

THE ECOLOGICAL DISTRIBUTION OF BATS IN FLORIDA

By

WILLIAM LAMAR JENNINGS

A DISSERTATION PRESENTED TO THE GRADUATE COUNCIL OF
THE UNIVERSITY OF FLORIDA
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

JUNE, 1958

ACKNOWLEDGMENTS

An unusually large number of people have helped with this study and many of them are unknown to me. I want to express my particular appreciation to the following people who have made important contributions over long periods of time: Drs. Hardy, Scatterday and Schneider of the Florida State Board of Health arranged for the financial support of that agency and the National Institutes of Health. They also shared the administrative work created by the study.

Dr. O. E. Frye, Jr. and E. B. Chamberlain, Jr. ably administered the resources of the Florida Game and Fresh Water Fish Commission, which carried the burden of the field work. Efforts of the Wildlife Officers and technical personnel who organized the collecting system are especially appreciated.

K. D. Huett and K. E. Sprayberry bought and shipped live bats from the processing plants they supervised.

A number of friends and fellow students helped collect bats and rumors of bats. Dr. D. Caldwell, T. R. Hellier, D. W. Rice, Dr. P. G. Pearson and D. E. Swindell, Jr. made especially valuable contributions.

Members of my graduate committee, Drs. L. Berner, J. H. Davis, A. B. Grobman and J. N. Layne supplied advice on many problems. My chairman, Dr. B. B. Leavitt, helped in many ways and supplied counsel and guidance on academic and administrative problems.

My wife Patricia Jennings provided financial and moral support and cheerfully shared the harassments.

TABLE OF CONTENTS

Introduction	1
List of Bats Recorded from Florida	3
History of Bat Study in Florida.	4
Methods and Materials.	6
Distribution of Bats in the Faunal Regions of Florida.	30
Species Discussions.	42
Discussion and Summary	.110
Conclusions.	.118
Bibliography	.120
Biographical Sketch.	.126

LIST OF ILLUSTRATIONS

Maps

Map 1.	Collecting effort expended in public bat shoots in Florida expressed in man-evenings for the counties and regions where successful shoots were held.	10
Map 2.	Number of bats of all species taken by public bat shoots in the counties and regions where successful shoots were held	11
Map 3.	Bats taken per man-evening of collecting effort at public shoots in each county where successful shoots were held.	13
Map 4.	Location of the bat shoot transects used to supplement data from public shoots.	19
Map 5.	Localities where <u>Myotis austroriparius</u> has been taken in Florida	44
Map 6.	Location of <u>Myotis grisescens</u> colony roosts in Florida . . .	49
Map 7.	Locality where <u>Myotis keenii</u> has been taken in Florida . . .	51
Map 8.	Locality where <u>Myotis sodalis</u> has been taken in Florida. . .	51
Map 9.	Range and estimated abundance of <u>Pipistrellus subflavus</u> in Florida	56
Map 10.	Relative abundance of <u>Pipistrellus subflavus</u> in Florida. Breeding localities are shown.	56
Map 11.	Localities where <u>Eptesicus fuscus</u> has been taken in Florida.	63
Map 12.	Range and estimated abundance of <u>Lasiurus borealis</u> in Florida.	65
Map 13.	Relative abundance of <u>Lasiurus borealis</u> in Florida. Breeding localities are shown.	65
Map 14.	Range and estimated abundance of <u>Lasiurus seminolus</u> in Florida	73

Map 15.	Relative abundance of <u>Lasiurus seminolus</u> in Florida. Breeding localities are shown	73
Map 16.	Range and estimated abundance of <u>Dasypterus floridanus</u> in Florida.	89
Map 17.	Relative abundance of <u>Dasypterus floridanus</u> in Florida. Breeding localities are shown	89
Map 18.	Range and estimated abundance of <u>Nycticeius humeralis</u> in Florida.	93
Map 19.	Relative abundance of <u>Nycticeius humeralis</u> in Florida. Breeding localities are shown	93
Map 20.	Localities where <u>Corynorhinus rafinesquii</u> has been taken in Florida.	101
Map 21.	Location of <u>Tadarida brasiliensis</u> colonies in Florida . .	104

