POPULATION ANALYSIS OF THE GUANO BAT *Tadarida brasiliensis mexicana* (Saussure) USING THE LENS-WEIGHT METHOD OF AGE DETERMINATION

By

ALFRED EUGENE PERRY

Bachelor of Arts
Walla Walla College
College Place, Washington
1953

Master of Arts
Walla Walla College
College Place, Washington
1958

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the Oklahoma State University
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Thesis Approved:

Bryan P. Glass
Thesis Adviser

Carl E. Marshall

F. M. Baumgartner

Roy W. Jones

William A. Drew

J. H. Boggs
Dean of the Graduate School

PREFACE

The objectives of the present study of the lens-weight method in population analysis of the guano bat, Tadarida brasiliensis mexicana (Saussure), were to: (1) devise equipment and techniques to determine the applicability of the lens-weight method of age determination to bats; (2) analyze nursery populations by this technique and construct life tables; (3) compare population composition in selected caves between two successive years.

Dr. Bryan P. Glass, major advisor, and Drs. F. M. Baumgartner, William Drew, Roy W. Jones, and Carl Marshall served on the advisory committee and criticized the manuscript. Gordon Beckett and George Rogers helped band the young bats and make field collections. The assistance of all these people is appreciated.

The state of Oklahoma Planning and Resources Board kindly donated living quarters during the first summer's study in the field. Mr. James Selman, Mr. Fred Dewey Merrihew, Jr., Mr. Dewey Fred Merrihew, Mr. S. J. Conner, Mr. L. R. Conner, Mr. and Mrs. Lincoln, Mr. Loyal Bell, Mr. Terrell, and Mr. G. W. Whitlaw permitted access to the caves on their properties.

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TABLE OF CONTENTS

LIST OF TABLES

Table | Page

LIST OF FIGURES

Figure | Page

CHAPTER I

INTRODUCTION

The Mexican free-tailed, or Mexican guano bat[1] Tadarida brasiliensis mexicana (Saussure), is the most abundant bat in the Southwest. The species migrates into the southwestern United States each spring and back into Mexico each fall (Glass, 1958; Glass, 1959; Villa, 1956). Bats of this species are found in caves in western Oklahoma from late March until the latter part of October. The population in the state of Oklahoma has been under observation for several years by Dr. Bryan P. Glass of Oklahoma State University. He banded 50,000 bats from 1954 to 1959.

The population dynamics of this species has been under study for some years by ecologists who have been trying various methods of analysis. Three methods have been used to determine the relative age of bats. One method involves sectioning teeth and counting growth rings. This method is based on the assumption that either hibernation or migration will upset the normal metabolism sufficently to result in a recognizable ring in the dentine. Christian (1953) used this method in the study of Eptesicus fuscus and found it to correlate with the age based on tooth wear. The method is laborious and probably cannot be

[1] Both common names are in use for this species. Mexican free-tailed bat is the older, but for sake of brevity the name guano bat will be used following Villa (1956).

used with accuracy on older bats. A second method correlates age with tooth wear. This procedure is limited by the number of age groups that can be distinguished. Three age groups have been used in analyses by Davis, et al. (1962). Christian (1953) and Twente (1956) used five classes. Each of these wear classes would undoubtedly contain bats of various ages since tooth wear is relatively slow. A third method involves banding and recovery. This technique has been used by a number of workers on various species of bats. The method has been ineffective because it has been impossible to band enough bats of certain ages in the population. Also, since diffusion of banded bats in Tadarida populations is great, recapture is difficult.

The lens-weight method of determining age has been developed in recent years on a number of animals. It has been known for some time that the crystalline lens in humans increases in weight even after sexual maturity has been reached (Smith, 1883; Burdon-Cooper, 1914). Correlation between age and lens weight was observed in Rattus norvegicus by Hatai in 1923 (Donaldson, 1924). Krause (1934) found a positive correlation of age and lens weight in laboratory rabbits, Oryctolagus cuniculus. He showed that the average weights of the lenses of the male and female of the same age were approximately equal.

Lord (1959) discussed the use of the crystalline lens as an indicator of age in the cottontail rabbit, Sylvilagus floridanus. He established a weight-age curve that was valid up to 30 months age. This was the greatest age attained by his experimental animals.

Since 1959, this technique has been applied to a number of different mammals with varying degrees of success. Lord (1961) used the method on the gray fox, Urocyon cinereoargenteus. Sanderson (1961) found the method useful in age determination of young raccoons, *Procyon lotor*; however, lens-weight increase was low in adults and individual variation too great to permit valid aging. Dudzinski and Mykytowycz (1961) found the method useful in aging Australian wild rabbits, *Oryctolagus cuniculus* up to about 150 days after birth. The method was found to be valid in separating young-of-the-year from adults in the fox squirrel, *Sciurus niger*, and possibly useful in separating yearly age classes up to 2½ years (Beale, 1962).

Kolenosky and Miller (1962) developed a growth curve for the lens in the pronghorn antelope, *Antilocapra americana*. The individuals were first aged by the examination of teeth. Martinson, et al (1961) worked with the lens weights of swamp rabbits, *Sylvilagus aquaticus*, in Missouri. They were successful in distinguishing adult from first-year individuals and felt this data agreed with results from the epiphyseal closure aging technique. Edwards (1962) used Lord's findings (1959) in population analysis of cottontail rabbits, *Sylvilagus floridanus*, in Ohio. Wight and Conaway (1962) also used this method to study cottontail rabbit populations in Missouri.

Lord (1962) indicated that care should be taken in lens-weight analysis because a difference exists between growth rate of the lens in wild populations and those raised in captivity in both cottontail rabbit, *Sylvilagus floridanus*, and in the white-tailed deer, *Odocoileus virginianus*. He stated this to be due to the difference in nutritional status of the two groups. Lord has used the the lens-weight method in age determination in the deer mouse, *Peromyscus maniculatus*, and the Norway rat, *Rattus norvegicus*.

Bauer, et al. (1964) used the lens-weight method on the fur seal, Callorhinus ursinus, and found that "except in the 1- and 2-year olds, variation in lens weight within an age-class is greater than yearly growth". They indicated that the lens-weight method could have little application as a criterion of age above the age of two years.

Tiemeier and Plenert (1964) used the lens-weight method on the black-tailed jackrabbit, Lepus californicus, and found it to be superior to age-determination techniques based on body size, total weight, and epiphyseal closure.

The technique has been applied to the Columbian black-tailed deer, Ococoileus hemionus columbianus, by Longhurst (1964). He found the method satisfactory for aging deer at least through five years.

This method has also been applied to the red fox, Vulpes fulva, by Friend and Linhart (1964). They found it valuable in separating juveniles from adults, but not as valid in separating adults.

Kirkpatrick (1964) has found the method satisfactory as an aging tool in the cotton rat, Sigmodon hispidus, up to the age of approximately 180 days.

Montgomery (1963) indicated that freezing of the lens and decomposition affected the lens weight. He indicated that immediate fixation of the lens was advantageous.

The lens-weight method seems to be of little value in age determination of birds. Payne (1961) found it to be valid only up to the age of two months in the house sparrow, Passer domesticus. Payne stated that Lord found the method unsatisfactory in the ring-necked pheasant, Phasianus colchicus, Campbell in the scaled quail, Callipepla squamata, and Bear in the red-winged blackbird, Agelaius phoeniceus. Roseberry and Verts (1963) found that due to the overlap in ranges of lens weights between age groups, the lens-weight method was unsatisfactory in aging bobwhites, Colinus virginianus.

Campbell and Tomlinson (1962) working with Turkish chukars, Alectoris graeca, and Dahlgren, et al. (1964) working with the sharp-tailed grouse, Pedioecetes phasianellus, found the method unsatisfactory in determining year classes amoung adults. The regression line on bird species has a flat slope indicating little growth after the adult stage was reached. Individual variation made age grouping impossible in the species studied.

The lens-weight technique in aging bats has provided a less laborious and possibly more accurate method of determining age than previously-used methods. Also, a reliable growth curve has been established by the use of statistical methods and large samples of guano bats from any population may be aged with reasonable accuracy. Since the technique has been perfected, each bat in the colony has become a potential source of data and not only the banded individuals. In the guano bat, samples of almost any magnitude may be taken without affecting the population composition in any way. Therefore, this technique has provided solutions to problems of population analysis in Tadarida brasiliensis mexicana.

CHAPTER II

DESCRIPTION OF CAVES

Five caves in western Oklahoma serve as nursery caves for the species (Fig. 1). These are Reed Cave in Greer Co., Vickery Cave and Conner's Cave in Major Co., Selman's Cave in Woodward Co., and Merrihew Cave in Woods Co. Glass and Ward (1959) gave the legal description of the cave locations. Twente (1955) mapped and described Merrihew Cave. The other caves, to the writers knowledge, have not been mapped.

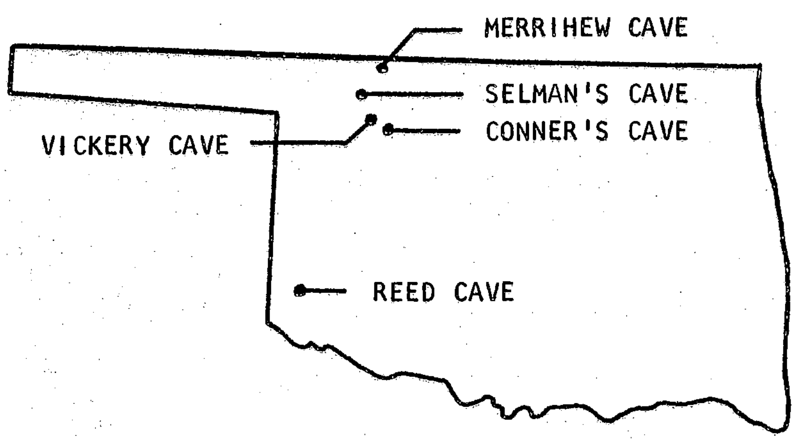

Fig. 1. Locations of Oklahoma Guano Bat Caves

All of the above caves are more or less of the cavern type with more than one external opening, however, some of these openings are small and impassable for a human. They are located in areas where an over-crust of gypsum exists, varying in thickness from 20 to over 100 feet. The caves have been formed by the washing out of the softer material from under the gypsum overcap. The water action has left a somewhat "V" shaped floor. In many places breakdown of gypsum blocks onto the cave floor has occurred.

Each cave is located at the head of a small ravine with a water course carrying water from the cave to a small stream nearby. Periodic, heavy rains cause large quantities of water to flow through the water courses in the caves. This washes out much of the accumulated guano and prevents large accumulations from occurring especially in the "V" shaped bottoms of the caves.

Conner's Cave is the smallest of the five with an opening approximately 30 feet wide and a height of 15 feet. The cave opening faces east-southeast and the cavern extends northwesterly from the opening for approximately 200 feet. The opening of Selman's Cave faces east-southeast and is approximately 40 feet wide and 20 feet in height. This cave extends about 350 feet in a northwesterly direction from the opening. Vickery Cave has an opening about 50 feet wide and 20 feet in height. The cave opening faces in a south-southwesterly direction and at a distance some 100 feet north-northeast of the entrance the cave bifurcates. One passage extends about 100 feet northwesterly and the other passage some 300 feet east-southeasterly. Reed Cave is the largest of the caves studied. The opening faces south and is approximately 40 feet wide and 15 feet high. The cave extends in a northerly direction about 400 or 500 feet. Ceiling heights exceed 40 feet in some areas.

Fairly large rooms with domed ceilings similar to those reported by Davis, et al. (1962) in Texas, are found in each of the caves except Conner's.

CHAPTER III

PROCEDURES

Field

Banding

It was necessary to band neonatal young as near after birth as possible in order to obtain samples of bats of known age. Originally, it was planned to band only young with the umbilical cord still attached. It was necessary to work during the daytime in the cave since most of the young seem to be born in the morning hours and the umbilical cord appears to drop off before night. Working during the day disturbed the adult bats and subsequently caused a rapid decline in the population numbers. This prevented further daytime work and another criterion had to be chosen to determine proximity to natality.

It was found that the umbilical scab persisted for three or four days. Banding was then restricted to those young with an umbilical scab present and night time work was then possible. This would allow for less disturbance of the adult bats.

During the summer of 1962, 5,400 young were banded in Selman's Cave using this criterion of age of neonatal young. Banding was more convenient in the cave entrance so the young were collected from the nursery areas and removed to this location. The young were sexed and placed in separate containers. The bats were banded with a number two United States Fish and Wildlife Service band on one forearm and with an anodized, unnumbered band of the same size on the other forearm.

The bands were anodized red, black, green, blue, and gold by Mac's Plating Works, 2138 South West Boulevard, Tulsa, Oklahoma. A color code was used for each night of banding. For example, a blue band on the left forearm and a numbered, uncolored band on the right forearm represents a particular date. This color coding made it possible to recognize the age of each individual. After banding the young were returned to the nursery areas.

An additional 4,600 young-of-the-year were banded using only the Fish and Wildlife Service bands.

Sampling Known Age Bats

After the initial banding, a collection of 20 individuals at birth, 7 days, 14 days, 21 days, etc., up to 18 weeks was made using the color coded bands, except that in later samples 20 individuals could not always be obtained. After collecting the known age individuals, the bats were sacrificed and the eyes removed with forceps. The eyes and appropriate data tags were placed in vials containing 10% formalin.

A search was made for individuals banded by Dr. Glass during the 1954 to 1959 period. These would provide data for plotting the upper end of the growth curve of lens weights. Small numbers of these banded older bats were found and processed.

During the summer of 1963, a total of 19,800 neonatal bats were banded. Of these, 10,200 were banded at Selman's Cave and 9,600 were banded at Conner's Cave. Only 2,000 of the total banded were males. Greater numbers of females were banded since it is mainly the females in the population which return to the nursery caves during ensuing years. This would permit a better chance of collection in subsequent years.

During the summer of 1964, 12,700 young were banded in Conner's Cave and 7,300 in Selman's Cave. A total of 6,000 of the 20,000 were males.

In 1963, a collection of one year old bats was made for use in establishing the lens-growth curve. The eyes were processed in the same manner indicated above.

Collections of bats one year of age and two years of age were made in 1964. The sample of bats one year of age was used to compare with results obtained in the 1963 sample of bats one year of age. This would give an indication of the amount of sampling error in this technique. During the three years study small samples of three, four, and five year old bats were obtained; however, the sample size was extremely small for the older bats.

