structure of Freetailed Bats in Reed Cave. Age Class 0 = Less than One Year Old, 1 = One Year, 2 = Two Years and Older

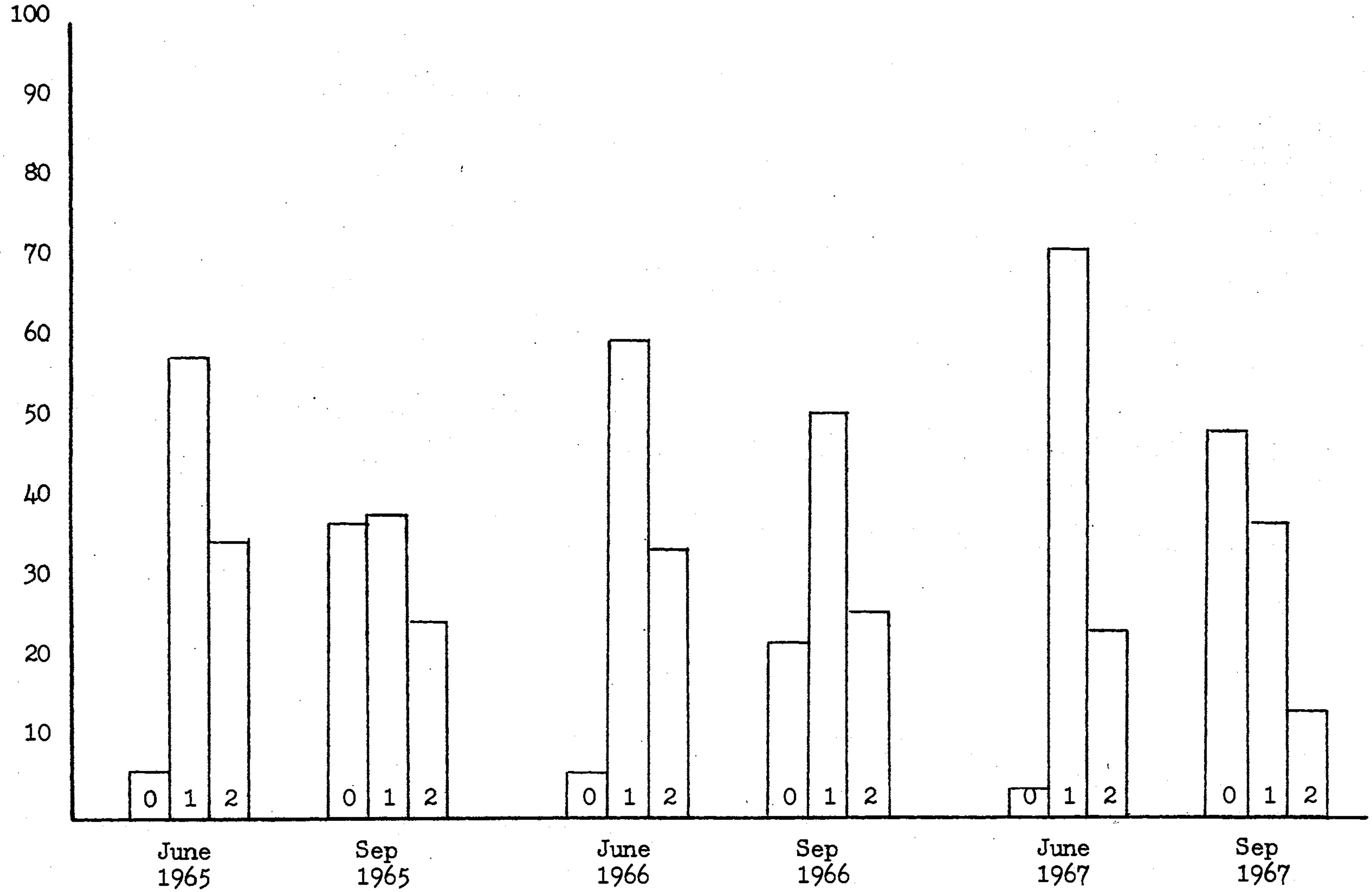

Figure 16. Age Structure of Freetailed Bats in Davis Cave. Age Class 0 = Less than One Year Old, 1 = One Year, 2 = Two Years and Older

class II bats were about 25% of the total. The ratio of young to year-old bats in September 1967 was opposite that of 1966. The change was most marked for young bats, which accounted for nearly 50% of the 1967 September sample. One-year-olds declined in relative numbers to below 40%. Age class II members also declined, to 10% of the colony.

Bracken Cave age class data (Fig. 17) illustrated a fairly stable population ratio of age classes during June of the three years. One-year-old bats were dominant, although the ratio of 1-year-olds to older bats decreased from 1965 to 1967. September samples indicated changes in ratios of young and 1-year-old bats in 1965 and 1966. Young-of-year bats constituted 50% of the 1965 sample, but only 30% for 1966. One-year-olds increased in relative abundance from 30% to nearly 60% from 1965 to 1966. The difference in relative abundance of these two age groups decreased in the September samples for 1967, when the young bats were 30% and 1-year olds were 40% of the colony. Age class II bats never exceeded 25% of the total.

Collections from Frio Cave, the southernmost cave sampled during the study, indicated similarity with the other Texas caves with reference to age class patterns (Fig. 18). June samples for the three years were characterized by dominance of 1-year-old bats, although 1966 samples included 40% of age class II bats. In 1967, the proportion of age class II bats was approximately 25%, while that of 1-year-olds was over 70%. September samples contained a majority of 1-year-old bats every year although percentages of 1-year olds increased yearly while young-of-year declined in relative numbers from 1965 through 1967.