Figures

Figure 1.	Number of bats taken per unit of collecting effort at public shoots of various sizes	17
Figure 2.	Wear stages of the first upper molar used to separate age groups of all bat species.	28
Figure 3.	Sex and age distribution in 633 adult <u>Myotis</u> <u>austroriparius</u> examined	44
Figure 4.	Sex and age distribution in 155 adult <u>Myotis</u> <u>grisescens</u> examined	49
Figure 5.	Aggregation response in <u>Pipistrellus subflavus</u>	59
Figure 6.	Sex and age distribution in 248 adult <u>Pipistrellus</u> <u>subflavus</u> examined	60
Figure 7.	Aggregation response in <u>Lasiurus borealis</u>	69
Figure 8.	Sex and age distribution in 56 adult <u>Lasiurus</u> <u>borealis</u> examined	70
Figure 9.	Aggregation response in <u>Lasiurus seminolus</u>	78

Figure 10.	Nocturnal activity of <u>Lasiurus seminolus</u> and some other bats	80
Figure 11.	Sex and age distribution in 413 adult <u>Lasiurus seminolus</u> examined	80
Figure 12.	Aggregation response in <u>Dasypterus floridanus</u>	90
Figure 13.	Sex and age distribution in 273 adult <u>Dasypterus floridanus</u> examined.	91
Figure 14.	Aggregation response in <u>Nycticeius humeralis</u>	94
Figure 15.	Sex and age distribution in 174 adult <u>Nycticeius humeralis</u> examined	96
Figure 16.	Sex and age distribution in 311 adult <u>Tadarida brasiliensis</u> examined.	108

LIST OF TABLES

Table 1.	Bats collected by various methods in Florida during the study.	6
Table 2.	Seasonal returns from collecting	8
Table 3.	Number of public shoots held each month.	12
Table 4.	Number of bats collected by public shoots in each region .	14
Table 5.	Bats taken per man-evening of effort in each region by public shoots.	15
Table 6.	Bats taken in Florida by public shoots compared with those taken on transects	21
Table 7.	Bats taken in the North Florida Region by public shoots compared with those taken on transects.	21
Table 8.	Bats taken from Spanish moss	23
Table 9.	Grown bats taken from Spanish moss compared with those shot in the same general area.	23
Table 10.	Comparison of age distribution in <u>Myotis</u> populations. . .	46
Table 11.	Number of <u>Myotis austroriparius</u> collected each month . . .	47
Table 12.	Number of <u>Pipistrellus subflavus</u> collected each month by productive methods.	54
Table 13.	Relative regional abundance of <u>Pipistrellus subflavus</u> in Florida	55
Table 14.	Number of <u>Lasiurus borealis</u> collected each month by productive methods	66
Table 15.	Relative regional abundance of <u>Lasiurus borealis</u> in Florida.	71
Table 16.	Number of <u>Lasiurus seminolus</u> collected each month by productive methods	74
Table 17.	Relative regional abundance of <u>Lasiurus seminolus</u> in Florida.	75

Table 18.	Number of <u>Dasypterus floridanus</u> collected each month by productive methods.	.87
Table 19.	Relative regional abundance of <u>Dasypterus floridanus</u> in Florida	.88
Table 20.	Seasonal distribution of age groups in <u>Dasypterus floridanus</u>	.88
Table 21.	Number of <u>Nycticeius humeralis</u> collected each month by productive methods	.97
Table 22.	Relative regional abundance of <u>Nycticeius humeralis</u> in Florida.	.98

INTRODUCTION

This study is a part of a program of research begun in 1953 by the Florida State Board of Health aimed at identifying the reservoirs of wildlife rabies in Florida. Intensive study of the role of bats in this relationship was begun in August, 1954, and continued through September, 1957, stimulated by a flurry of attacks by rabid bats and supported by grants-in-aid from the National Institutes of Health.

In the beginning it was obvious that a thorough study of the distribution and ecology of bats was necessary to the logical pursuit of the primary goal. It was necessary to know what species of bats were found here, whether or not they migrated outside the state, what habitats were used for feeding, roosting and other activities, and what seasonal movements took place inside our boundaries. Data on life history, abundance and population dynamics were particularly desired.

These details were basic requirements for a thorough understanding of rabies epidemiology in our bats in addition to their intrinsic value as items of zoological interest. The findings contributing to the latter are presented here.

Florida is a particularly fortunate locale for this type of investigation because here the flora and fauna of boreal North America approach the tropics in a region where formidable barriers exclude most of the tropical bats found in the Antilles to the south. This selection of species is an example of geographical restriction of range without

any evidence of ecological replacement by other species. It should prove conducive to identification of some of the factors affecting bat distributional ecology.