<u>Random Sampling of Population</u>

Starting in June of 1963, random samples of the population in each cave were taken using a modified Constantine bat trap (Constantine, 1958). Fig. 2 shows the trap set up for use at Reed Cave. Sub-samples were obtained at 30 minute intervals during the evening emergence flight from the cave. The number of sub-samples was determined by the length of the emergence flight and varied from one to as many as six in the

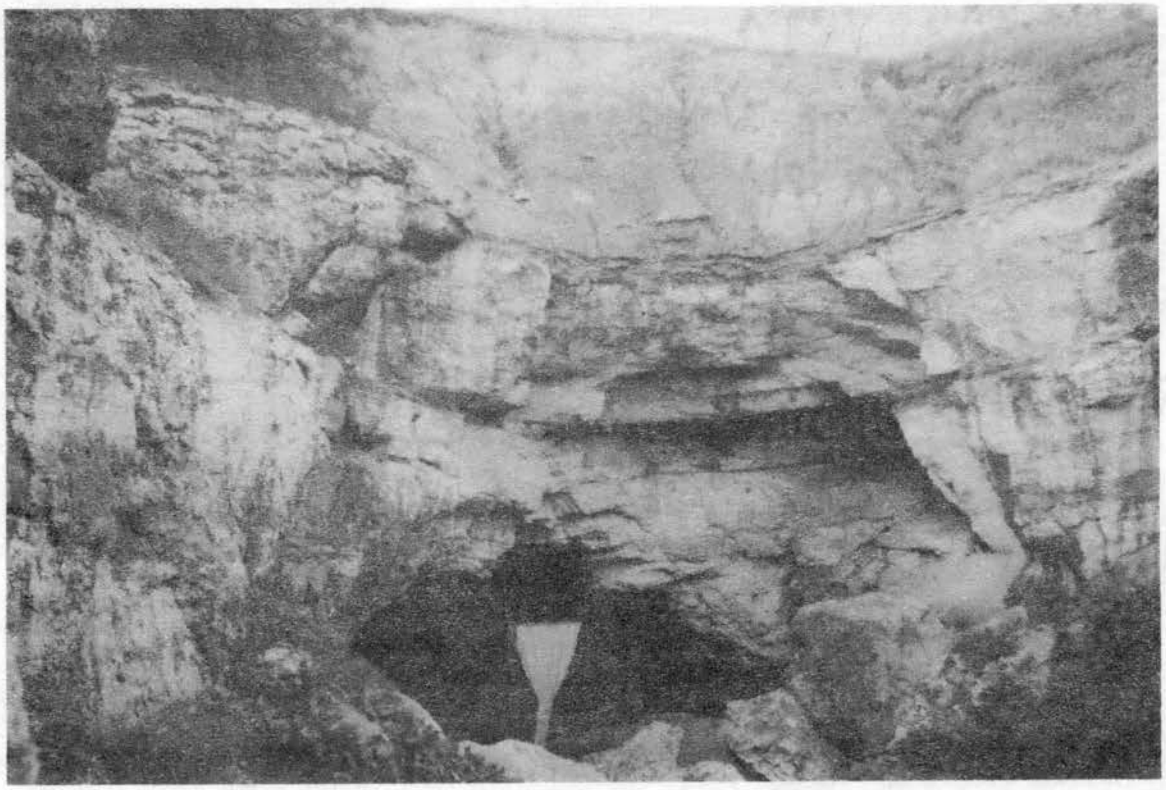

Fig. 2. Bat Trap in Mouth of Reed Cave.

various caves. Each sub-sample contained approximately 50 bats. Sex ratios were obtained in each sub-sample. One eye was removed from each bat and processed for later work in population analysis. The number of samples, sub-samples, duration of emergence flight and dates of collections in each of the five caves is given in Table I.

During the spring and summer of 1964, random samples were again obtained using approximately the same procedure indicated above. This provided comparative data for the two years. Sub-samples of 30 to 40 bats were taken in midsummer, but in spring and fall collections were not divided into sub-samples and consisted of approximately 100 bats each. The number of samples, sub-samples, duration of emergence flight, and dates of collections in each of the five caves in 1964 is given in

TABLE I

COLLECTING DATES, TIMES, AND LOCALITIES - 1963

Sample No.	Date 1963	Reed Cave Sub. Time	Vickery Cave Sub. Time	Conner's Cave Sub. Time	Selman's Cave Sub. Time	Merrihew Cave Sub. Time
3	12 June				(3) 8:10-10:00	
3	13 June					(3) 8:30-10:30
3	16 June		(3) 8:05-9:45			
3	17 June			(4) 8:10-10:20		
3	18 June	(3) 8:03-9:20				
4	26 June				(3) 8:20-9:55	
4	27 June					(3) 8:25-10:30
4	30 June		(2) 8:20-9:25			
4	1 July			(3) 8:15-9:45		
5	10 July				(2) 8:00-8:50	
5	11 July					(3) 8:15-10:30
5	14 July		(1) 8:12-8:25			
5	15 July			(4) 8:05-10:30		
5	16 July	(6) 8:05-10:50				
6	24 July				(6) 7:40-11:00	
6	25 July					(3) 8:10-9:43
6	29 July		(3) 7:20-8:50			
6	30 July			(4) 7:20-9:30		
7	7 Aug.				(5) 7:33-10:00	
7	8 Aug.					(3) 8:00-9:55
7	12 Aug.		(5) 7:20-9:45			
7	13 Aug.			(3) 7:40-10:00		
7	14 Aug.	(6) 7:20-10:00				
8	20 Aug.				(5) 7:22-9:40	
8	21 Aug.					(3) 7:35-8:55
8	26 Aug.		(4) 7:27-9:12			
8	27 Aug.			(4) 7:33-9:50		
9	3 Sept.				(2) 7:10-8:20	
9	15 Sept.		(3) 7:00-8:25			
10	22 Sept.				(3) 7:05-8:55	
10	3 Oct.		(2) 6:35-7:25			

Sub. = Number of subsamples in the sample.

TABLE II

COLLECTING DATES, TIMES, AND LOCALITIES - 1964

Sample No.	Date 1964	Reed Cave Sub. Time	Vickery Cave Sub. Time	Conner's Cave Sub. Time	Selman's Cave Sub. Time	Merrihew Cave Sub. Time
1	19 Apr.		(1)	(1)	(1)	
1	20 Apr.					(1)
2	17 May		(1)	(1)	(1)	(1)
3	8 June		(1)	(1)	(1)	(1)
4	22 June	(5) 8:00-10:25				
4	23 June		(1)		(1)	(1)
4	24 June			(1)		
5	6 July		(3) 8:00-9:40			
5	7 July			(3) 7:50-9:45		
5	8 July				(3) 7:25-9:10	
5	9 July					(2) 8:18-9:01
6	19 July	(4) 7:50-9:55				
6	20 July	(5) 4:40-7:11 AM				
6	20 July		(3) 6:50-9:00			
6	21 July			(4) 7:15-9:30		
6	22 July					(2) 7:56-8:50
6	23 July				(4) 7:10-9:15	
7	3 Aug.		(4) 6:47-8:56			
7	4 Aug.			(4) 6:37-8:34		
7	5 Aug.					(1) 7:58-8:25
7	6 Aug.				(3) 7:40-9:10	
8	16 Aug.	(3) 6:27-7:45				
8	17 Aug.		(3) 6:35-8:07			
8	18 Aug.			(3) 6:30-7:57		
8	19 Aug.					(2) 7:30-8:21
8	20 Aug.				(2) 7:09-7:44	
9	13 Sept.		(1)		(1)	
10	11 Oct.		(1)			

Sub. = Number of subsamples in the sample.

Table II.

Laboratory

Lens Removal

The eyes remained in the 10% formalin solution at least two weeks. They were then removed and allowed to soak for approximately 10 minutes in a petri dish containing water. This aided in removal of the formalin.

An incision was made with a knife needle in the cornea of the eye. Pressure was then applied to the eyeball to force the lens through the incised opening into the water bath. Each lens was carefully brushed with a camel hair brush, under water, to remove any adhering material. A binocular microscope was used to detect extraneous matter and to check the condition of the lens surface.

The lens was removed from the water and placed into 95% isopropyl alcohol for approximately 10 minutes. The alcohol bath served to partially dehydrate the lens and allow for more even drying. This also helped prevent the lens from adhering to the edges of the drying vials.

Drying

The lenses were first air-dried in small containers and then transfered to screwcap vials for storage. They were transfered from the screwcap vials to Exax (Kimble 15146) weighing bottles and oven-dried in an Aloe Scientific 300 watt Boekel oven for 48 hours at 70 C. At the end of the drying period, the vials were capped inside the oven and immediately transfered to a dehumidified weighing chamber.

Weighing

A 30 x 22 x 16-inch dehumidified weighing chamber (Fig. 3) was constructed of $\frac{1}{4}$ inch plexiglas. The relative humidity inside the chamber was reduced to 13 to 20% by the use of Dryrite (calcium sulfate). The large surface area of the lens in comparison to its mass and its hygroscopic nature necessitated the use of the chamber. This procedure reduced the up-take of atmospheric moisture to a minimum.

The lenses were handled with small forceps pre-cleaned with carbon tetrachloride before introduction into the chamber.

Rubber obstetrical gloves were mounted in two openings in the front of the chamber. This allowed weighing and handling of the lenses in a relatively dry environment and prevented entry of extraneous moist air.

The lenses were introduced into the chamber in a small sliding tray (Fig. 4). The tray slid back and forth through a small opening in the side of the chamber and held eight weighing bottles. The tray provided a tight seal when either in the open or closed position.

Each lens was weighed individually on a Sartorius Precision Micro Torque Balance. Weights were determined to 0.001 milligram with the aid of a reading glass.

In most cases, both lenses of known-age bats were weighed, however, only one lens was weighed from each bat in the random samples. This was done under the assumption that there is no significant difference between lens weights from the same bat. The lens weights were recorded on a tape recorder. The data were later transfered to data sheets and punched on I.B.M. cards for analysis.

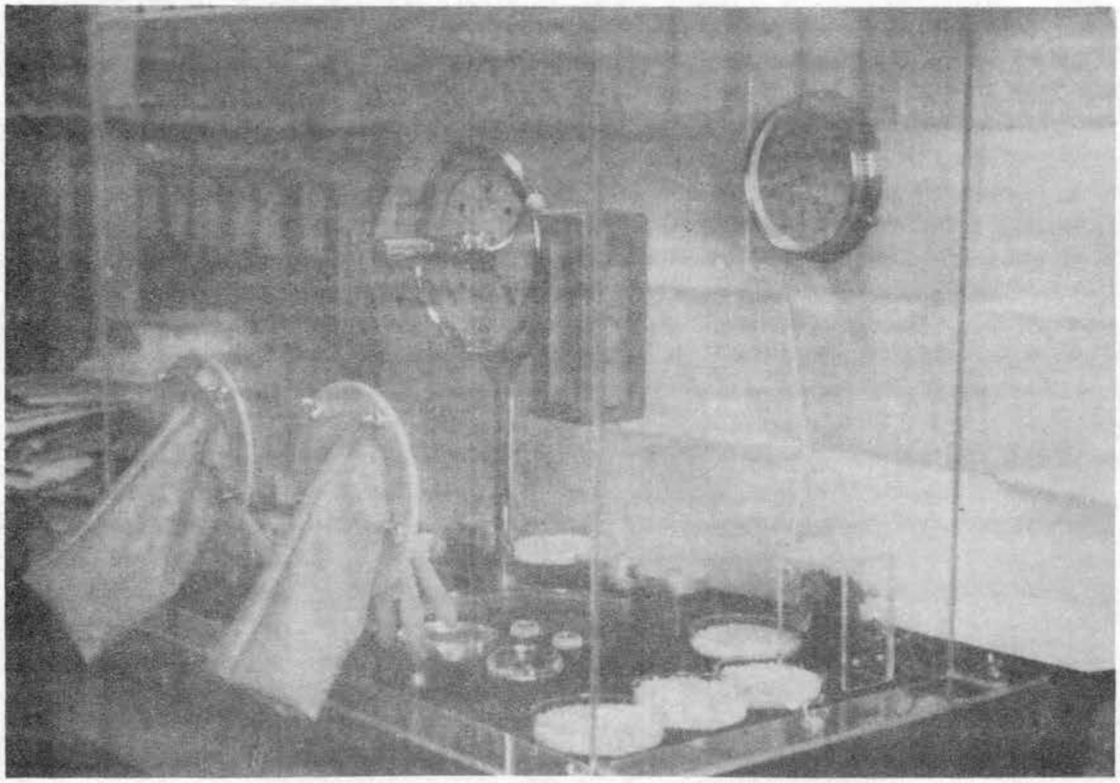

Fig. 3. Dehumidified Weighing chamber.

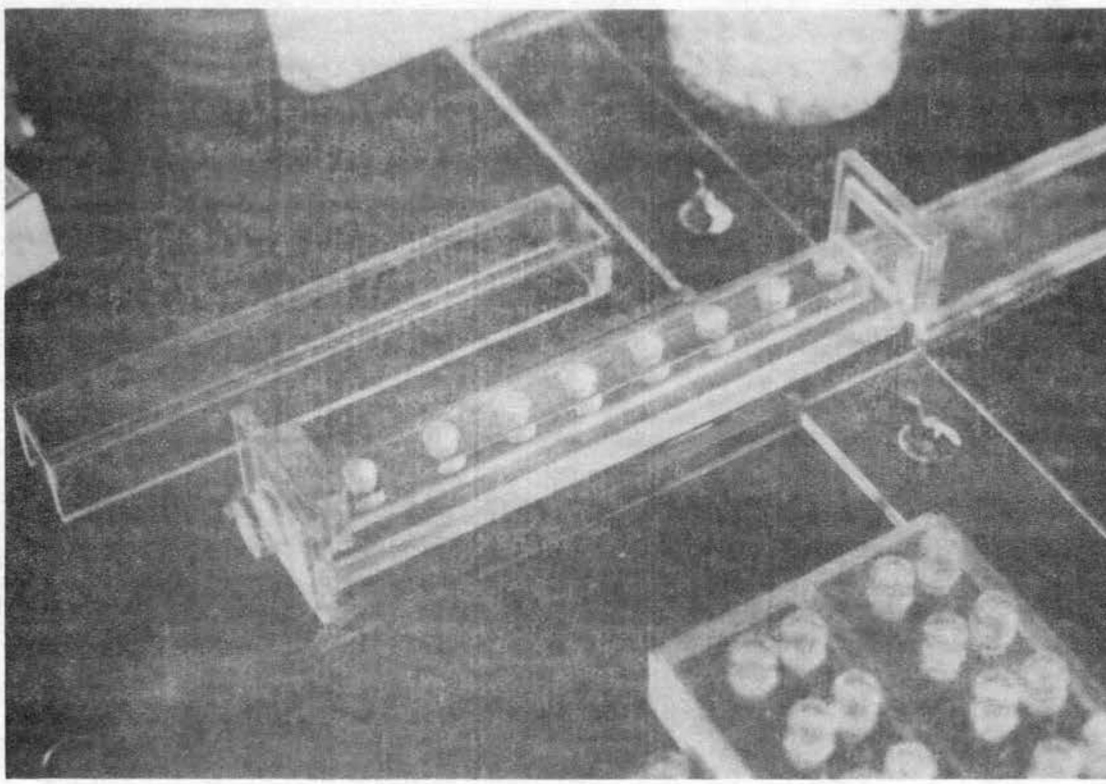

Fig. 4. Sliding tray for introduction of lenses into weighing chamber.

CHAPTER IV

VALIDITY OF METHOD

The analysis of 825 lenses from known age guano bats indicates the lens-weight method of age determination in this species is not valid for individual bats or for samples of small size. Overlap of weights between the various known-age classes is so great that any given lens could properly be placed in as many as nine weekly categories ranging from seven to 15 weeks. In the older groups a given lens might fall in any category from 10 weeks through one year, and lenses from one through three years could not be separated. Figs. 5 and 6 show this overlap. These figures are based on weights of 425 lenses from known age bats. The graph shows mean weight (horizontal line), one standard deviation on each side of the mean (open block), two standard errors of the mean either side of the mean (black block), and the range (vertical line), of the sample.

An indication that the variation is real and not wholly due to sampling error can be seen in the comparison of the two samples for the one-year age group (Fig. 7). This shows almost identical mean and variation measurements. These samples were taken one year apart, the first in 1963, the second in 1964. This would seem to indicate that comparable results can be obtained with this method used year after year in analysis. It would also give confidence that the unmeasurable level of experimental error seems to remain the same.