Data in Table VII represent yearly averages of age class ratios for each study cave. This scheme ignores monthly fluctuations in age class

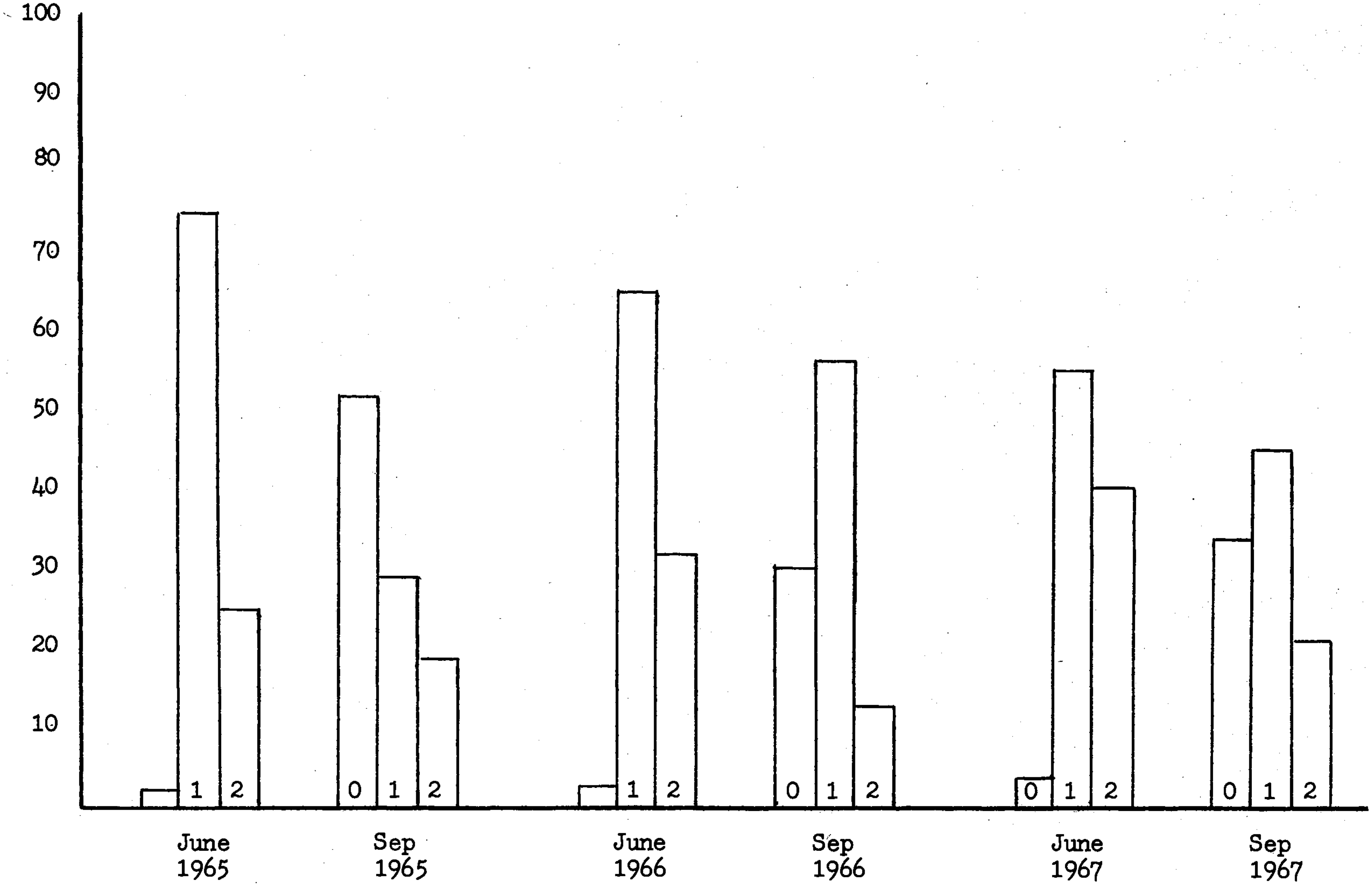

Figure 17. Age Structure of Freetailed Bats in Bracken Cave. Age Class 0 = Less than One Year Old, 1 = One Year, 2 = Two Years and Older