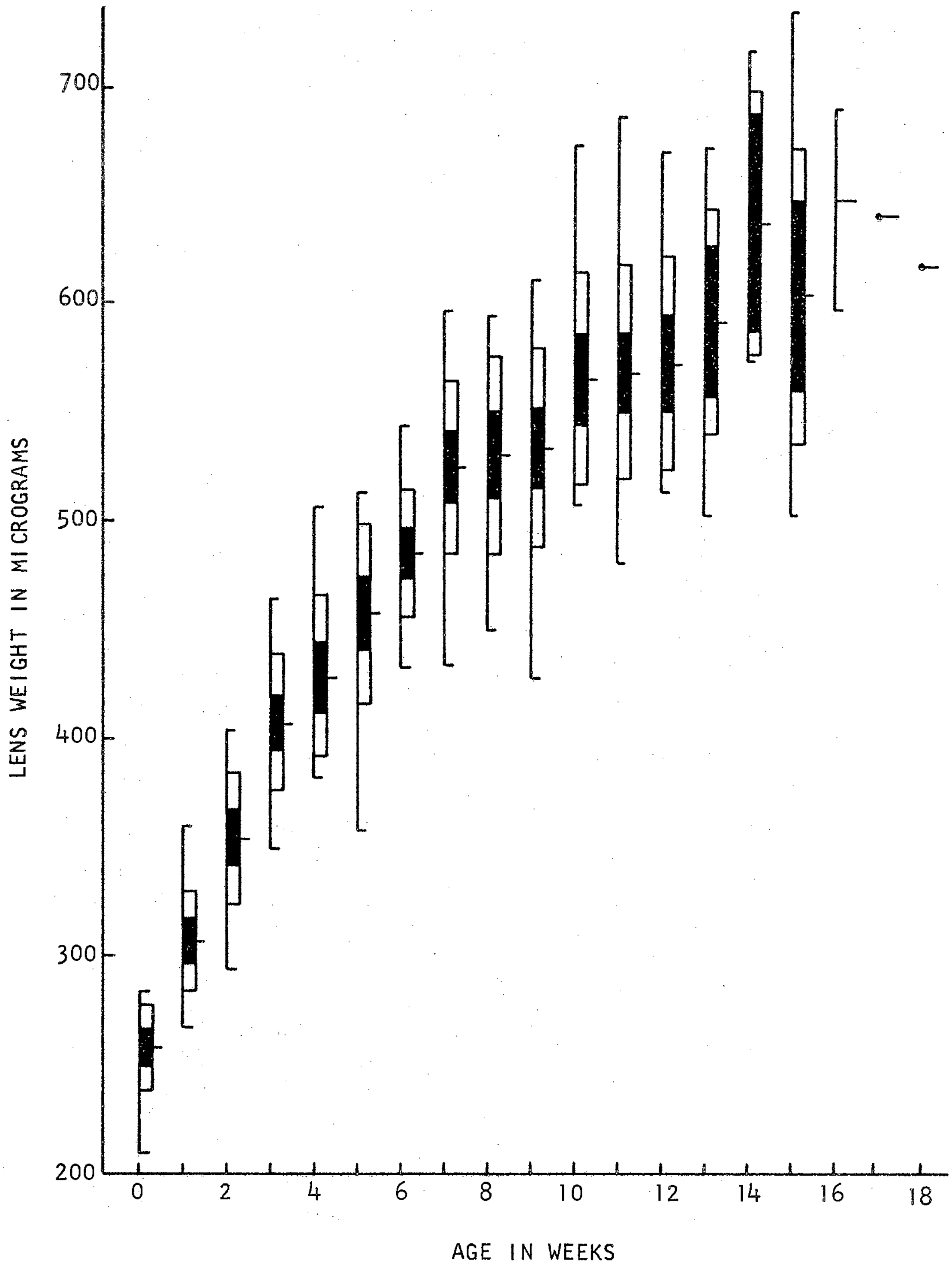

Fig. 5. Variation in lens weight of bats from birth to 18 weeks of age. Horizontal line = mean, open block = one standard deviation on each side of the mean, black block = two standard errors of the mean on either side of the mean, vertical line = range.

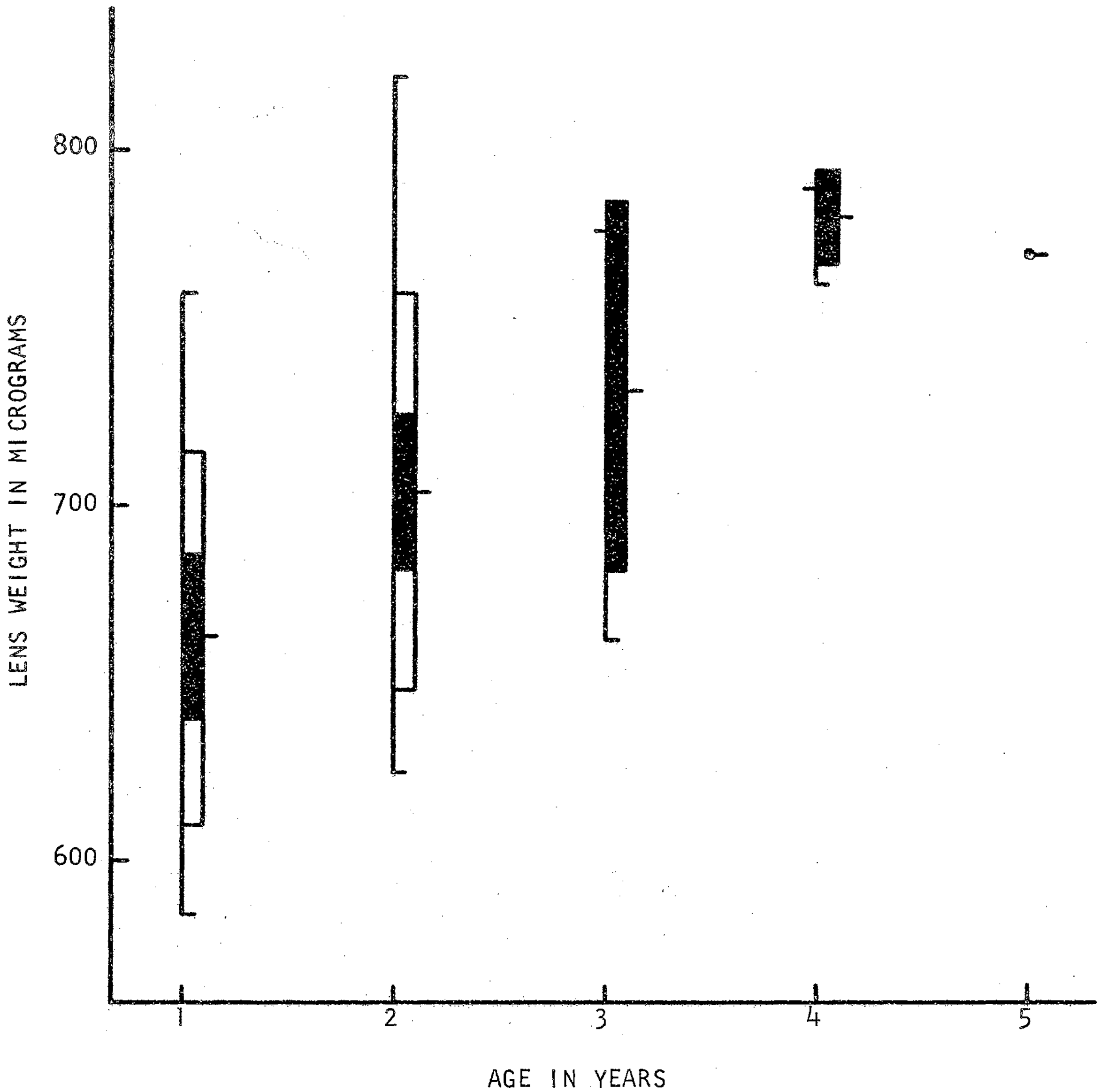

Fig. 6. Variation in lens weight of bats one to five years of age. Horizontal line = mean, open block = one standard deviation on each side of the mean, black block = two standard errors of the mean on either side of the mean, vertical line = range.

It is the feeling of the writer that much of the experimental error has been removed by using the techniques described in the laboratory methods section. Lenses weighed at the beginning and end of a 20 minute period, exposed in the weighing chamber, gained an average of two micrograms weight. The maximum amount of time any lens used in the analysis

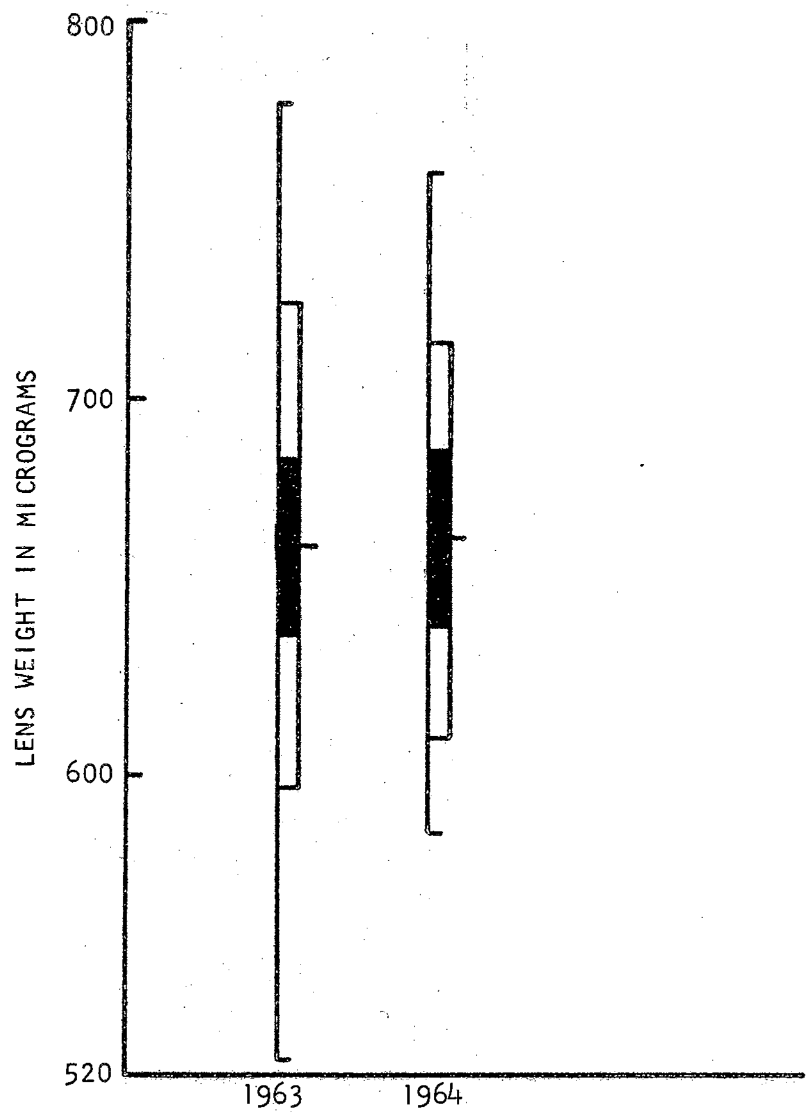

Fig. 7. Comparison of lens weights of one-year-old bats sampled in 1963 and 1964. Horizontal line = mean, open block = one standard deviation each side of the mean, black block = two standard errors of the mean either side of the mean, vertical line = range.

was exposed in the chamber was seven minutes. Repetitive weighing up to five times with oven-drying between each weighing showed a decrease in weight of several micrograms. Repetitive weighings without oven-drying also showed an overall loss of weight of several micrograms. This loss was probably due to damage incurred in the repeated handling of the lenses. Loss of small particles from the surface of the lens could cause this difference. To counteract this factor, all weights used in the analysis were those obtained during the first weighing where repeated weighing was carried out.

Weights of both lenses were obtained for 400 individual bats. These were not categorized as to left or right lenses but only analysed as lens I and lens II. Tables III and IV give the age groups, number in the sample, means, and standard deviation of these two lens sets. An average difference of 7.6675 micrograms was observed between the two lenses of the 400 individuals. This would amount to about 1.46% of the average lens weight. This is comparable to the results obtained by Kolenosky and Miller (1962) in their work on the lenses of the antelope. They found an average difference of 1.1% of the mean.

Table V shows the means, standard deviations, number in the sample, and indication of the larger mean and its magnitude of the females and males on lens set I. Fig. 8 shows the means of the two groups in graphic form. This would indicate that there is little difference in the lens weights of males and females of the same age. In eight classes the female means were the larger and in eight classes the male means were the larger. The greatest magnitude of difference in the two groups is about equal. The smaller number of males present in the older age groups would account for some of the observed difference. Data were pooled in regression analysis since little difference occurred in weights between sexes.

Although the lens-weight method lacks the desired discriminating power, estimates of age structure can be made with as much accuracy as obtained with other methods used. It allows segregation into more age categories than other methods which have been used heretofore.

TABLE III

COMPARISON OF MEAN LENS WEIGHT (IN MICROGRAMS) OF KNOWN AGE *TADARIDA BRASILIENSIS*

Lens Set I			
Age Class	Number in Sample	Mean Lens Weight	Standard Deviation
0 (Birth)	19	257.95	20.0262
1 (Week)	22	307.14	22.9541
2	23	354.57	29.8949
3	25	407.64	31.3553
4	23	427.61	37.7079
5	25	457.92	41.2805
6	26	485.46	29.2728
7	25	524.88	40.0918
8	21	530.86	45.3787
9	25	534.36	45.8101
10	23	566.17	48.6721
11	31	569.13	48.8922
12	20	573.15	49.1199
13	9	592.56	51.8317
14	6	637.50	60.2254
15	10	604.50	68.1767
16	3	648.67	46.7047
17	1	641.00	
18	1	618.00	
1 (Year) (1963)	31	660.84	63.8953
1 (Year) (1964)	21	662.86	52.7525
2	25	704.04	55.6959
3	4	733.75	51.9511
4	4	781.75	12.6854
5	1	772.00	
5 ≠ (More than 5 years)	1	810.00	

TABLE IV

COMPARISON OF MEAN LENS WEIGHT (IN MICROGRAMS) OF KNOWN AGE *TADARIDA BRASILIENSIS*

Lens Set II			
Age Class	Number in Sample	Mean Lens Weight	Standard Deviation
0 (Birth)	17	258.06	18.7331
1 (Week)	20	307.15	26.0046
2	19	344.68	31.1217
3	24	407.29	32.6437
4	22	427.36	35.1251
5	22	456.45	45.0245
6	24	483.00	32.1003
7	25	527.32	41.0718
8	21	523.19	61.8422
9	25	534.32	41.7140
10	23	565.52	46.8158
11	30	570.50	48.3655
12	20	578.25	50.6036
13	9	594.78	57.4081
14	6	635.33	63.1939
15	10	605.40	65.6475
16	3	659.00	53.8609
17	1	641.00	
18	1	618.00	
1 (Year) (1963)	23	657.26	58.1207
1 (Year) (1964)	20	662.45	55.0736
2	25	703.24	55.9079
3	4	732.00	52.1855
4	4	783.00	25.4165
5	1	771.00	
5 ≁ (More than 5 years)	1	805.00	

TABLE V

COMPARISON OF MALE AND FEMALE MEANS OF KNOWN AGE GUANO BATS

Age Class	Number in Sample	Female Mean	Male Mean	Male - Female	Standard Deviation
0 (Birth)	11	262.64			15.4094
0 (Birth)	8		251.50	-11.14	24.6981
1 (Week)	10	303.50			24.0566
1	12		310.17	+ 6.67	22.5905
2	15	363.53			27.2525
2	8		337.75	-25.78	28.7738
3	12	411.08			30.4495
3	13		404.46	- 6.62	33.0696
4	10	414.00			35.4024
4	13		438.08	+24.08	37.3328
5	9	454.33			44.7605
5	16		459.94	+ 5.61	40.5701
6	14	478.57			31.3018
6	11		493.50	+14.93	25.6640
7	15	515.40			44.8694
7	10		539.10	+23.70	27.9303
8	10	527.90			37.5661
8	11		533.55	+ 5.65	53.2134
9	12	535.25			50.5518
9	13		533.54	- 1.71	43.0476
10	10	569.40			56.1193
10	13		563.69	- 5.71	44.3366
11	16	581.19			56.1655
11	15		556.27	-24.92	37.4041
12	15	571.07			50.6648
12	5		579.40	+ 8.33	49.1050
13	8	591.13			55.2202
14	4	647.25			75.2479
14	1		618.00	-29.25	2.8284
15	5	626.00			84.5725
15	5		583.00	-43.00	46.3681
16	3	648.67			46.7047
1 (Year)	25	652.76			64.8596
1	6		694.50	+41.74	51.1576
				-17.42	