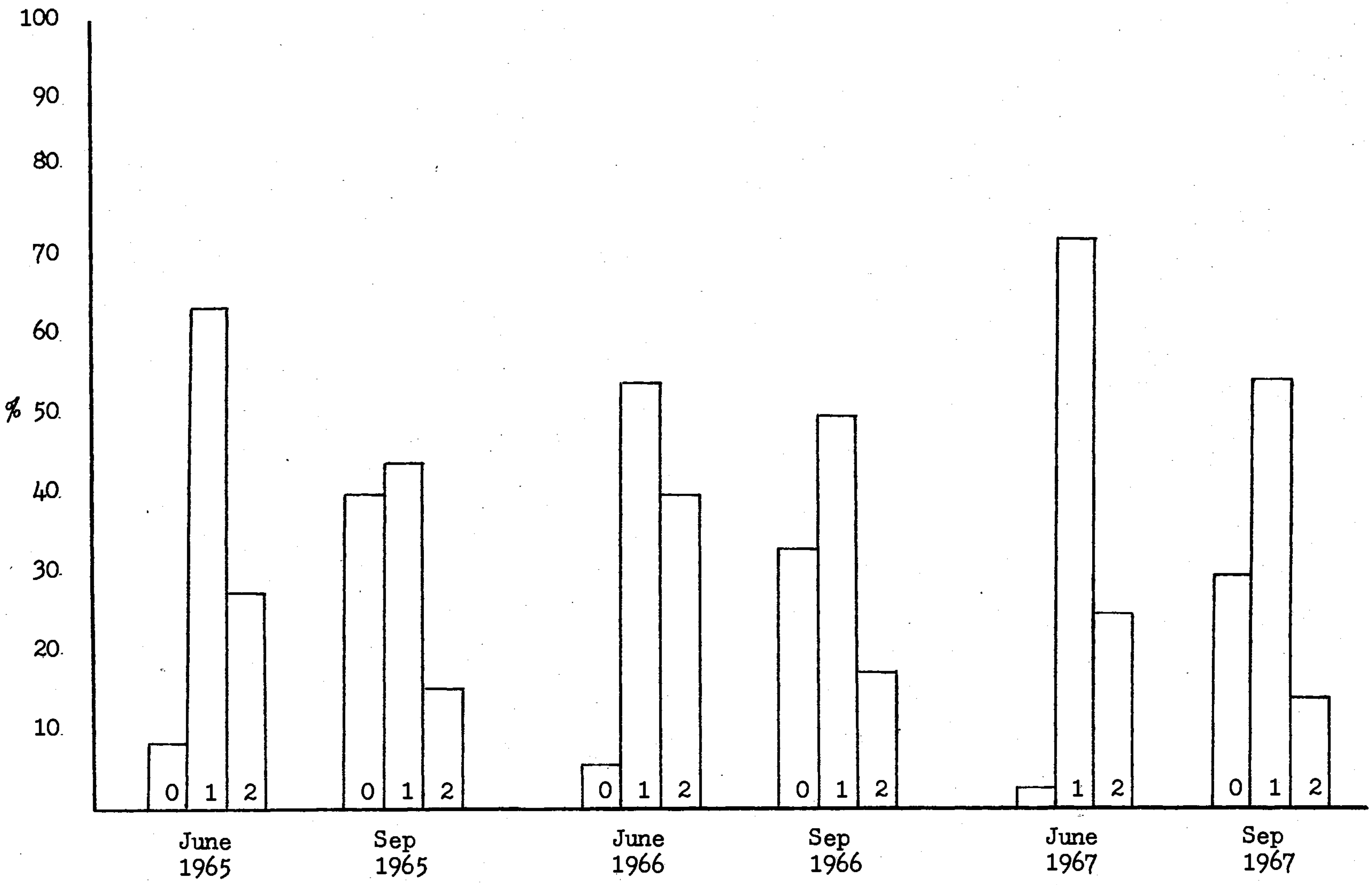

Figure 18. Age Structure of Freetailed Bats in Frio Cave. Age Class 0 = Less than One Year Old, 1 = One Year, 2 = Two Years and Older

TABLE VII

MEAN ANNUAL PERCENT COMPOSITIONS OF AGE CLASSES OF FREETAILED BATS

CAVE	1965			1966			1967			Number	Average		
	0	1	2	0	1	2	0	1	2		0	1	2
Merrihew's	27%	49%	24%	38%	42%	20%	34%	42%	24%	540	32%	45%	23%
Selman's	42	34	24	39	42	19	37	38	25	895	39	38	23
Vickery	35	38	27	51	32	17	38	40	22	1010	41	37	22
Conner's	31	45	24	29	47	24	26	43	31	830	29	45	26
Reed	30	50	20	41	42	17	45	39	16	710	38	44	18
Davis	18	50	32	15	55	30	38	46	16	729	22	51	27
Bracken	34	41	25	19	60	21	22	52	26	640	24	53	23
Frio	22	54	24	11	60	25	16	62	22	770	17	59	24
										6124			
MEAN	30	45	25	30	47	22	32	45	23		30	47	23

ratios but serves to characterize the overall age composition of the cave populations for a given year and to note differences in the populations from year to year. In addition, the overall age class composition for each cave is given in the table's right-hand column.

During the study Merrihew's cave population consisted of 45% one-year-olds, 32% young-of-year, and 23% older bats. The relative abundance of age class II freetailed bats remained fairly constant throughout the study. Greatest variability was apparent among young-of-year bats, which fluctuated in relative abundance from 27% in 1965 to 38% in 1966. The ratio of young to year-old bats was approximately equal in Selman's Cave and less yearly variability was evident for these two age groups. The same was true for the less abundant older bats. Vickery Cave age class ratios were nearly identical to those for Selman's Cave, although yearly fluctuations of age class data were more pronounced. Vickery was the only cave characterized by a larger proportion of young (41%) than one-year-olds (37%). Conner's Cave data indicated a stable ratio of one-year-old bats (45% of the population) but young-of-year ratios were lower and older (class II) ratios higher than for previously described caves of northern Oklahoma. The proportion of young declined from 1965 to 1967, while the class II ratio increased during the same period.

Composite ratios for Reed Cave bats were similar to those for other Oklahoma caves, but yearly ratios were quite variable. Young bats increased in relative abundance from 30% in 1964 to 45% in 1967. The ratio of one-year-olds meanwhile declined from 50% in 1965 to 39% in 1967. Age class II bat ratios were fairly stable although a small decline was evident from 1965 to 1967.

Texas caves were highest in terms of ratios of 1-year-olds, which comprised at least 50% of the overall cave populations. Unlike for Oklahoma caves, young-of-year bat ratios for Texas caves were exceeded by age class II ratios. Davis Cave 1-year-olds uniformly constituted approximately one-half of the population during the study. The low proportion of young was evident in 1965 - 1966 samples, which contained less than 20% age class 0 specimens. For 1967, the same sample ratio of young increased markedly to 38%, which proportion approximated that of Oklahoma cave young-of-year. Older bats declined in 1967 from about 30% to 16% of the colony.

Bracken Cave 1-year-olds also constituted slightly over one-half of the overall population ratio, but varied considerably in yearly figures. Thus, only 41% of the 1965 sample consisted of 1-year-olds, while the 1966 sample was 60% 1-year-old bats. Young bats declined from 34% of the total in 1965 to 19% in 1966. The 1967 ratios approximated those for 1966 for young-of-year and year-old bats. Older bats consistently constituted 20-25% of the samples.

Frio Cave had the widest range of age class proportions of any of the study caves. Composite figures showed a relative abundance of nearly 60% 1-year-olds, while young-of-year bats were only 17% of the total. Age class II bats totaled approximately 25% of the population. The disparity in age class ratios was most evident in 1966 when young comprised only 11% and 1-year-olds 60%. These age class figures were similar to figures for 1965 and 1967, although age class data for the latter two years were somewhat less disproportionate.

Sex Ratios

Previous studies have noted the disproportionate sex ratio for free-tailed bats in large nursery colonies (Davis et al., 1962; Perry, 1965; Cockrum, 1967; Constantine, 1967a). Data in Table VIII summarizes sex ratio statistics collected during monthly samples from the study caves. The ratios are based on bats processed for eye lenses and, when time permitted, additional specimens whose sex was determined prior to their release. The data are expressed in terms of total bats examined and percent female.

The proportion of females in Merrihew's Cave samples was, with three exceptions, relatively low. The exceptions were April, 1965, when the sample was 96% female, July, 1965, (80% female), and May, 1967 (98% female). All other samples had relatively large percentages of males. Large numbers of males could be expected by July or later because of entrance of young bats into the emergence flights. However, pre-July samples contained large percentages of males, and the June, 1967, sample contained a majority of male bats. Presence of a significant number of males in most samples resulted in an overall sex ratio of 64% females.

All other Oklahoma colonies were predominantly female, with the highest composite female ratio of 90% occurring in Conner's Cave. In contrast to Merrihew's Cave data, sex ratios of females exceeded 50% in all samples collected during the study, and several 1965 samples were 100% female. In most samples the female:male ratio approached or exceeded 3 to 1 even after young bats entered late summer flights.