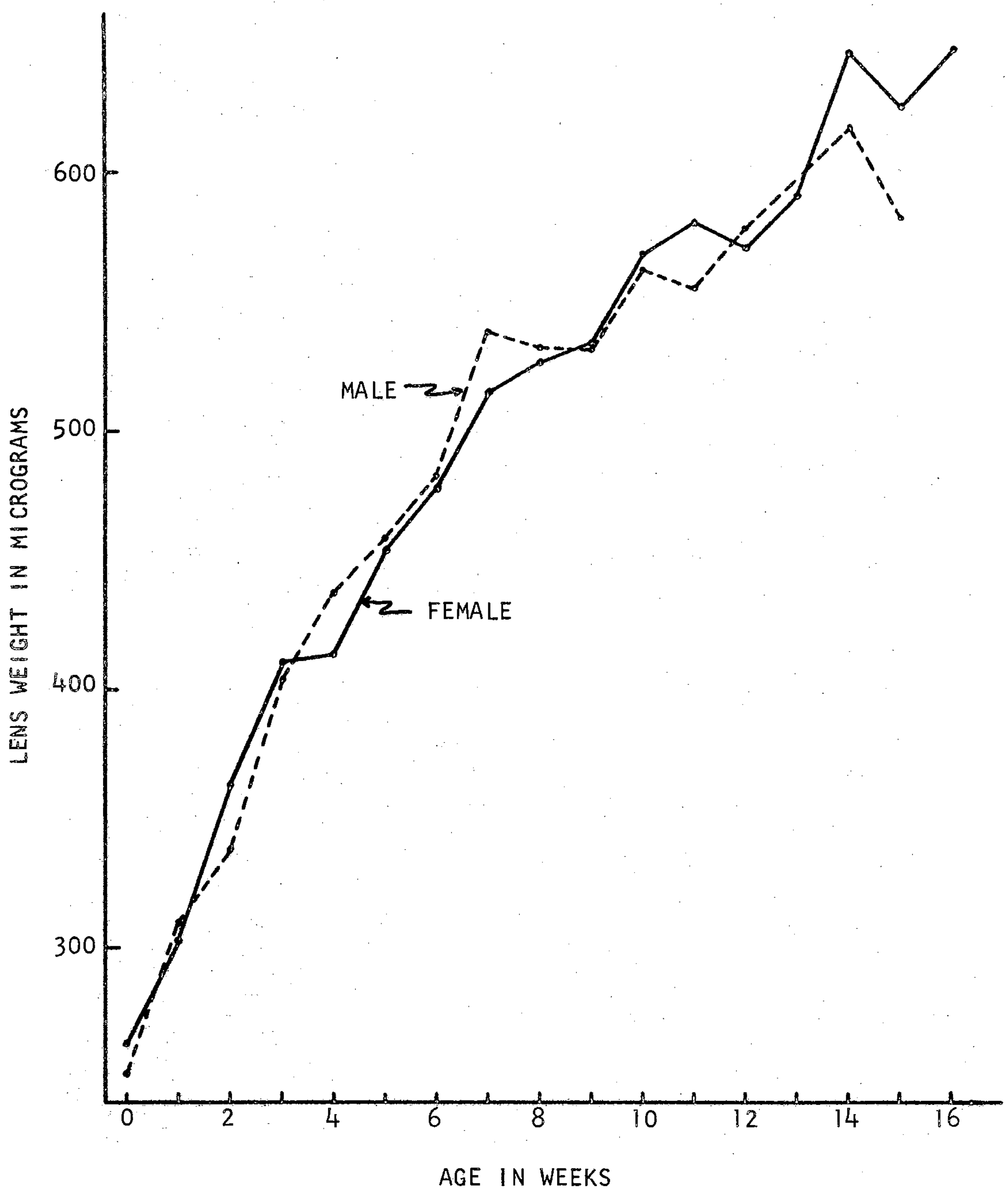

Fig. 8. Lens-weight means of male and female guano bats

CHAPTER V

DISCUSSION OF RESULTS

Abundance

The abundance of guano bats in the nursery caves in Oklahoma follows an annual cycle much the same as that found in the caves of Texas as reported by Davis, et al. (1962). There seems to be an increase in the caves in the spring of the year with some fluctuation in numbers. A fairly stable population is attained just prior to the birth of the young in June. This stable population persists until the young start to fly at which time the numbers increase noticeably. A decline in numbers follows this increase starting in most caves about the latter part of August. Populations in the caves are nonexistant from November until early spring. Fig. 9. and Fig. 10 give an estimation of this cycle.

Estimates of abundance are difficult to obtain and the accuracy is undoubtedly low. The figures given reflect only crude estimates and are useful only in comparing relative orders of magnitude. The figures given are based on combinations of estimates; area covered by clusters inside the cave, rates of capture at the trap during sampling periods, and density and duration of exodus flights.

At peak population levels in 1963, the estimates were: Reed Cave - 4,000,000; Vickery Cave - 1,400,000; Selman's Cave - 800,000; Conner's

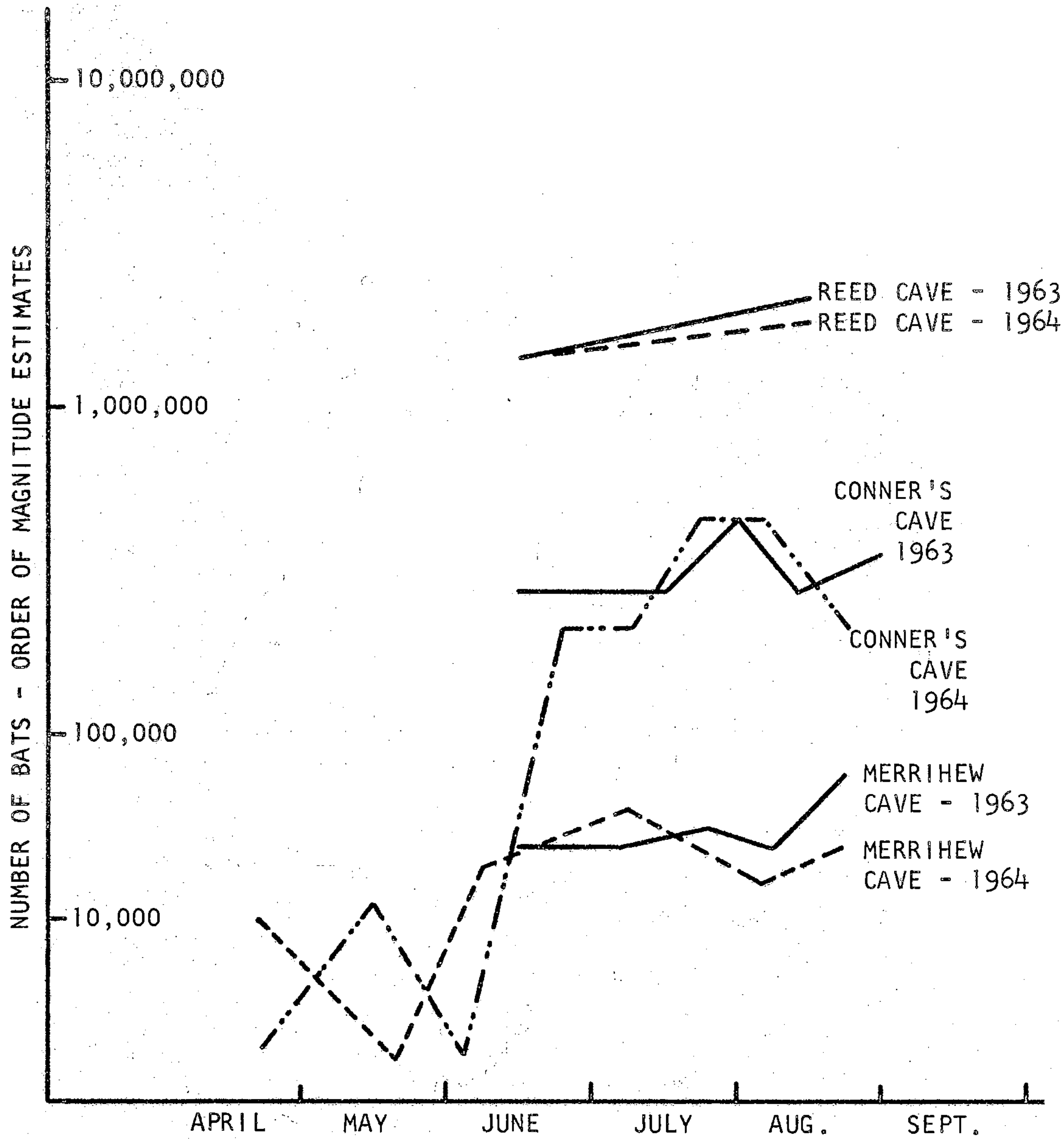

Fig. 9. Abundance of guano bats in three Oklahoma caves

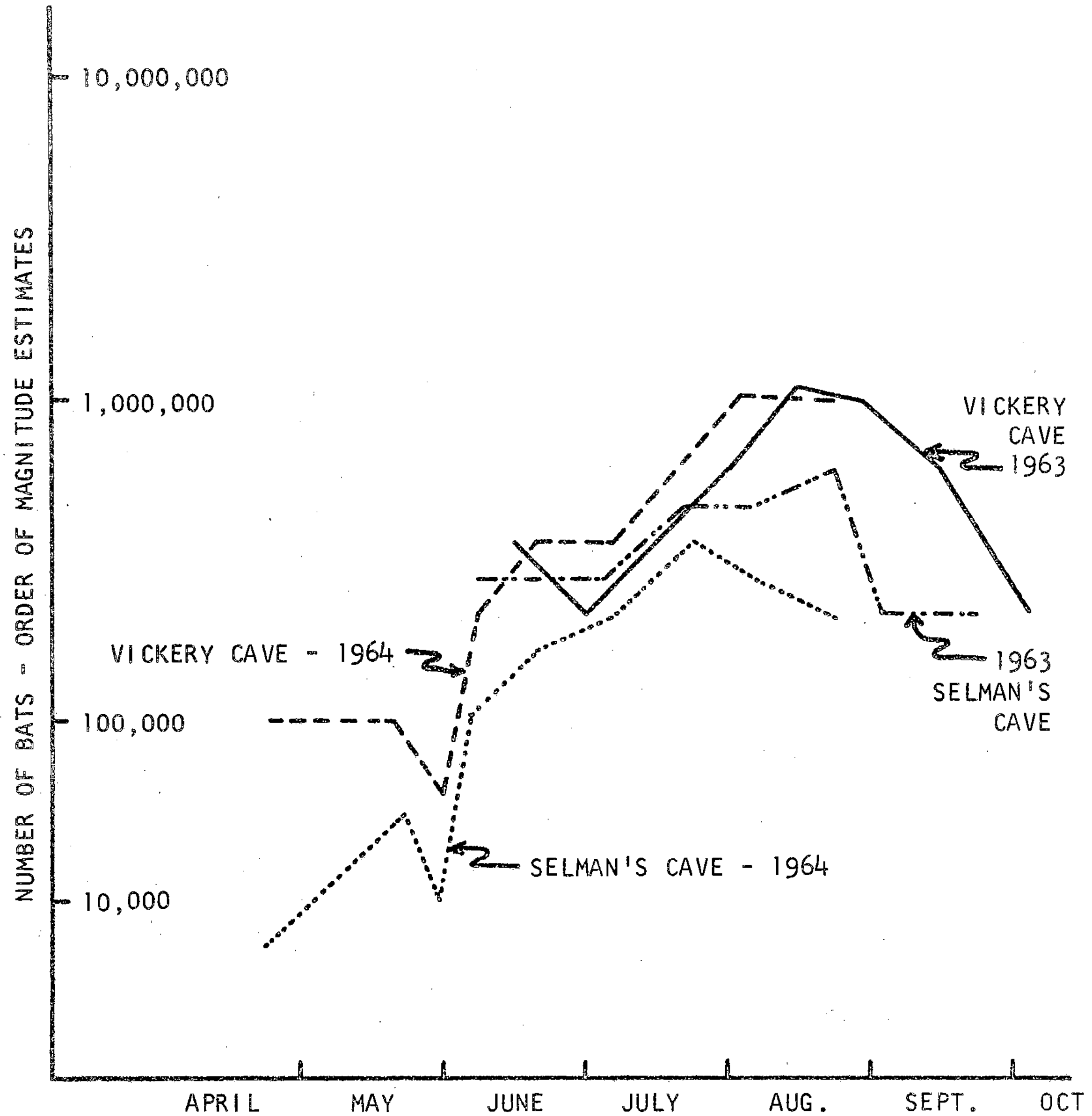

Fig. 10. Abundance of guano bats in two Oklahoma caves

Cave - 700,000; Merrihew Cave - 60,000; and a total of 6,060,000 in the state.

The population levels were not systematically estimated during the summer of 1962; however, from abundance of adults and young at Selman's Cave it was evident that the population was significantly higher during this year.

Another indication that population levels were higher was found at Merrihew Cave. In 1962, a small nursery colony was present in each of two sections of the cave. Babies were not found in Merrihew Cave during the two subsequent years.

There seemed to be a decrease, in total population, of approximately 1,000,000 bats per year in Oklahoma during the years studied. This would be an overall reduction of about 2/7 of the population since 1962.

Sex Ratios

A disproportionate sex ratio in the guano bat populations in Texas caves has been observed by Davis, et al. (1962). They suggested that most of the males do not return to northern latitudes with the females in the spring. Further, the males which do return usually appear before the females and tend to be more nomadic in nature. This same phenomenon was observed in caves in Oklahoma during the present study. The sex ratios observed during 1963 and 1964 are given in Table VI and Table VII. The early appearance of the males is reflected in the data for Conner's Cave where the population was 67% males in April and less than 10% one month later.

The percentage of females in the population increased during the

TABLE VI

SEX RATIOS OF GUANO BATS. FIVE CAVES -- 1963 SEASON

Date	Reed		Vickery		Conner's		Selman's		Merrihew		Subtotal	
	No.	%F	No.	%F	No.	%F	No.	%F	No.	%F	No.	%F
12 June							261	97.3				
13 June									170	83.5		
16 June			181	91.7								
17 June					294	99.3						
18 June	205	95.6										
											1111	94.5
26 June							216	98.6				
27 June									113	22.1		
30 June			107	79.4								
1 July					179	98.9						
											615	81.3
10 July							132	90.9				
11 July									153	27.5		
14 July			58	72.4								
15 July					230	90.4						
16 July	364	93.7										
											937	80.3
24 July							449	69.3				
25 July									170	38.8		
29 July			179	67.0								
30 July					218	68.8						
											1016	63.6
7 Aug.							302	57.9				
8 Aug.									174	56.9		
12 Aug.			286	77.6								
13 Aug.					156	74.4						
14 Aug.	369	79.7										
											1287	70.3
20 Aug.							292	63.4				
21 Aug.									160	61.9		
26 Aug.			220	60.0								
27 Aug.					218	79.4						
											890	66.1
3 Sept							110	73.6				
15 Sept			165	57.6								
											275	64.0
22 Sept							161	49.7				
3 Oct.			110	75.5								
											271	60.1
Totals	938	88.5	1306	72.3	1295	86.1	1923	73.3	940	50.3	6402	74.7

No. = Number of bats in the sample.
F = Female

TABLE VII

SEX RATIOS OF GUANO BATS. FIVE CAVES -- 1964 SEASON

Date	Reed		Vickery		Conner's		Selman's		Merrihew		Subtotal	
	No.	%F	No.	%F	No.	%F	No.	%F	No.	%F	No.	%F
19 Apr.			104	81.7	103	33.0	103	76.7				
20 Apr.									103	71.8		
											413	65.8
8 May							19	89.5	43	76.7	62	80.6
17 May			105	92.4	109	91.7	102	80.4	102	66.7	418	83.0
29 May			93	96.8			108	84.3			201	90.0
8 June			101	100.0	102	99.0	102	94.1	101	96.1	406	97.5
22 June	138	89.9										
23 June			100	81.0			103	96.1	101	64.4		
24 June					102	100.0						
											544	86.6
6 July			157	86.0								
7 July					173	99.4						
8 July							115	96.5				
9 July									300	59.3		
											745	80.0
19 July	122	68.9										
20 July	145	98.6	76	56.6								
21 July					182	90.1						
22 July									64	39.1		
23 July							131	84.7				
											720	79.2
3 Aug.			131	69.5								
4 Aug.					134	69.4						
5 Aug.									35	45.7		
6 Aug.							101	53.5				
											401	63.3
16 Aug.	101	70.3										
17 Aug.			138	61.6								
18 Aug.					96	82.3						
19 Aug.									50	78.0		
20 Aug.							70	58.6				
											455	69.2
13 Sept			100	87.0			100	84.0			200	85.5
11 Oct.			80	92.5							80	92.5
31 Oct.			25	72.0					20	45.0	45	60.0
Totals	506	83.4	1210	81.6	1001	84.4	1054	82.1	919	65.8	4690	79.4

No. = Number of bats in the sample
F = Female

spring in all of the caves used as nurseries. The highest percentage level was reached when parturition was at its peak. After fledging, the male ratio increased, as expected. This was undoubtedly caused by the dilution of the female population by flying young males. A disproportionate sex ratio in the young was not observed in approximately 50,000 neonatal bats banded during the period of study.