The largest percentage of males (33%) in a pre-July sample occurred in Conner's Cave during April, 1966. This sample, which numbered only

TABLE VIII

SEX RATIOS OF FREETAILED BATS

	1965							1966						1967					
Cave	Apr	May	Jun	Jul	Aug	Sep	Oct	Apr	May	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep	Total
Merrihew	50* 96%	102 **56%	103 54%	50 80%	92 63%	119 68%	-	-	50 66%	56 82%	-	60 47%	-	103 98%	71 47%	-	141 42%	-	997 64%
Selman's	-	96 92%	110 100%	50 90%	109 53%	124 74%	106 79%	-	50 84%	135 96%	90 81%	60 60%	50 82%	50 98%	165 96%	60 85%	119 66%	48 79%	1422 82%
Vickery	124 88%	132 91%	96 94%	50 100%	167 71%	140 70%	107 83%	-	50 92%	136 87%	90 66%	30 47%	50 88%	108 99%	117 86%	159 82%	107 69%	50 88%	1713 82%
Conner's	202 88%	100 92%	101 100%	112 100%	90 89%	103 82%	-	50 66%	-	184 98%	60 72%	60 83%	-	86 99%	156 92%	156 92%	92 85%	-	1552 90%
Reed	-	-	197 96%	50 98%	162 82%	-	-	-	-	241 95%	80 75%	30 77%	-	-	239 96%	263 70%	138 78%	-	1400 87%
Davis	-	-	278 91%	-	-	169 72%	-	-	-	182 99%	-	-	150 69%	-	72 54%	-	-	341 67%	1192 78%
Bracken	-	-	146 99%	-	-	166 69%	-	-	-	219 95%	-	-	150 73%	-	207 94%	-	-	316 61%	1204 80%
Frio	-	-	441 77%	-	-	120 72%	-	-	-	439 46%	-	-	100 74%	-	210 76%	-	-	201 57%	1511 65%
Totals	376 89%	430 83%	1472 87%	312 95%	620 72%	941 71%	213 81%	50 66%	150 81%	1592 81%	320 73%	240 63%	500 75%	346 99%	1237 85%	638 80%	597 68%	956 65%	

* = Number of bats in sample
** = Percent females

50 bats collected from a small colony, was thought to be from a transient group of bats, because no other Oklahoma caves contained freetailed bats in April, and Conner's Cave was empty when next visited in May.

June samples from Reed Cave were nearly exclusively female during the study, but the July, 1965, sample contained 98% females, while samples for the same month in 1966 and 1967 were 25% to 30% males. August samples for all three years contained roughly 25% males.

Sex ratio data for Texas caves (Table VIII) were collected in June, when the colonies consisted of adults, and September, when young-of-year had entered emergence flights. Davis Cave samples during June, 1965 and 1966 were over 90% female, but the sample collected in June, 1967, contained a large number (46%) of males. This was a rain-disrupted sample and probably is not a true reflection of sex ratios. September samples from Davis Cave were uniformly composed of approximately 70% females.

Bracken Cave was characterized by uniformly female-dominant sex ratios in all June samples. The September sex ratios also were fairly stable, ranging from 69% in 1965 to 73% in 1966.

Sex ratios for Frio Cave samples were characterized by relatively large numbers of males. The percentage of females in samples, including those collected in June, never exceeded 77%, and the June, 1966, sample was 54% male. Sex ratios for samples from this, the southernmost study cave, were very similar to those for samples from Merrihew's Cave, which is the northernmost cave visited during the study.

Sex Ratio Changes During Emergence Flights

Data were recorded on changes in sex ratio of bats during evening emergence flights as reflected in ratio changes from initial to final emergence flight subsamples. The data (Tables IX and X) include presence or absence of a "preflight" (i.e., brief, heavy exodus in advance of the regular emergence flight), number of subsamples collected during the flight, and sex ratios of the initial and final samples. Data for 1965 sex ratio changes in Oklahoma emergence flights were incomplete due to a change in sampling schedule (see Materials and Methods) and led to exclusion of these data from Table IX.

Occurrence of preflights was sporadic during the study and usually occurred in July, when Oklahoma cave colonies were at their maximum size prior to fall migration. Sampling schedules precluded observation of July emergence flights from Texas caves (Table X), but preflights were recorded at Bracken Cave during September, 1965 and June, 1967.

Patterns of sex ratio changes during emergence flights were evident in Oklahoma caves. During June flights, when no young were present, the evening emergence flights were predominantly female from beginning to end. July samples, which included flying young, were characterized by an initial sex ratio that was nearly 100% females and a final figure that approached a one-to-one sex ratio. August sex ratio data during emergence flights either remained relatively unchanged or exhibited an increase in the number of females from initial to final sample.

Data for sex ratio changes in emergence flights from Texas caves (Table X) reflected patterns which were apparent in the Oklahoma flights. June samples displayed a steady and relatively changeless sex ratio throughout the flights. Low female sex ratios were apparent in the June, 1967, sample from Davis Cave (the flight from which was disrupted by a rainstorm) and in the June, 1966, sample sex ratios from Frio Cave. During the emergence flight from Frio on that date, the samples contained

TABLE IX

SEX RATIO CHANGES DURING EMERGENCE FLIGHTS FROM OKLAHOMA CAVES

	1966			1967		
	June	July	Aug.	June	July	Aug.
Selman's Cave						
Preflight	No	Yes	No	No	No	No
No. of Samples	2	3	2	2	2	2
First Sample	95% F	100% F	35% F	100% F	96% F	66% F
Last Sample	100% F	50% F	87% F	92% F	63% F	68% F
Vickery Cave						
Preflight	No	No	No	No	Yes	Yes
No. of Samples	2	3	1*	2	2	2
First Sample	99% F	97% F	47% F	97% F	97% F	70% F
Last Sample	74% F	50% F	--	80% F	55% F	70% F
Conner's Cave						
Preflight	No	No	No	No	Yes	No
No. of Samples	3	2	2	2	2	2
First Sample	100% F	98% F	70% F	100% F	100% F	81% F
Last Sample	95% F	50% F	95% F	93% F	78% F	90% F
Reed Cave						
Preflight	No	Yes	No	No	No	No
No. of Samples	4	3	1*	3	3	2
First Sample	100% F	100% F	77% F	100% F	96% F	82% F
Last Sample	89% F	50% F	--	90% F	50% F	67% F

* = Flight disrupted by rain
F = Female

a relatively small number of females, whose sex ratio increased during the duration of the flight. The relative number of females increased during evening flights from initial to final samples. This occurred in September flights from Texas caves as well as in August flights from Oklahoma caves.

TABLE X

SEX RATIO CHANGES DURING EMERGENCE FLIGHTS FROM TEXAS CAVES

	1965		1966		1967	
	June	Sept	June	Sept	June	Sept
Davis Cave						
Preflight	No	No	No	No	No	No
No. of Samples	5	3	3	3	1	3
First Sample	90% F	67% F	98% F	66% F	54% F	71% F
Last Sample	86% F	71% F	100% F	74% F	--	82% F
Bracken Cave						
Preflight	--	Yes	No	No	Yes	No
No. of Samples	1**	3	2	3	2	3
First Sample	--	66% F	100% F	72% F	98% F	61% F
Last Sample	--	77% F	90% F	72% F	90% F	73% F
Frio Cave						
Preflight	No	No	No	No	No	No
No. of Samples	6	3	4	2*	2	2
First Sample	86% F	74% F	60% F	72% F	88% F	48% F
Last Sample	71% F	79% F	71% F	76% F	64% F	64% F

* = Flight disrupted by rain
** = Daytime sample
F = Female

Crowding pressures during peak population periods, when young were old enough to fly, forced adult females from the cave prior to the time when bats usually began the evening flights. Thus, most preflight samples were 100% female. Preflights routinely occurred 45 to 60 min. earlier than flights which occurred near to or after sunset. Exceptions to the trend of all-female preflights occurred during the August, 1967, Vickery sample (30% males in preflight) and the September, 1965, Bracken Cave sample (33% males in preflight). Sex ratios for these preflights were similar to ratios for flights from other Texas caves for the same dates, and did not resemble ratios for Oklahoma cave preflights. The reason for these atypical preflights was not apparent.

Parturition Rates

Perry (1965) hypothesized that peak parturition rates occurred at an earlier date for more southerly caves as compared to dates for northernmost caves. This hypothesis was based on comparison of Oklahoma data accumulated in 1964 and 1965 with data collected in Texas caves during 1957 and 1958 by Davis et al. (1962). The latter researchers, using data on length of the right uterine horns, designated June 8 as the date of peak incidence of birth in 1958 and June 19 for 1957. They noted that 90% of young were born within 15 days of the date of peak parturition. Perry (1965) using percentages of pregnant females collected during mid-June, 1964, placed the period of peak parturition in late June and early July.

June samples collected during the present study were analyzed for percentages of pregnant females (Table XI). The information, although sketchy because of a limited number of sampling dates, indicated that

TABLE XI

PROPORTIONS OF PREGNANT FEMALES IN JUNE SAMPLES FROM OKLAHOMA AND TEXAS CAVES

	1965			1966			1967		
Cave	No. Female	No. Pregnant	Percent Pregnant	No. Female	No. Pregnant	Percent Pregnant	No. Female	No. Pregnant	Percent Pregnant
Merrihew's	56	22 (22 Jun)	39%	46	7 (30 Jun)	15%	34	30 (27 Jun)	88%
Selman's	110	19 (22 Jun)	17%	130	2 (29 Jun)	2%	159	38 (26 Jun)	24%
Vickery	90	27 (21 Jun)	30%	118	14 (28 Jun)	12%	101	22 (25 Jun)	22%
Conner's	101	16 (21 Jun)	16%	180	1 (27 Jun)	0.5%	132	17 (24 Jun)	13%
Reed	242	108 (17 Jun)	44%	230	7 (26 Jun)	3%	229	27 (23 Jun)	12%
Davis	134	112 (13 Jun)	83%	180	26 (21 Jun)	14%	39	36 (8 Jun)	92%
Bracken	144	122 (14 Jun)	85%	209	40 (22 Jun)	19%	194	149 (9 Jun)	77%
Frio	135	121 (16 Jun)	89%	203	62 (23 Jun)	31%	159	146 (10 Jun)	92%

during 1965, Texas cave females had not entered a parturition peak by mid-June when 80-90% of females in the sample were pregnant. Females from the Oklahoma caves apparently reached a peak of parturition activity during the same period, as demonstrated by the fact that samples from Reed Cave, visited one day after the southernmost Texas cave, contained less than 50% pregnant females. Samples from the other Oklahoma caves, collected within five days of the Reed sample, contained less than one-third gravid females, except for Merrihew's Cave, samples from which contained 39% pregnant females.

Sample dates for 1966 were concentrated in late June for all caves, but indicated that parturition activity had peaked in Texas caves and was virtually completed in Oklahoma caves. Texas samples in 1966 were collected on the same dates as were Oklahoma samples in 1965 and proportions of pregnant females were essentially the same in both cases. Data for 1967 substantiated patterns which were apparent during the preceeding years in that Texas samples collected in early June contained high percentages of pregnant females, while late June samples from Oklahoma caves contained less than 25% pregnant females. A late June sample from Merrihew's Cave, in exception to other Oklahoma caves, contained 88% pregnant females. This indicated that Merrihew's Cave, which contained no significant nursery colony during the study, served as a temporary roost for late-bearing females.

Data from Table XI were combined and graphically presented in Fig. 19 to illustrate parturition activity patterns of bats in the study caves. Extension of an imaginary line horizontally from the 50% pregnancy level would indicate that the peak parturition period for Oklahoma and Texas caves was about 18 June. This determination of the peak parturition