The sex ratio in Merrihew Cave, which was not used as a nursery cave in 1963 or 1964, differed greatly from that observed in the other four caves. In this cave the percentage of females tended to decrease as the season progressed. When female percentages were minimal in Merrhiew Cave, they were maximal in the other four caves. The percentage of females increased again in the late summer and fall in Merrihew Cave as the movement of young between caves occurred.

It appeared that as the caves used as nurseries became filled with gravid females, the males departed. A number of these males apparently moved to Merrihew Cave. Concomitantly, some of the females in Merrihew Cave appeared to move into the caves used as nurseries.

A 76% female population was observed in Merrihew Cave during the summer of 1953, however, the sampling period was not indicated (Twente, 1956). The cave was used as a nursery in 1953 and the population level was above 100,000 bats. The observed 76% female population exceeded the female proportion in Merrihew Cave in 1963 and 1964, however, the sex ratio in this cave in 1953 agrees with mean annual sex ratios observed in the four caves used as nurseries in the present study.

Comparisons of sex ratios in Oklahoma caves with data obtained in Texas by Davis, et al. (1962) is possible for the spring and early summer. In Texas, sex ratios of adult bats were obtained in four caves during the 1957 season. This population consisted of about 85% females at the peak of parturition. The same general sex ratio was also observed in the four nursery caves in Oklahoma during the present study. Spring observations of sex ratios also generally agree for the two areas. Fall comparisons were not possible since adults and young were not analysed separately during the present study.

Age Structure of Population

The analysis of the population age structure in this study was based upon the lens-weight analysis of 8,312 randomly collected bats from five caves, of which 5,977 were collected in 1963 and 2,335 were collected in 1964. The dates and places of collection are shown in Tables I and II.

A total of 425 lenses of known age bats were used in regression analysis to establish a basis for segregation of ages. The means of these lens weights are listed as lens set I in Table III. Unobtainable data for ages between 18 weeks and one year made it necessary to divide the analysis into the following two parts: (1) ages from birth to 18 weeks (Fig. 11) and (2) ages from one year through five years (Fig. 12). Both linear and quadratic equations were fitted to each of the two groups (Steele and Torrie, 1960). For the first 18 weeks, the growth curve more closely fits the quadratic equation and linear regression is not applicable. Form one through five years a linear relationship exists. The fit of the quadratic equation is only slightly better than that of the linear equation and contributes nothing of significance.

An analysis of age structure is only possible by making a decision as to where lines should be drawn to segregate the age classes in the

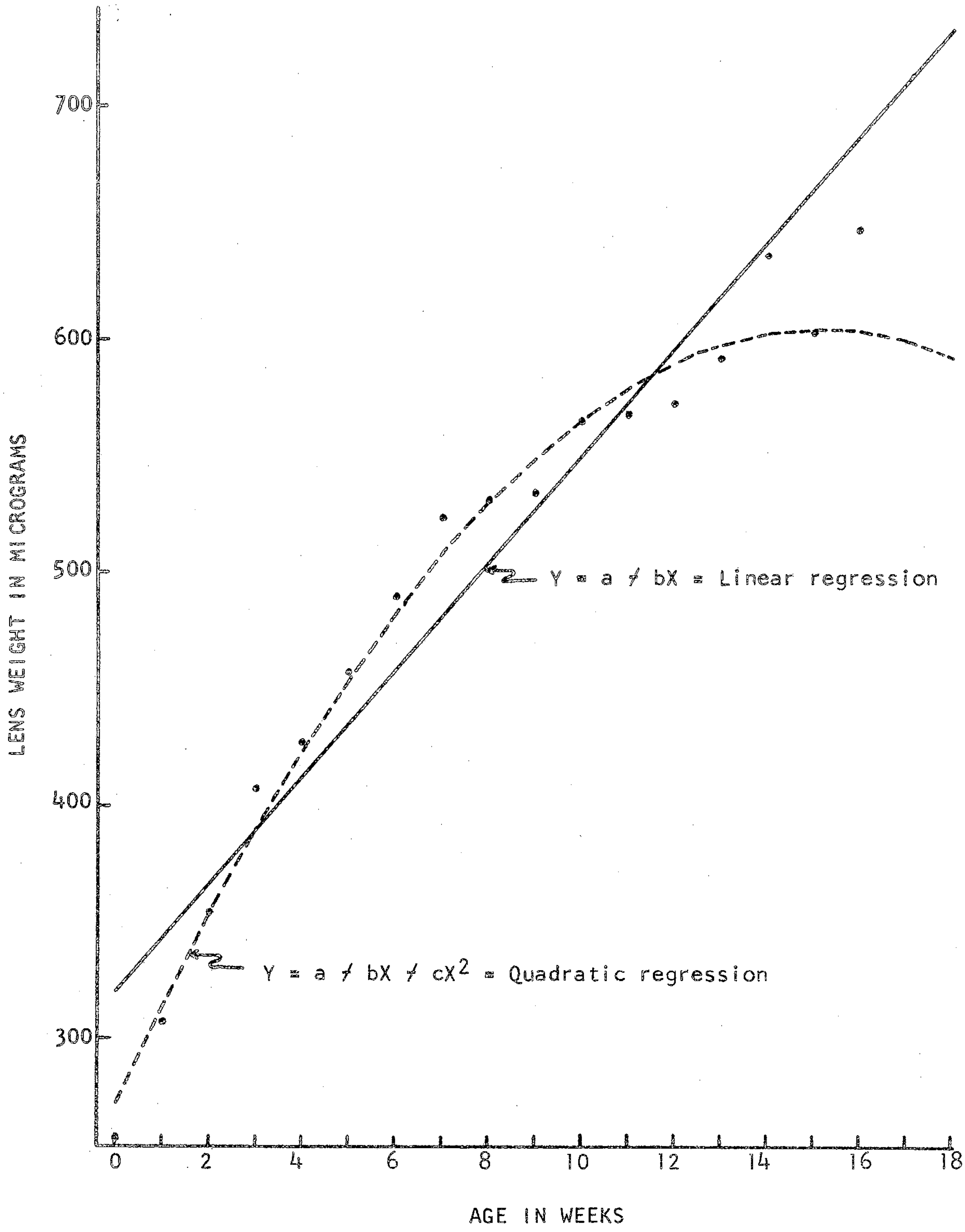

Fig. 11. Linear and quadratic regression of lens weights of guano bats from birth to 18 weeks of age. Dots indicate means.

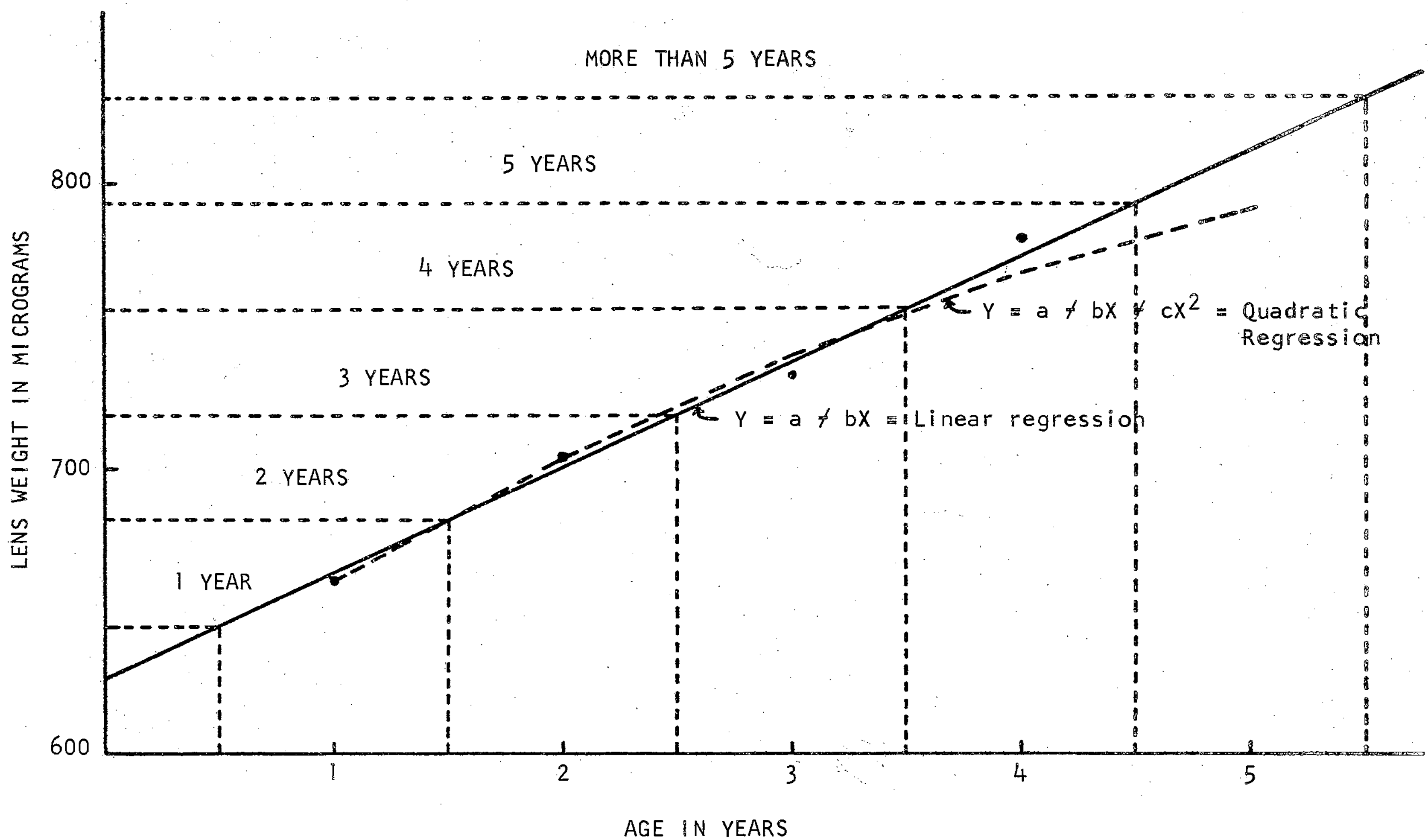

Fig. 12. Linear and quadratic regression of lens weights of guano bats from one to five years of age. Dots indicate lens-weight means for age class.

lens-weight regression. In this study seven age classes were chosen: (0) less than one year; (1) one year; (2) two years; (3) three years; (4) four years; (5) five years; (6) more than five years. These seven age classes were delimited by points midway between the point estimate for the given age and the next higher and lower age. The point estimate is that point on the regression line which would be intersected by a line drawn vertically from the age point on the horizontal axis. Fig. 12 shows these plotted on the regression line of the one year to five year group. The younger weekly age groups were not considered in the analysis of age structure as little would be gained by knowing weekly ages of infant bats. In the analysis, any bat with a lens weight between 0 and 644 micrograms would be considered to be less than one year old; 645-681 = one year; 682-718 = two years; 719-755 = three years; 756-792 = four years; 793-829 = five years; 830-upward = more than five years. This would be an annual increase in lens weight of 36 micrograms. It is necessary to assume that there will be as many errors made on one side of any age class as on the other; thus, compensating for the errors and giving an estimate of the number in any given catagory. The greatest error would be in the end catagories (those less than one year and those more than five years). A measure of the error in the lower category can be obtained by noting the number of those in this catagory which could not possibly fall here. As an example, in June all individuals in the emergence flight would be at least one year of age; however, lens-weight criterion would place some of these individuals in the less than one year category. This error could amount to as much as 20% of the sample number; however, in most cave samples it is somewhat lower than this.

The age structure of the population was analysed separately for each sex in each cave. Figs. 15 through 22 show age structure for each cave expressed in percentages of the total number of that sex present on any given sampling day. The change in the age composition is apparent as the season progresses. Fig. 13 and Fig. 14 show in bar graph form the average age composition for each cave and for each year in the study.

It appeared that the age structure of the guano bat population in Oklahoma caves was relatively constant for the two years studied. Little overall difference in the age structure between caves was seen in the four caves used as nurseries during 1963 and 1964. Table VIII shows the age structure averages for the season for five caves in 1963 and for three caves during 1964. Conner's Cave and Reed Cave appeared to be similar in composition and Selman's Cave and Vickery Cave appeared to be similar in composition. The main difference in these two sets of caves appeared to be in the male component. Merrihew Cave, which was a non-nursery cave during the present study, contained a population whose age structure differed greatly from that found in the other four caves. In this cave the number of younger-age females was less and the male component was composed of greater percentages of bats in the older age groups.

The bulk of the male population of the nursery caves was made up of bats less than one year old. These were mainly young-of-the-year taken in the samples primarily during the later part of the season. Males one year old or older were few in number in all caves except Merrihew Cave.

A general pattern of age structure change during the season occur-

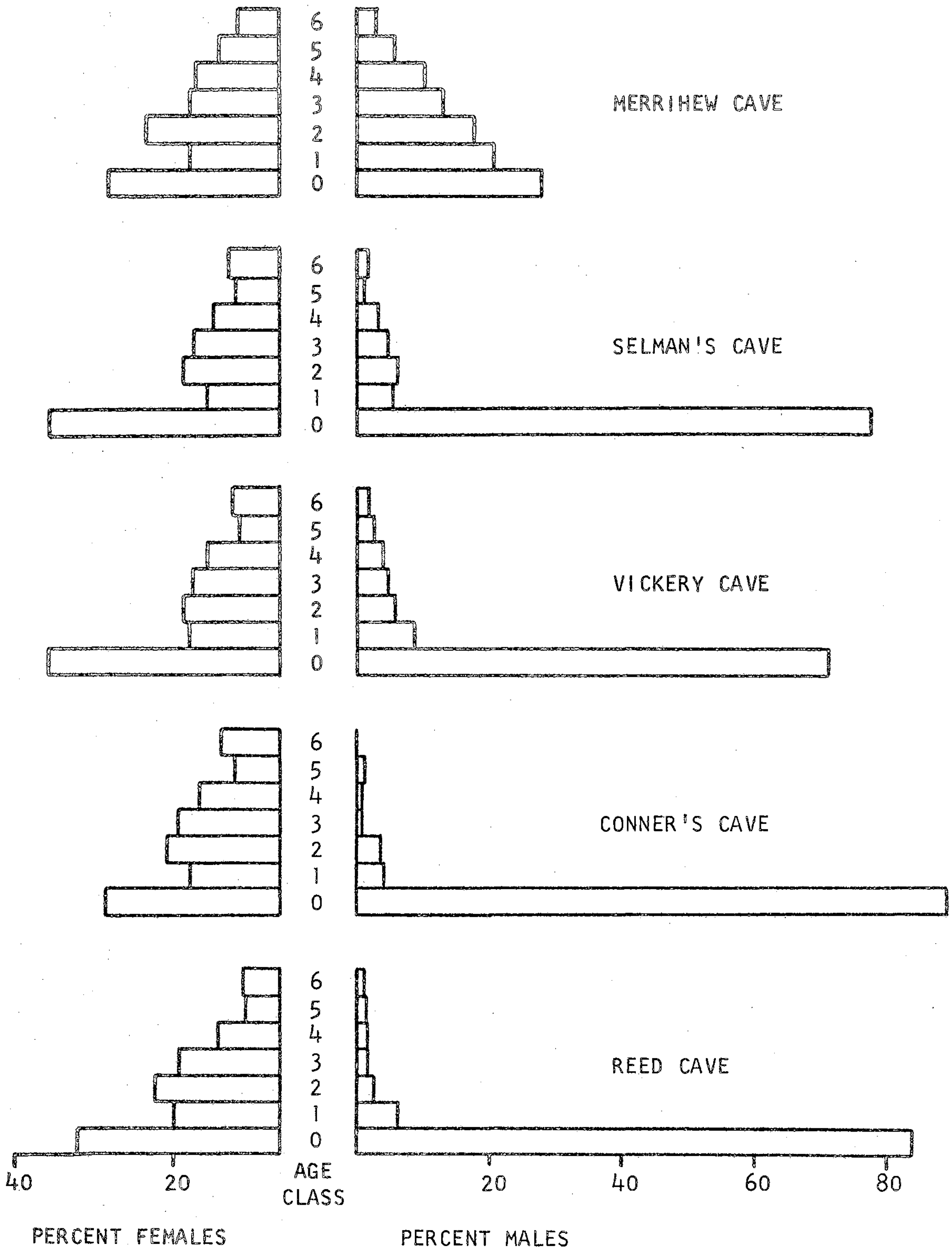

Fig. 13. Age composition averages of guano bats in five Oklahoma caves during 1963. Age Class 0 = Less than one year, 1 = one year, 2 = two years, 3 = three years, 4 = four years, 5 = five years, 6 = more than five years of age.

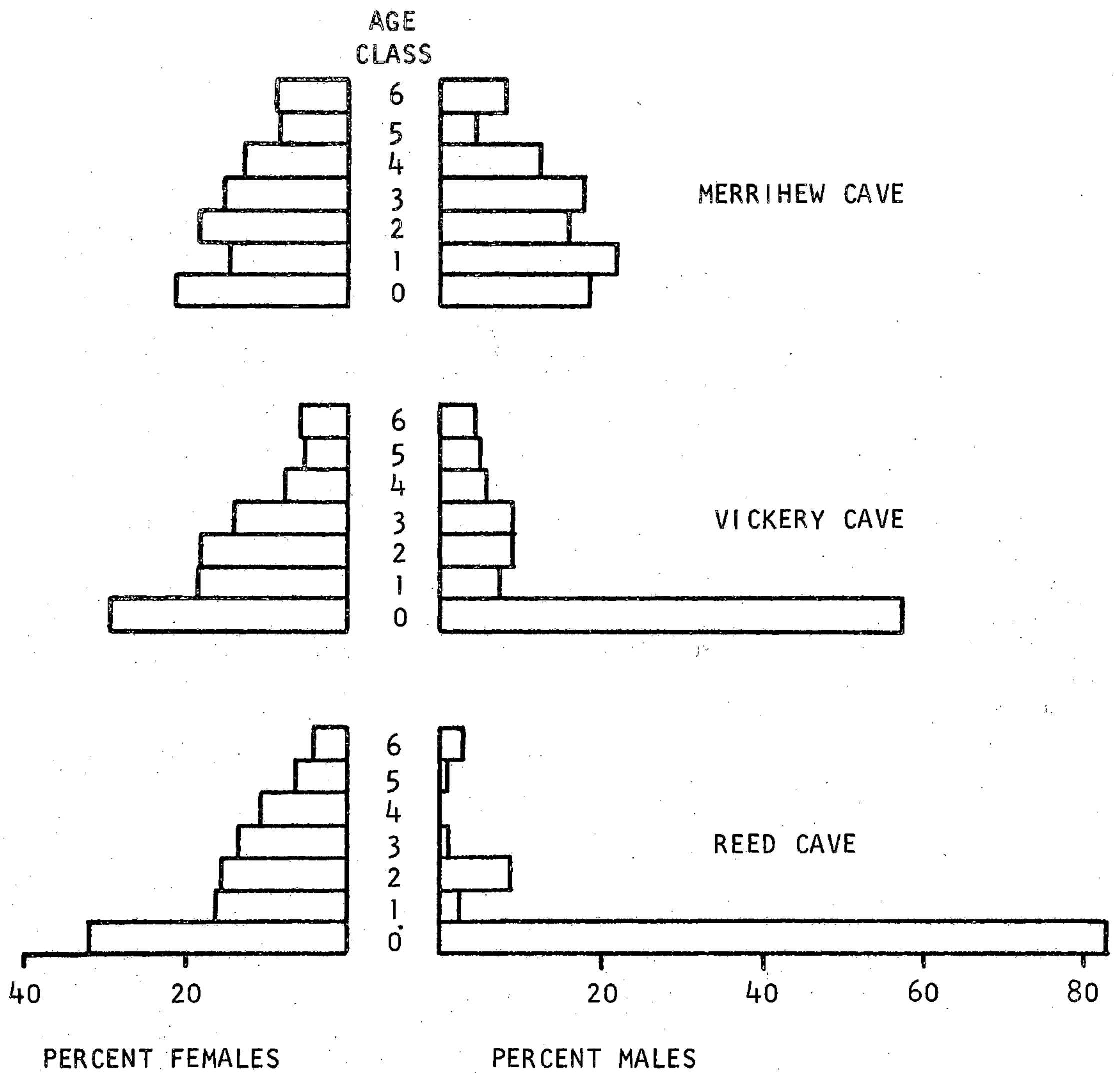

Fig. 14. Age composition averages of guano bats in three Oklahoma caves during 1964. Age class 0 = Less than one year, 1 = one year, 2 = two years, 3 = three years, 4 = four years, 5 = five years, 6 = more than five years of age.

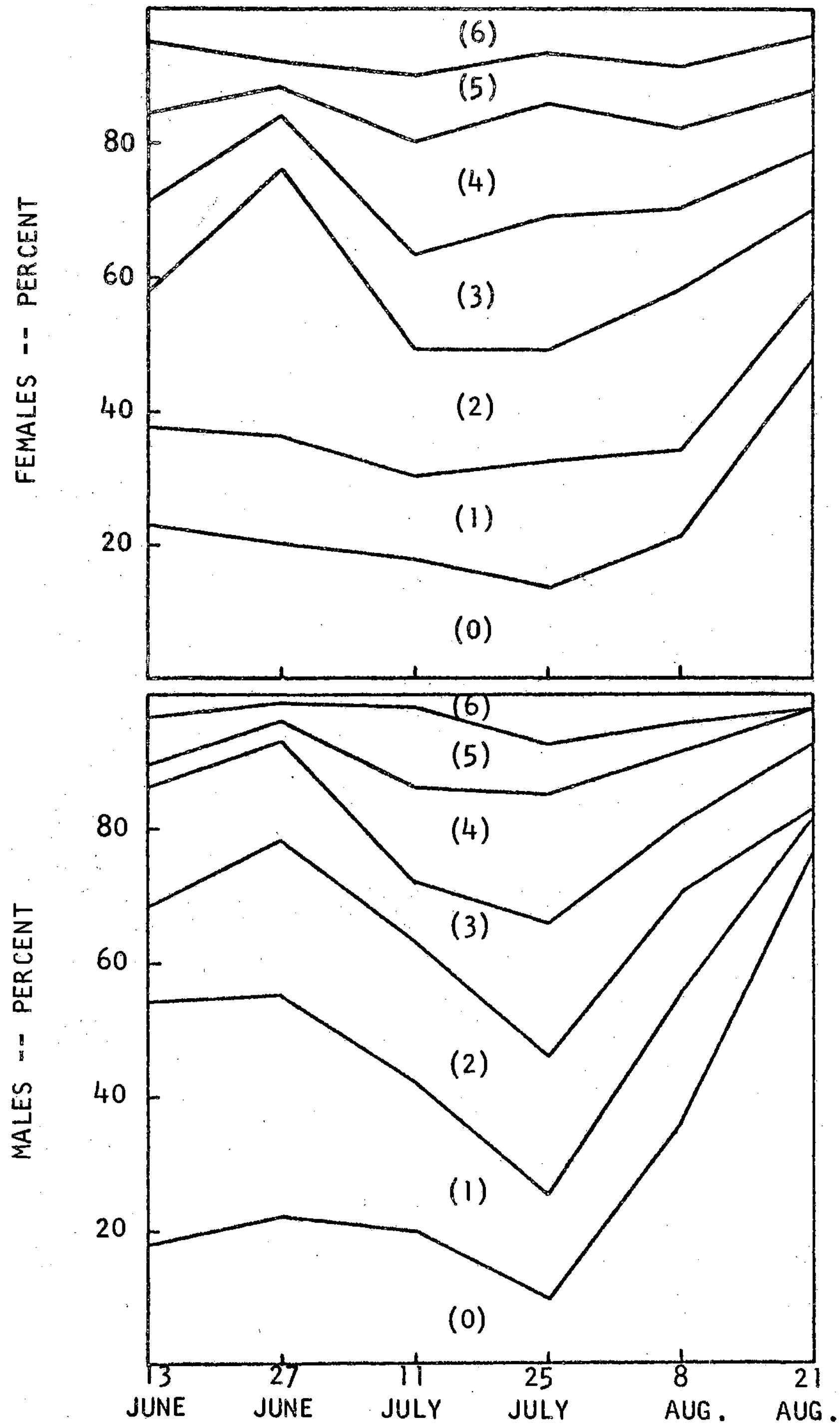

Fig. 15. Age structure of bats in Merrihew Cave - 1963 season. Age class 0 = less than one year, 1 = one year, 2 = two years, 3 = three years, 4 = four years, 5 = five years, 6 = more than five years of age.

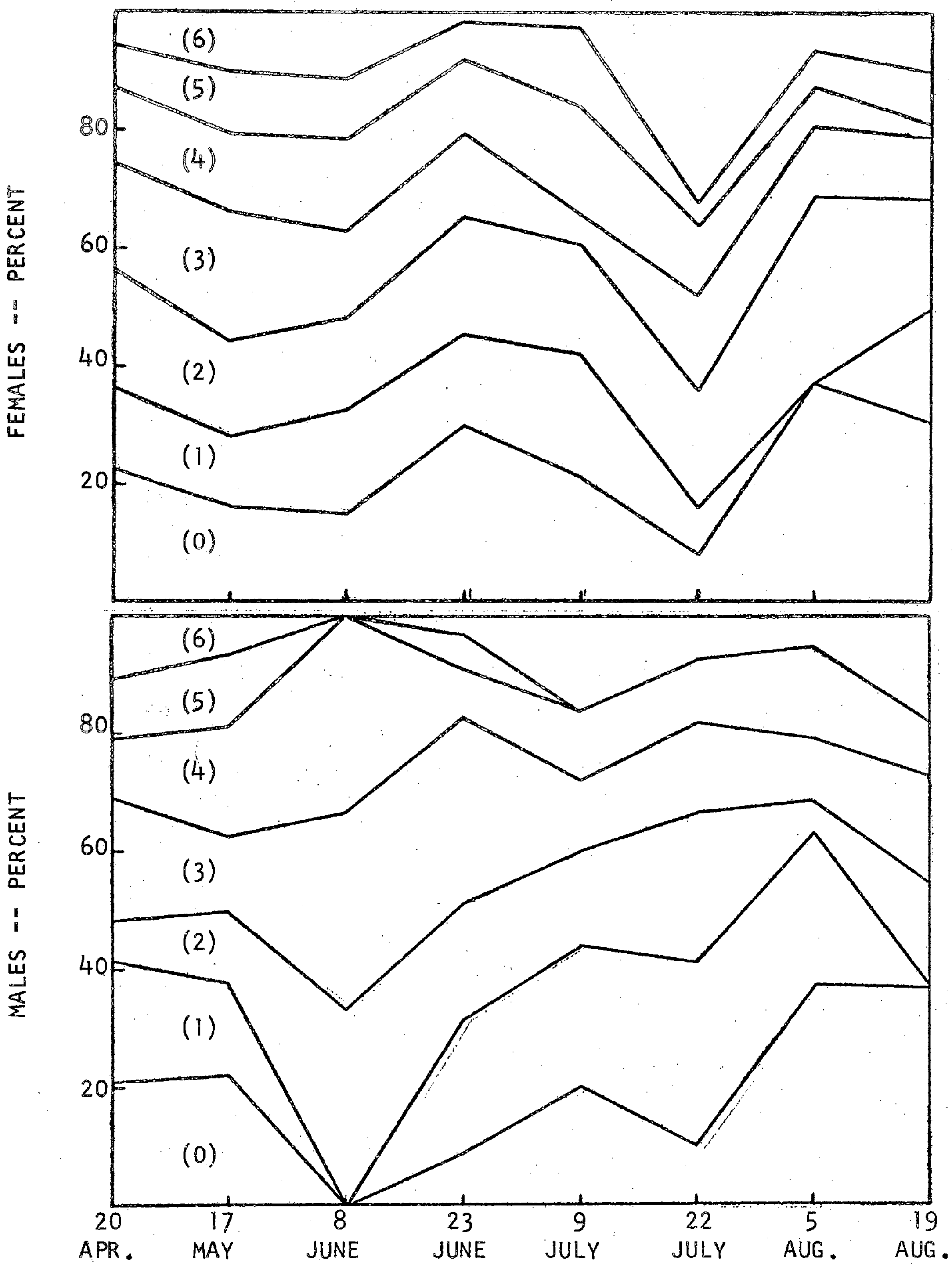

Fig. 16. Age structure of bats in Merrihew Cave - 1964 season. Age class 0 = Less than one year, 1 = one year, 2 = two years, 3 = three years, 4 = four years, 5 = five years, 6 = more than five years of age.

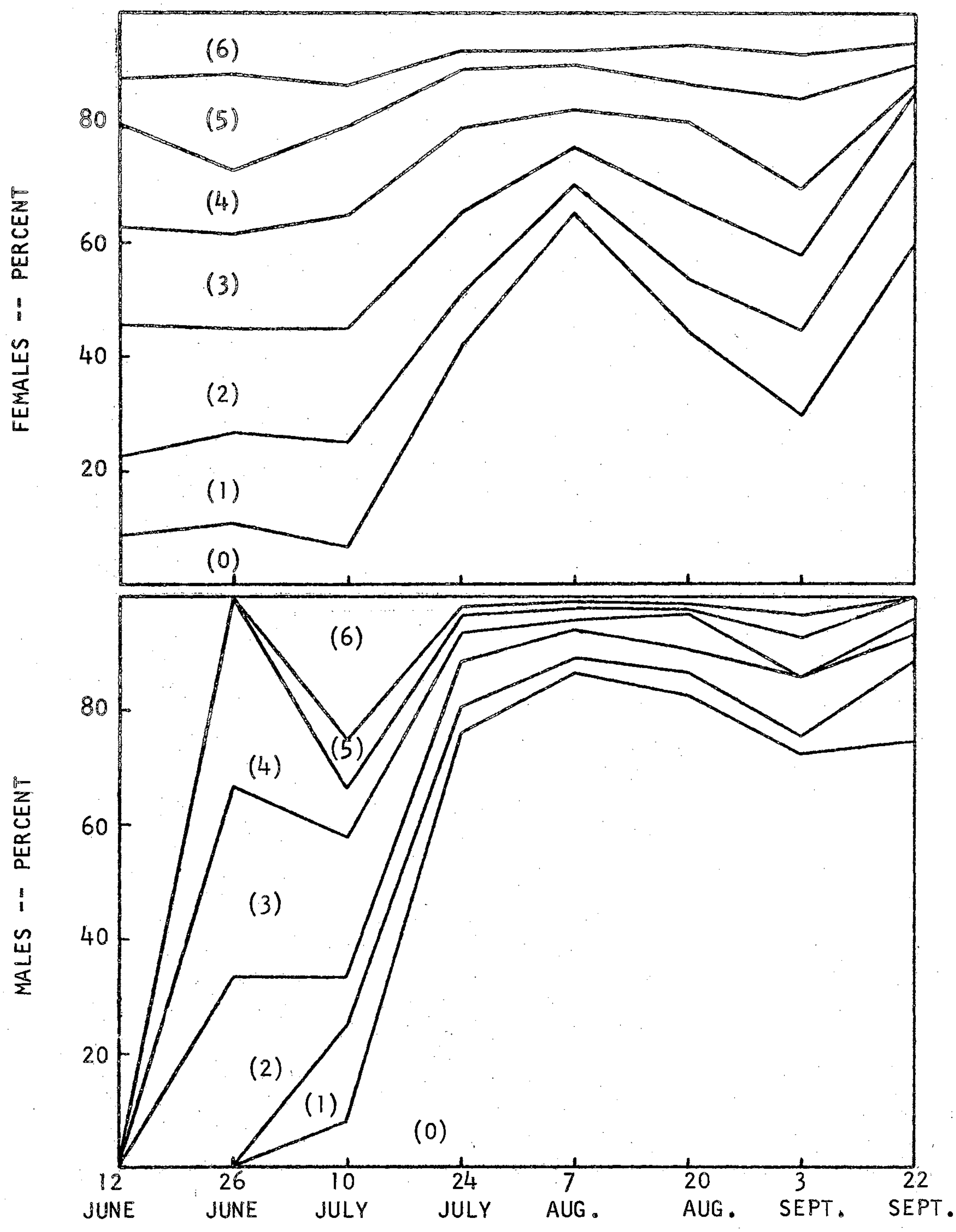

Fig. 17. Age structure of bats in Selman's Cave - 1963 season. Age class 0 = less than one year, 1 = one year, 2 = two years, 3 = three years, 4 = four years, 5 = five years, 6 = more than five years of age.