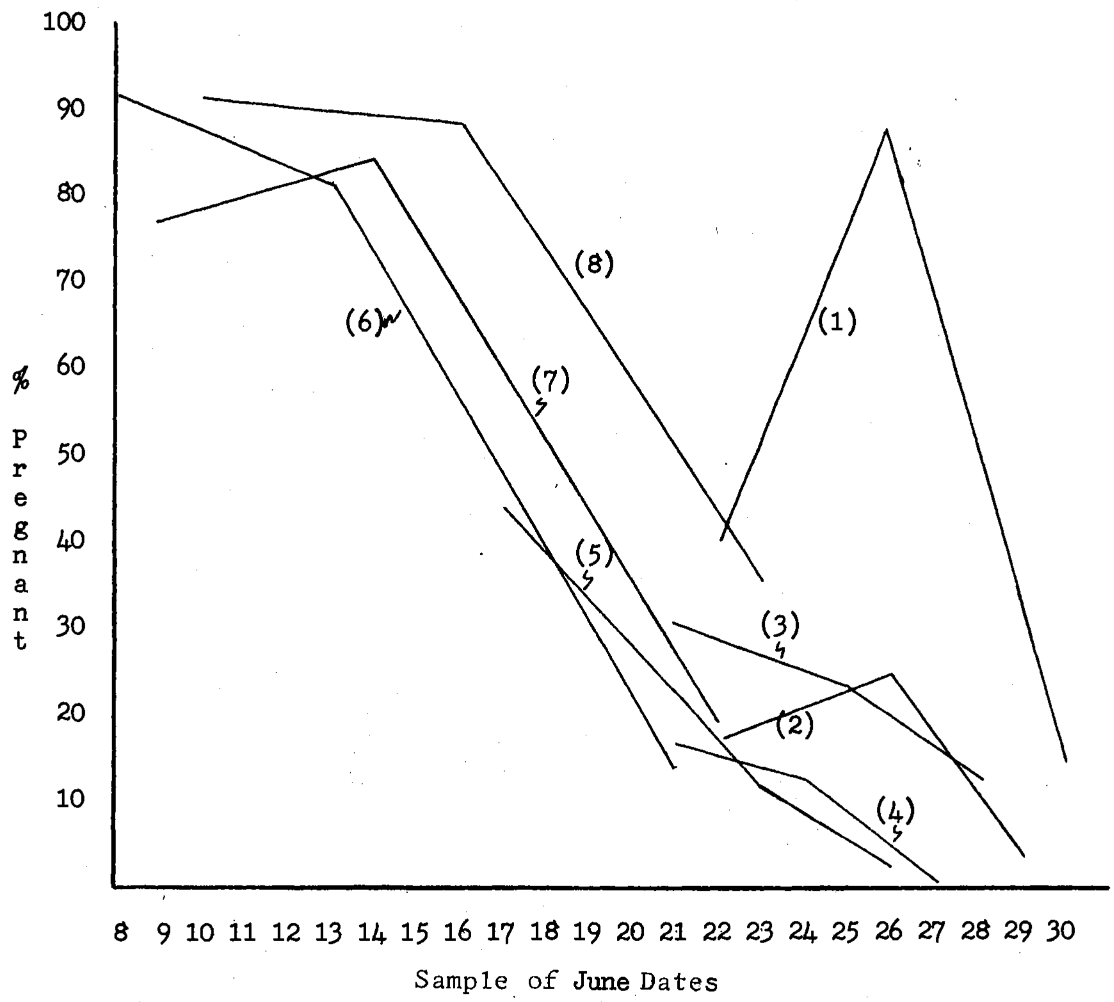

Figure 19. Parturition Rates of Freetailed Bats. (1) = Merrihew's Cave, (2) = Selman's Cave, (3) = Vickery Cave, (4) = Conner's Cave, (5) = Reed Cave, (6) = Davis Cave, (7) = Bracken Cave, and (8) = Frio Cave.

date, although tenuous because of a paucity of data, agrees with that postulated by Davis et al. (1962) for Texas caves in 1957.

summering in Texas. Initial flights into Oklahoma caves in spring contained a small proportion of males, the majority of which are thought not to migrate northward from Mexico each year (Davis et al., 1962). Absence of males from many June samples support their contention that males moved out of most nursery caves upon arrival of large numbers of females.

As parturition approached, the nursery cave colonies became almost exclusively female. A large proportion of these females were 1-year-old, although older females often approached, and sometimes exceeded 1-year-olds in number. With weaning and fledging of young bats in July and August, adult females began fall migration as indicated by changes in both young-adult ratios and sex ratios. The disparity of young and adult ratios lessened in late summer and the ratio of males decreased markedly during September as compared to August, indicating that young began migrating southward in August. Colonies were then composed of young bats and adult females which might have borne their young relatively late and remained in the caves until those late-born young had been weaned.

Because samples in Texas caves were collected only in June and September, analysis of population changes by month was impossible. June data for Oklahoma and Texas cave colonies were predominantly females and 1-year-olds. September samples in 1965 suggested that age and sex ratios for Oklahoma and Texas colonies were similar. Initial comparison of September, 1966, and 1967 data, however, indicated that Texas cave samples contained greater numbers of 1-year-olds and a higher proportion of males than Oklahoma samples. Validity of the comparison is questionable because of the small sample sizes from the two Oklahoma caves which harbored September colonies.

Yearly variations of sex and age ratio data were apparent in regard to individual cave colonies, but overall patterns of population composition remained fairly stable from 1965 through 1967. Averages of age class ratios for bats from the entire population changed little during the course of the study. Young-of-year bats consistently comprised approximately 30% of the population, 1-year-old freetails constituted about 45% of the total and bats 2-years or older averaged less than one-fourth of the freetails in the Oklahoma-Texas study caves. The trends suggested by these data are reflected in sex ratio averages for monthly samples from 1965 to 1967. Minimizing the importance of April samples, which contained few bats, comparisons of monthly sex ratio averages are similar for all three years of the study. The similarity of yearly sex and age ratios indicated that the freetail population as represented in the eight study caves was relatively stable in Oklahoma and Texas from 1965 through 1967.

Characteristics of Cave Colonies

Perry (1965) noted that some Oklahoma caves tended to differ from others in function. He suggested that Reed and Conner's caves served as female-dominant nursery caves, while the larger Vickery and Selman's caves served as nursery caves which were variable in number of young depending upon fluctuations in population size. Vickery and Selman's caves also contained a slightly more mixed population. Perry also stated that Merrihew's Cave served as an overflow cave; male ratios were high in this cave and it was not used as a nursery colony in 1963 or 1964.

Sex and age ratio data collected from 1965 through 1967 agreed with Perry's observations for most caves. Conner's Cave sex ratios were consistently highest in terms of percent females, but its mean percentage of young-of-year was lowest of the Oklahoma caves. The contradiction might indicate that fledged young moved from this small and crowded cave to larger nearby caves such as Vickery. Data in Fig. 6 support this hypothesis; although fledgling bats comprised the majority of bats in August, large numbers of adult bats persisted in the colony during the same period. Vickery Cave data, especially during 1966, indicated larger proportions of fledgling bats were in the colony during August. Selman's, Vickery and Reed caves had similar colonies in terms of sex and age ratios in the samples.

Data supported Perry's (1965) analysis of Merrihew's as an overflow cave. No baby clusters were present in this cave during 1965-67, and approximately one-third of the colony was composed of males. In addition, the cave population tended to be erratic as the cave was nearly empty of bats in July in 1966 and 1967. Another of this cave's roles in the population was apparent from parturition data. Merrihew's Cave contained a high percentage of pregnant females when most Oklahoma females had already borne young. This suggests that Merrihew's Cave served as a roost for late-bearing females which might have been forced out of crowded nursery caves. These late-bearing females presumably returned to the active nurseries to bear their young. Upon fledging, young bats and adults from crowded caves used Merrihew's Cave as a temporary roost prior to fall migration.

Because of the limited sampling schedule, analysis of individual Texas cave colonies is difficult. Davis and Bracken colonies were similar in sex and age ratio statistics, but Frio Cave was notable in that, like Merrihew's Cave, a large portion of the colony was composed of males. The Frio colony apparently was an exception to the typical situation concerning movements. Observations by several authors indicate that migratory patterns of males differ from those of females (Davis et al., 1962; Perry, 1965; Constantine, 1967a; Cockrum, 1969). Males in winter ranges are thought to be essentially non-migratory. Relatively small numbers do, however, migrate northward in springtime, preceeding females into summer ranges. Presence of these early migrators in nursery caves was demonstrable in Oklahoma sex ratio data for April and May after which times the nursery colonies rapidly became nearly exclusively female. Data presented by Davis et al. (1962) and Cockrum (1969) indicate that males leave the nursery colonies for man-made structures or similar suitable small colony sites such as Merrihew's Cave. Frio Cave then was anomalous in that is contained a relatively large contingent of males despite its sizeable nursery colony. This probably did not result from size since Bracken Cave, of comparable size, was a female dominant nursery colony. Physical layout may have caused the anomaly since Frio Cave is a multi-chambered cave which could support a large nursery colony in one region and a non-nursery, male-dominated colony in another region. This situation has been observed in Carlsbad Cavern, which may serve as both summer breeding site for females and summer roost for males (Constantine, 1967a).

Significance of Parturition Data

Davis et al. (1962) suggested that a latitudinal stratification of pregnant females may occur in Texas, New Mexico, and Oklahoma, so that females in one region give birth at a different time than in another region. Thus, early bearers could fill southernmost caves first, causing late bearers to seek caves further north. In this situation colonies in southern latitudes would give birth earlier than those in northern latitudes. Perry (1965) noted that 1964 Oklahoma colonies peaked in birth of young in late June and early July, in contrast to the situation for Texas caves, where 1957 and 1958 parturition peaks occurred in mid-June (Davis et al., 1962). Data for Carlsbad Caverns, New Mexico, during 1957 placed the parturition peak in early July (Constantine, 1967a).

The parturition data accumulated in this study do not support the idea of stratification of females. Examination of samples for proportions of pregnant females in Oklahoma and Texas during mid-June lead to the conclusion that peaks of parturition activity occurred nearly simultaneously in all study caves during a given year.

The explanation for this could lie in migratory habits of free-tailed bats. Although Davis et al. (1962) and Constantine (1967a) stated that all freetails do not necessarily return each year to the caves in which they were born, a tendency for bats to return to a given roost or area each year is indicated by our consistent recovery of large numbers of our bands at the same natal colonies during subsequent years. If, then, migratory movements of pregnant females were based on an instinctive return to an "ancestral roost" rather than on colonization of the first cave with available space, the stratification postulate would be invalid. If winter aggregations of females from several nursery caves were fertilized over a short period of time, return of these females to their respective ancestral caves or regions would be marked by near simultaneous parturition peaks in those caves or regions irrespective of their latitudinal location. Females in Frio and Selman's Caves, for example, would bear young on approximately the same date if they were impregnated on the same date. If breeding periods varied annually, then yearly parturition peak periods would also vary. Comparison of Texas parturition peaks for one year with Oklahome peaks in another year could indicate different periods of parturition activity.

CHAPTER VII

SUMMARY

Eight Oklahoma and Texas cave colonies of the Mexican freetailed bat, *Tadarida brasiliensis mexicana*, were studied from 1965 through 1968 with reference to population composition. Sex ratio tables were constructed, and age ratio tables were developed through age class data based on eye lens weight.

Validity of age class data was felt to be questionable on two points. A significant disparity existed between lens weights of bats of known age that were collected during the present study and data collected during a previous population study of Oklahoma freetails (Perry, 1965). Secondly, slower growth rates of lenses in older bats resulted in overlaps of variances between yearly age groups, complicating assignment of higher-weight lenses to correct age classes. Accuracy of assignment of these lenses was improved by consolidating older age groups into a single class. Three age classes were developed: young-of-year, 1-year-olds, and bats 2-years and older.

Cave colonies were characterized by changes in age composition from spring to fall. Adult (mainly 1-year-old) bats persisted until late July or early August, when fledgling young entered the evening emergence flights. Data from subsequent samples indicated that many adult bats commenced fall migration upon fledging of the young. Late summer samples indicated that most young began migration in late August or

September, leaving residual cave populations of late-bearing adult femlaes and late-born young.

Most caves were predominantly female, although significant numbers of males were evident in many spring samples, and again in late summer samples when fledgling males entered the flight.

Sex and age ratio data suggested that the caves, with the exception of two, served as sites of female-dominated nursery colonies. The two exceptions were Merrihew's and Frio caves, both of which contained comparatively large numbers of males. Merrihew's Cave, which did not contain clusters of young, was evidently an overflow cave that served as a roost site for males and late-bearing females. Frio Cave, which contained extensive clusters of newborn bats, evidently served both as a nursery colony site and a roost for males.

Data concerning percentages of pregnant females during mid-June indicated that the difference in peak parturition dates for Oklahoma and Texas nursery colonies suggested by Perry (1965) was not real. The present study suggests that females return to their "ancestral" cave or cave region after mating rather than entering the first cave with available space that they encounter during northward migration. The result, assuming mass breeding over a short period of time, would be near simultaneous parturition dates in caves throughout the summer range, regardless of latitude.

LITERATURE CITED

Beale, D. M. 1962. Growth of the eye lens in relation to age in fox squirrels. J. Wildl. Manage. 26:208-211.

Birney, E. C., and E. D. Fleharty. 1968. Comparative success in the application of aging techniques to a population of winter-trapped mink. Southwest. Natur. 13:275-282.

Christian, J. J. 1956. The natural history of a summer aggregation of the big brown bat, *Eptesicus fuscus fuscus*. Amer. Midl. Natur. 55:66-95.