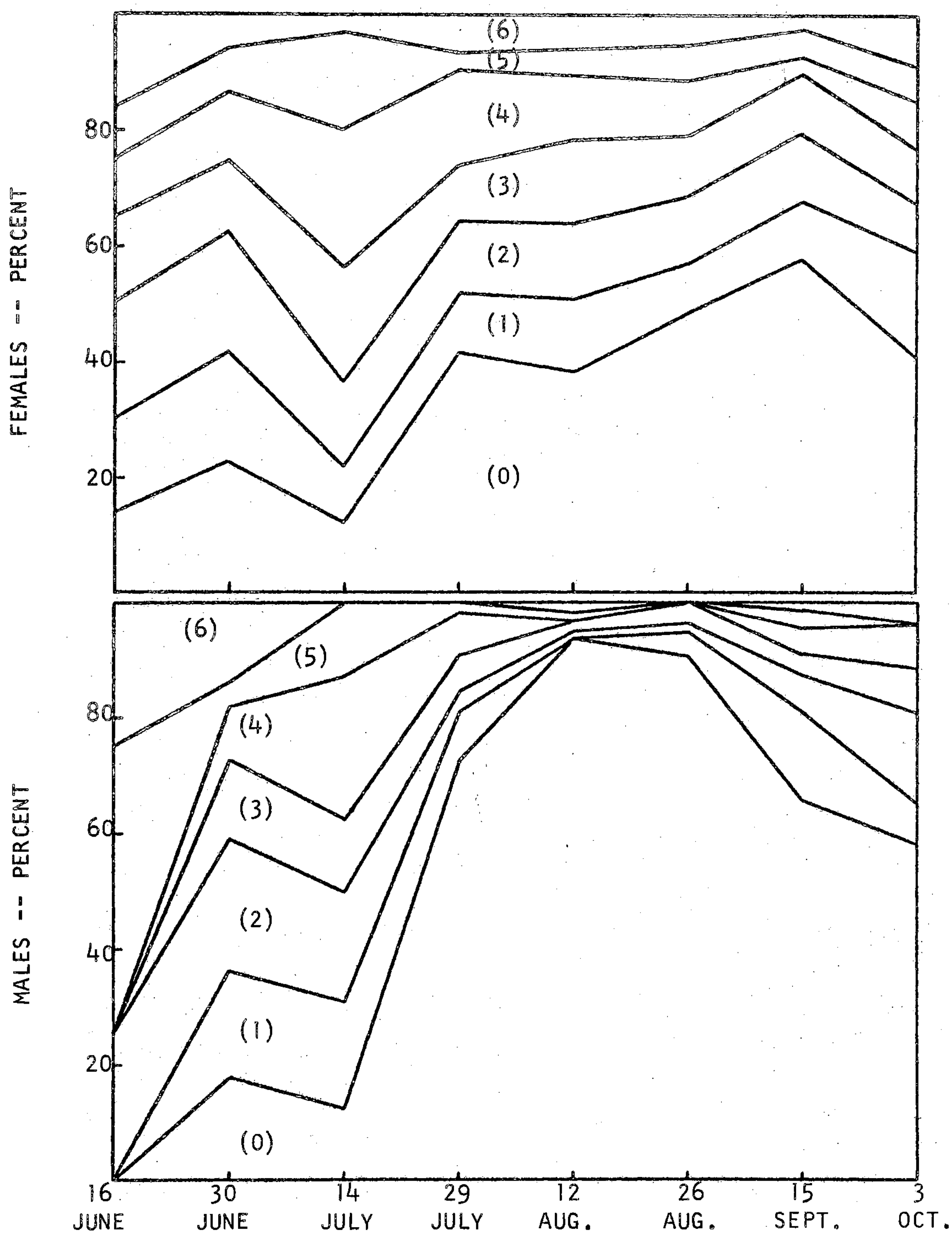

Fig. 18. Age structure of bats in Vickery Cave - 1963 season. Age class 0 = less than one year, 1 = one year, 2 = two years, 3 = three years, 4 = four years, 5 = five years, 6 = more than five years of age.

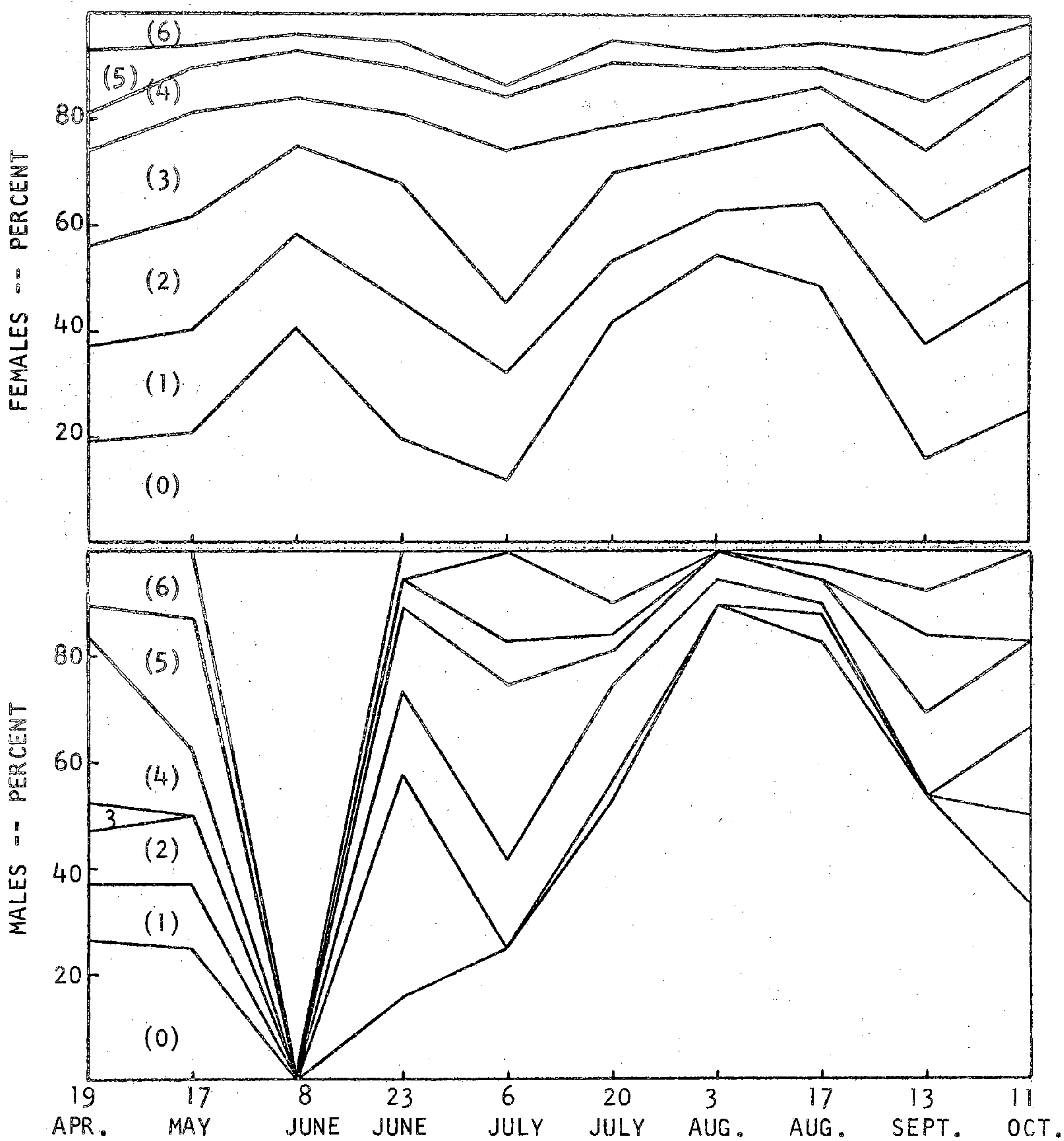

Fig. 19. Age structure of bats in Vickery Cave - 1964 season. Age class 0 - less than one year, 1 - one year, 2 - two years, 3 - three years, 4 - four years, 5 - five years, 6 - more than five years of age.

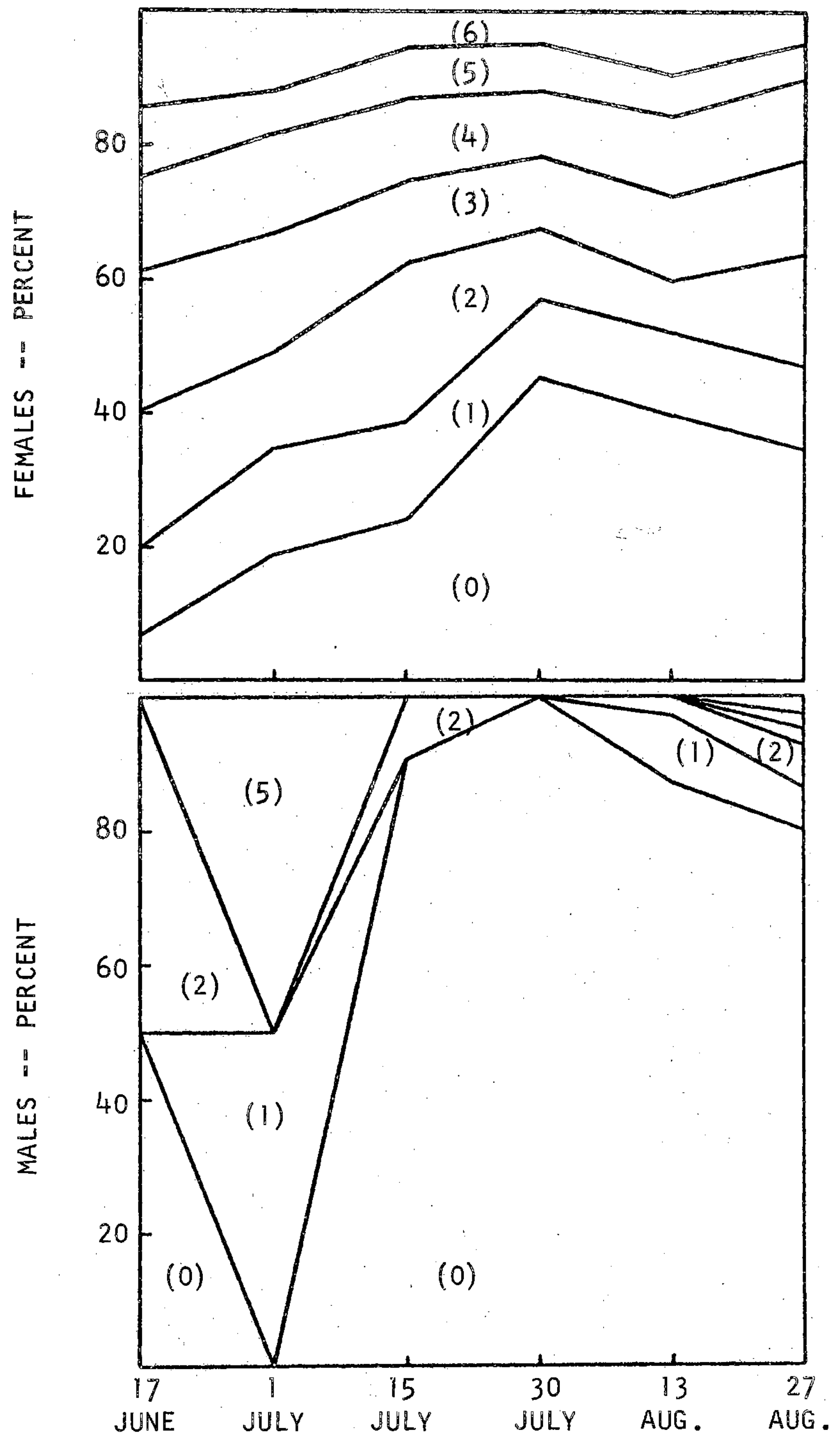

Fig. 20. Age structure of bats in Conner's Cave - 1963 season. Age class 0 = less than one year, 1 = one year, 2 = two years, 3 = three years, 4 = four years, 5 = five years, 6 = more than five years of age.

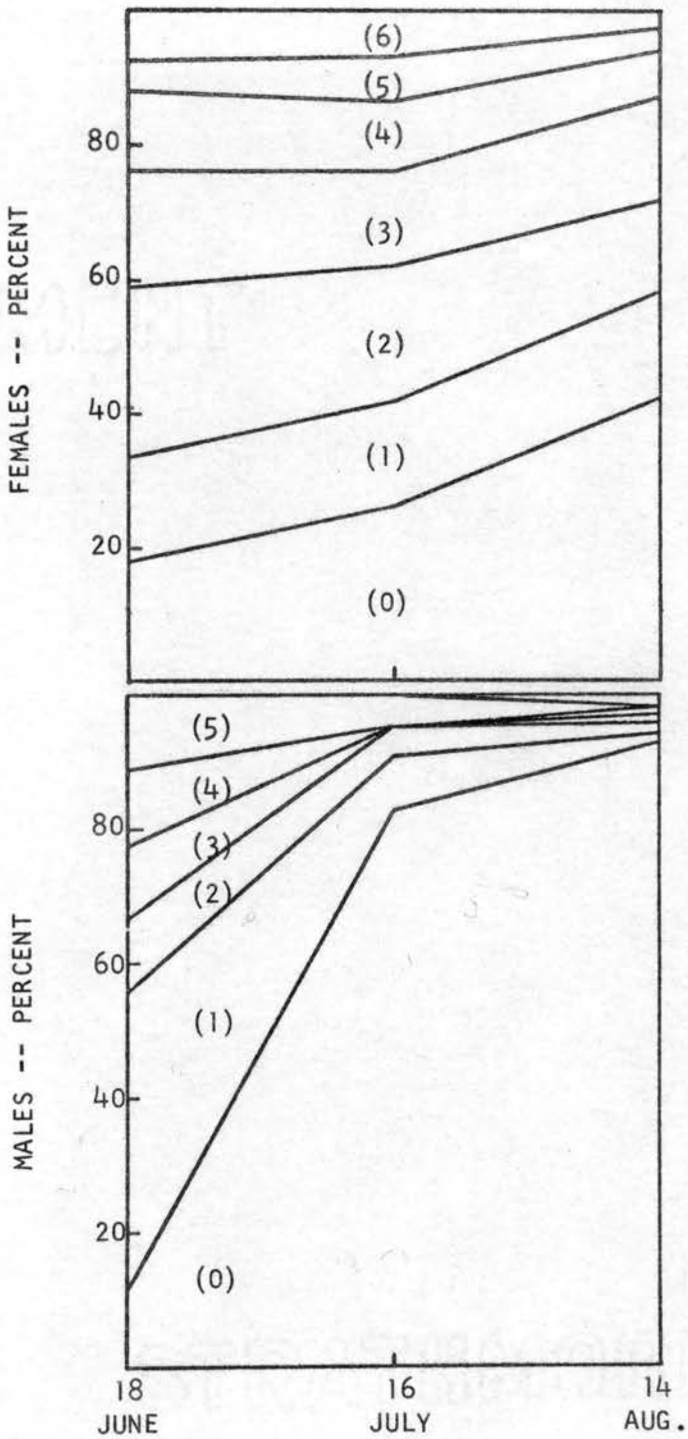

Fig. 21. Age structure of bats in Reed Cave - 1963 season. Age class 0 = less than one year, 1 = one year, 2 = two years, 3 = three years, 4 = four years, 5 = five years, 6 = more than five years of age.