Cockrum, E. L. 1969. Migration in the guano bat, *Tadarida brasiliensis*. Univ. Kans. Mus. Natur. Hist., Misc. Publ. 51:303-336.

Collins, W. J. 1905. An address on the crystalline lens in health and in cataract. Brit. Med. J. 2:1440-1445.

Connolly, G. E., M. L. Dudzinski, and W. M. Longhurst. 1969. The eye lens as an indicator of age in the black-tailed jack rabbit. J. Wildl. Manage. 33:159-164.

Constantine, D. G. 1958. An automatic bat-collecting device. J. Wildl. Manage. 22:17-22.

Constantine, D. G. 1967a. Activity patterns of the Mexican freetailed bat. Univ. New Mexico, Publ. Biol. No. 7:79 pp.

Constantine, D. G. 1967b. Rabies transmission by air in bat caves. U. S. Public Health Service Publ. No. 1617, ix + 51 pp.

Davis, R. B., C. F. Herreid II, and H. L. Short. 1962. Mexican free-tailed bats in Texas. Ecol. Monogr. 32:311-346.

Dudzinski, M. L., and R. Mykytowycz. 1961. The eye lens as an indicator of age in the wild rabbit in Australia. C.S.I.R.O. Wildl. Res. 6(2):156-159.

Eads, R. B., J. S. Wiseman, and G. C. Menzies. 1957. Observations concerning the Mexican free-tailed bat, *Tadarida mexicana*, in Texas. Texas J. Sci. 9:227-242.

Friend, Milton. 1967a. A review of research concerning eye-lens weight as a criterion of age in animals. N. Y. Fish and Game J. 14:152-165.

Friend, Milton. 1967b. Some observations regarding eye-lens weight as a criterion of age in animals. N. Y. Fish and Game J. 14:91-121.

Friend, Milton. 1968. The lens technique. Trans. Thirty-third N. Amer. Wildl. Natur. Resources Conf. 33:279-297.

Glass, B. P. 1958. Returns of Mexican freetail bats banded in Oklahoma. J. Mammal. 39:435-437.

Glass, B. P. 1959. Additional returns from free-tailed bats banded in Oklahoma. J. Mammal. 40:542-545.

Glass, B. P., and C. M. Ward. 1959. Bats of the genus Myotis from Oklahoma. J. Mammal. 40:194-201.

Hatai, S. 1913. On the weights of the abdominal and the thoracic viscera, the sex glands, ductless glands, and the eyeballs of the albino rat (Mus norvegicus albinus) according to body weight. Amer. J. Anat. 15:87-119.

Herreid, C. F. II. 1959. Sexual dimorphism in teeth of the free-tailed bat. J. Mammal. 40:538-541.

Jackson, C. M. 1913. Postnatal growth and variability of the body and of the various organs in the albino rat. Amer. J. Anat. 15:1-68.

Kirkpatrick, R. D. 1964. Evaluation of the lens weight as an aging technique for the cotton rat, Sigmodon hispidus Say and Ord. Ph.D. Diss., Okla. State Univ., Stillwater. v + 43 pp.

Kolenosky, G. B., and R. S. Miller. 1962. Growth of the lens of the pronghorn antelope. J. Wildl. Manage. 26:112-113.

Krause, A. C. 1935. Chemistry of the lens. VII. Growth and senescence. Arch. Ophthal. 13:71-77.

Krutzch, P. H. 1955. Observations on the Mexican free-tailed bat, Tadarida mexicana. J. Mammal. 36:236-242.

Laws, R. M. 1967. Eye lens weight and age in African elephants. E. Af. Wildl. J. 4:1-37.

Longhurst, W. M. 1964. Evaluation of the eye lens technique for aging Columbian black-tailed deer. J. Wildl. Manage. 28:773-784.

Lord, R. D., Jr. 1959. The lens as an indicator of age in cottontail rabbits. J. Wildl. Manage. 23:358-360.

Lord, R. D., Jr. 1962. Aging deer and determination of their nutritional status by the lens technique. Proc. First Natur. White-tailed Deer Disease Symposium: 89-93.

Martinet, L. 1966. Determination de l'age ches le campagnol des champs par la pesee du crystallin. Mammalia. 30:425-430.

Mead, R. A. 1967. Age determination in the spotted skunk. J. Mammal. 48:606-616.

Perry, A. E. 1965. Population analysis of the guano bat Tadarida brasiliensis mexicana (Saussure) using the lens-weight method of age determination. Ph.D. Diss., Oklahoma State Univ., Stillwater. vii + 60 pp.

Perry, A. E., and C. F. Herreid II. 1969. Comparison of the tooth-wear and lens weight methods of age determination in the guano bat, Tadarida brasiliensis mexicana. J. Mammal. 50:357-360.

Sanderson, G. C. 1961. The lens as an indicator of age in the raccoon. Amer. Midl. Natur. 65:481-485.

Scammon, R. E., and M. B. Hesdorffer. 1937. Growth in mass and volume of the human lens in postnatal life. Arch. Ophthal. 17:104-112.

Scammon, R. E., and H. A. Wilmer. 1950. Growth of the components the human eyeball. II. Comparison of the calculated volumes of the eyes of the newborn and of adults and their components. Arch. Ophthal. 43:620-637.

Schwarz, S. S. 1964. Biological peculiarities of seasonal generations of rodents, with special reference to the problems of senescence in mammals. Acta Theriologica. 8:11-43.

Smith, P. 1883. Diseases of crystalline lens and capsule. I. On the growth of the crystalline lens. Trans. Ophthal. Soc. United Kingdom. 3:79-99.

Twente, J. W., Jr. 1955. Some aspects of habitat selection and other behavior of cavern-dwelling bats. Ecology. 36:706-732.

Twente, J. W., Jr. 1956. Ecological observations on a colony of Tadarida mexicana. J. Mammal. 37:42-47.

Villa-R., Bernardo. 1956. Tadarida brasiliensis mexicana (Saussure), el murcielago guanero, es una subspecie migratoria. Acta Zoologica Mexicana. 1:1-11.

Villa-R., Bernardo, and E. L. Cockrum. 1962. Migration in the guano bat Tadarida brasiliensis mexicana (Saussure). J. Mammal. 43:43-64.

White, P. J. 1948. The caves of central Texas. National Speleological Soc. Bull. 10:46-64.

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