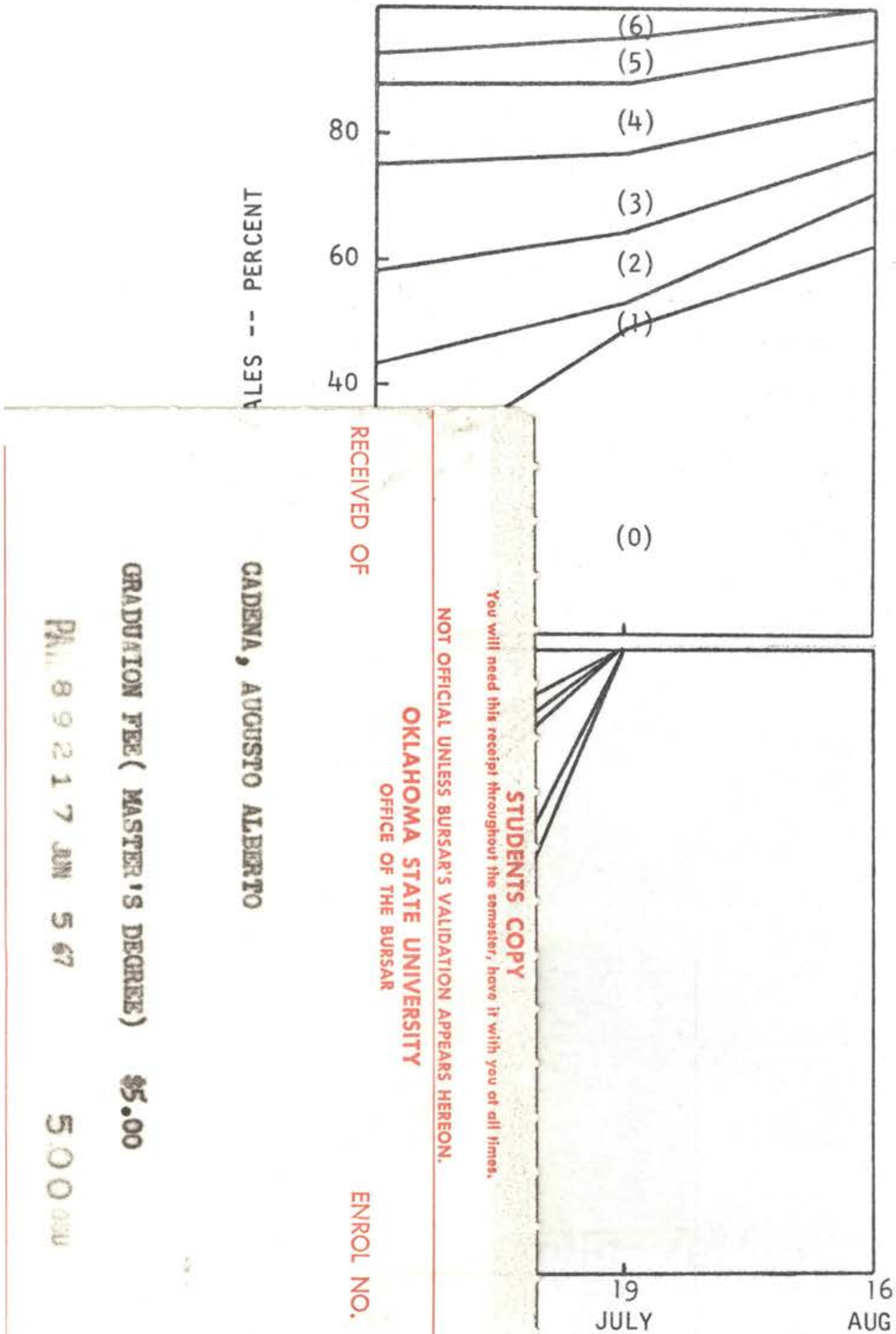

Fig. 22. Age structure of bats in Reed Cave - 1964 season. Age class 0 = less than one year, 1 = one year, 2 = two years, 3 = three years, 4 = four years, 5 = five years, 6 = more than five years of age.

TABLE VIII

AGE STRUCTURE OF GUANO BAT POPULATIONS IN FIVE OKLAHOMA CAVES

Age Class	Selman's	Vickery	Conner's	Reed	Merrihew
1963					
Female %					
0	24.96	25.71	22.54	26.89	12.98
1	8.18	9.52	11.36	13.80	6.87
2	10.56	10.59	14.01	16.39	9.98
3	9.58	9.29	13.24	13.33	6.65
4	7.49	8.06	10.08	8.02	6.22
5	4.93	4.68	6.15	4.36	4.40
6	5.75	5.45	7.26	4.72	3.22
Male %					
0	22.23	19.11	13.75	10.50	13.84
1	1.57	2.23	0.68	0.83	10.41
2	1.80	1.61	0.60	0.35	8.69
3	1.22	1.38	0.08	0.24	6.76
4	0.87	1.15	0.08	0.24	5.36
5	0.35	0.69	0.17	0.24	2.90
6	0.52	0.54	0.00	0.12	1.72
Number	(1,723)	(1,303)	(1,171)	(848)	(932)
1964					
Female %					
0		23.74		26.93	14.66
1		14.89		13.66	10.10
2		14.79		13.27	12.70
3		11.48		11.29	10.42
4		6.31		9.31	8.79
5		4.34		5.54	5.86
6		4.76		3.56	6.03
Male %					
0		11.27		13.66	5.86
1		1.55		0.40	6.84
2		1.86		1.39	5.05
3		1.76		0.20	5.70
4		1.24		0.00	3.91
5		1.03		0.20	1.47
6		0.93		0.59	2.61
Number		(967)		(505)	(614)

Age Classes - 0 = Less than one year, 1 = One year, 2 = Two years, 3 = Three years, 4 = Four years, 5 = Five years, 6 = More than five years.

red in all five caves in the state (Figs. 15 through 22). The magnitude of change was greater in the male component than in the female component. This pattern showed a marked increase in the number of young after the time of fledging in July and August. The increase in young was due to the new fledglings in the emergence flights. In the late summer and fall samples the young again decreased in number as fall scattering and migration to southern latitudes began.

There is some indication in the data that events such as peak parturition and fledging occurred at earlier dates in the southern caves. This is also reflected to some extent by the numbers of gravid females found in the population during the period from 22 June 1964 to 24 June 1964 (Table IX). This would indicate that the peak parturition occurred during the latter part of June and early July in Oklahoma; whereas, in Texas, it seemed to occur between the 8th and 19th of June (Davis, et al. (1962). The increase in numbers of young bats in the samples taken during emergence appeared earlier in Reed Cave and Conner's Cave than in the other caves in Oklahoma.

TABLE IX

COLLECTIONS OF GUANO BATS DURING JUNE 22 TO 24, 1964

Cave	No. Females	No. Males	No. Gravid Females	% Gravid
Reed	124	14	36	29.03
Vickery	81	19	60	74.07
Selman's	99	4	37	37.37
Conner's	102	0	14	13.73
Merrihew	65	36	59	90.77
Totals	471	73	206	43.74

Attrition and longevity

An indication of the attrition rates in the population can be obtained by analysis of the age structure in the population (Fig. 13; Fig. 14; and Table VIII). Since most of the males do not return to nursery caves only female age composition was considered.

The age structure of the Tadarida population in Oklahoma caves would suggest that mortality rates were higher in bats less than one year of age than in any of the other age classes. There appeared to be little mortality difference in the one year through four year old bats. In most caves in the study the percentage of individuals in the two year old class was equal to or exceeded the percentage found in the one year old class and in three of the caves; Selman's, Conner's, and Merrihew, the three year age class contained percentages above that of the one year age class. From this point onward, mortality ratios seemed to increase in stepwise fashion with increased age. The oldest class contained all individuals older than five years of age so percentages in this class would be expected to be higher than for the single five year age class.

The maximum percentage found in the oldest age group of the female component was 7.26%, the minimum was 4.84%. This would indicate that population turnover is probably complete in seven or eight years. This period is somewhat shorter than that indicated by Davis, et al. (1962). They suggested that about 75% of the female population should live to about 10 years of age. The difference undoubtedly lies in the two different methods used in population analysis. A study of the correlation of lens weight and tooth wear may aid in the understanding of this difference. Analysis of band recoveries would not indicate that population turnover required more than seven or eight years.

Only three individuals were collected during the entire study whose lens weight exceeded 1,000 micrograms. If the regression is linear beyond the five year age class, these few individuals would be about 11 years of age. Davis, et al. (1962) gave the maximum longevity for female guano bats as about 15 years. If the relationship beyond the five year class is not linear, which is quite possible, the maximum age in the present study would be higher and possibly approach the 15 year estimate given for the Texas population.

Postulates

Both sex ratio and age ratio data tend to indicate that Reed Cave and Conner's Cave serve primarily as female-dominant nursery caves. Selman's Cave and Vickery Cave had a more mixed population with higher percentages of males present during the season. Merrihew Cave seemed to serve as an overflow cave for the population during the present study. Possibly, population analysis in this cave could be used as an indicator of the status of Tadarida in the whole state since during low population levels it apparently is not used as a nursery cave and the male ratio is significantly higher than in the nursery caves.

The reasons for the similarity of Reed Cave and Conner's Cave populations are probably different for the two caves. It could be explained as follows: Davis, et al. (1962) suggested that breeding probably occurred in the southern latitudes. This may possibly be the factor which initiates migration to the northern latitudes for parturition. Data from the present and other studies suggest that the southern caves fill first in the spring. Later migrants are than forced to move farther north to find suitable caves for nurseries. Since Reed Cave is the southernmost cave in the state of Oklahoma it would be expected that this cave would fill somewhat earlier and serve primarily as a nursery cave. There is little difference in the latitudinal location of Selman's Cave, Vickery Cave, and Conner's Cave, so it would be expected that these caves should fill about equally and contain a similar age-sex ratio composition. This is not the case. Conner's Cave appeared to have a different composition. The reason for this is probably due to the relative size of the caves. Conner's Cave is the smallest of the five caves studied and at peak population levels is filled with bats from the back, well into the twilight area of the cave, similar to the situation observed at Reed Cave. Selman's Cave and Vickery Cave are larger than Conner's Cave and leave more room available. Suitable nursery domes in these caves are not always used and their use seemed to be dependant upon the overall magnitude of the population. Finally, Merrihew Cave would only be filled and used as a nursery during years when population levels would force the females to move farther north to find suitable nursery areas. It is possible that because of the colonial nature of this species, there may be an optimum density for the population in any cave and this could account for the movement of gravid females from Merrihew Cave to one of the other caves for parturition.

Even though the northern caves appeared to be marginal nursery caves and sometimes contained higher percentages of male bats than the southern caves, there was no indication that the male component of the population migrated to northern latitudes in magnitudes comparable to that of the female component. Most of the males seemed to remain in southern latitudes following fall migration.

Age structure analysis indicated that most of the mortality occurred during the first year after birth and after the third or fourth year after birth. Lower percentages in the one year age class than that found in the two and sometimes three year age classes would suggest the possiblity that conception rates may be lower in first year females. These barren females may not migrate or may move into overflow caves such as Merrihew Cave and not be found in the nursery populations. If this occurred, it could account for the lower percentages in this age class observed in all of the Oklahoma caves.

Most of the mortality in the population is probably due to accidents occurring to the young from birth through the first southward migration. It would appear that after this time mortality rates decrease greatly until after the fourth year at which time old age seemingly starts to take its toll.

These hypotheses are not proven by the present study but data obtained would strengthen these ideas. None of the data tends to disprove the hypotheses.

CHAPTER VI

SUMMARY

1. A study of the population structure of guano bats, *Tadarida brasiliensis mexicana* (Saussure), in five caves in western Oklahoma was conducted between June, 1962, and October, 1964. Equipment and techniques were devised to determine the applicability of the lens-weight method of age determination to bats. Nursery populations were analysed by this technique and age ratio tables constructed. Population composition between caves was studied and population compositions in selected caves were compared between two sucessive years.

2. The lens-weight method of age determination was found to be invalid for individual bats or samples of small size due to the magnitude of variation within age groups. An average difference of 1.46% of the average lens weight was found to exist between the two lenses of any individual bat. No significant difference was found to exist between the lens weights of males and females of the same age. Regression analysis of lens weights showed that between the ages of birth and 18 weeks a curvilinear relationship exists and this best fits the quadratic equation. Between one year and five years of age a linear relationship exists. There was an average annual increase in weight of 36 micrograms from one year through five years of age.

3. Population age structure was determined by applying decision criteria to the regression analysis of the one-year through five-year

age group. Seven age classes were delimited by points equidistant on either side of point estimates for any given age. Percentages of the population falling within each age class were determined for each cave for each collecting period. Little overall difference was observed in the age structure in the caves used as nurseries; however, Merrihew Cave, which was not used as a nursery, contained a population whose age structure differed greatly from the others. The number of younger-age females was smaller and the number of older-age males was larger in this cave. The age structure was relativly constant for the two years in the study. The bulk of the male population in nursery caves was made up of bats less than one year of age. The pattern of age structure change showed a marked increase of young after the time of fledging and then a decrease as the fall scattering and migration began to occur.

4. Sex ratios were disproportionate in all caves and varied with the time of year. In nursery caves the female percentages increased in the spring until maximal levels were reached during peak parturition and then decreased after fledging of the young. There was no indication of a disproportionate sex ratio in 50,000 neonatal bats banded during the study. The sex ratio in Merrihew Cave differed greatly from that found in the other caves. This cave contained a population with a much higher percentage of males at most times during the season. The overall female percentage for the season was 50.3% in 1963 and 65.8% in 1964. All of the other caves were over 72% females.

5. Attrition rates appeared to be highest during the first year of life. Between one year and three years little mortality appeared to occur and after four years mortality increased in a stepwise fashion with increased age. Population turnover seemed to be complete in seven

or eight years. Maximum longevity seemed to be between 10 and 15 years in the female component of the population.

6. The abundance of guano bats followed a cycle in which there was a fluctuating increase during the early spring. A stable population was attained just prior to parturition and this persisted until fledging of the young. The young in the population caused a marked increase in overall abundance and then in the fall a decline in number was observed from late August until late October. Populations were nonexistant from late October until early spring. In 1963 there was an estimated 6,060,000 guano bats in the state of Oklahoma at peak abundance. Population levels were higher in 1962 and lower in 1964. There was an estimated overall reduction of about 2/7 of the population over the three-year period.

7. Merrihew Cave seemed to serve as an overflow cave for the population. Vickery Cave and Selman's Cave appeared to have populations whose sex-age ratio structure differed somewhat from that found in Reed and Conner's Caves. The latter two seemed to serve as female dominant nursery caves, whereas Vickery and Selman's Caves contained a slightly more mixed population. Suitable nursery domes were not used in these caves in 1964 when population levels were lower than in preceding years.

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VITA

Alfred Eugene Perry

Candidate for the Degree of

Doctor of Philosophy

Thesis: POPULATION ANALYSIS OF THE GUANO BAT *Tadarida brasiliensis mexicana* (Saussure) USING THE LENS WEIGHT METHOD OF AGE DETERMINATION

Major Field: Zoology

Biographical:

Personal Data: Born in Pendleton, Oregon, January 12, 1931, the son of Aubrey E. and Essa Phelma Perry.

Education: Graduated from Columbia Academy, Battleground, Washington, in 1948; received Bachelor of Arts degree, 1953, and Master of Arts degree, 1958, with majors in zoology, Walla Walla College, College Place, Washington; completed requirements for Doctor of Philosophy degree, May, 1965.

Professional Experience: Graduate teaching assistant, Walla Walla College, College Place, Washington, 1953-1955; junior high school teacher, Boise Jr. Academy, Boise, Idaho, 1955-1956; biology teacher, Weiser High School, Weiser, Idaho, 1956-1958; vice president and general manager, N. C. Jones Contractor, Inc., Halfway, Oregon, 1958-1960; instructor in biology, Union College, Lincoln, Nebraska, 1960-1962; research assistant, Oklahoma State University, Stillwater, 1962-1965.

Member: American Institute of Biological Sciences, American Society of Mammalogists, American Ornithologists Union, Ecological Society of America, Phi Sigma Society, and Wildlife Society.