A study covering 15 species inhabiting a state spread over 700 miles and designed to trace an infection identifiable in only a small percentage of the population obviously requires a large collection of specimens and a considerable amount of organization of the collecting personnel. Both were attained, but not without sacrificing some of the niceties of zoological collecting. It was particularly difficult to obtain data from cooperators on collecting failures, or the quantity of effort expended fruitlessly in searches for bat aggregations suitable for collecting by organized groups of bat shooters. These studies may be duplicated in other situations with confidence in the conclusions revealed by a comparison of results.

The purpose here is to attempt to utilize the material collected so as to elucidate factors affecting the ecological distribution of bats in Florida.

LIST OF BATS RECORDED FROM FLORIDA

Artibeus jamaicensis parvipes Rehn - Jamaican Fruit-eating Bat

Myotis austroriparius austroriparius (Rhoads) - Southeastern Myotis

Myotis grisescens Howell - Gray Myotis

Myotis keenii septentrionalis (Trouessart) - Keen's Myotis

Myotis sodalis Miller and G. M. Allen - Indiana Myotis

Pipistrellus subflavus subflavus (F. Cuvier) - Eastern Pipistrelle

Pipistrellus subflavus floridanus Davis - Eastern Pipistrelle

✓ Eptesicus fuscus fuscus (Palisot de Beauvois) - Big Brown Bat

✓ Eptesicus fuscus osceola Rhoads - Big Brown Bat

✓ Lasiurus borealis borealis (Muller) - Red Bat

✓ Lasiurus seminolus (Rhoads) - Seminole Bat

Lasiurus cinereus cinereus (Palisot de Beauvois) - Hoary Bat

✓ Dasypterus floridanus Miller - Florida Yellow Bat

Nycticeius humeralis humeralis (Rafinesque) - Evening Bat

Nycticeius humeralis subtropicalis Schwartz - Evening Bat

Corynorhinus rafinesquii (Lesson) - Rafinesque's Big-eared Bat

Tadarida brasiliensis cynocephala (LeConte) - Brazilian Free-tailed Bat

Eumops glaucinus (Wagner) - Eastern Mastiff Bat

HISTORY OF BAT STUDY IN FLORIDA

Any historical account of the study of bats in Florida can only be a summary, with deletions, of the study of mammalogy in the state. Most accounts of early bat observations are contained in general faunal studies or in taxonomic works resulting from sporadic collecting trips, often made as working vacations by the familiar pioneers of American mammalogy.

Good summaries of early mammalogy in Florida can be found in Chapman (1894) and Sherman (1937). Comments on mammal studies in the historical section of Howell's (1932) Florida Bird Life are also enlightening.

The earlier students and casual observers of natural history were attracted by more spectacular and useful animals than bats. Ribaut (Connor, 1927), Bartram (1791), Romans (1775), Williams (1827 and 1837), and Audubon (1831-1839) left no clear descriptions of bats. It was not until the last three decades of the nineteenth century that a beginning was made on a faunal list which included bats. Allen (1871), Maynard (1871 and 1873) and Rhoads (1894) made several contributions. Chapman (1894) referred to their works and to that of his collecting team and compiled a state list of ten species. Four of these, Pipistrellus subflavus, Lasiurus borealis, Nycticeius humeralis and Eptesicus fuscus include two forms each in Florida by present accounting. Thirty years passed before this list was expanded. Sherman (1934) added Myotis grisescens, Barbour (1936) Eumops glaucinus, Rice (1956) Myotis keenii, and

Jennings and Layne (1957) Myotis sodalis.

A number of mammal studies, primarily local faunal lists, added knowledge of range and natural history of the more common species. Those of Barrington (1949), Blair (1935), Frye (1948), Moore (1946, 1949 and 1949b), Pearson (1954), Pournelle (1950) and Schwartz (1952) contributed further to our knowledge of bats in Florida. Sherman's lists of Florida mammals (1937 and 1945) contained locality records of bats not published elsewhere. Only four studies were devoted to ecology or natural history of bats. Sherman (1937 and 1945) and Rice (1955 and 1957) reported on Tadarida brasiliensis, Dasypterus floridanus, Myotis austroriparius and Myotis grisescens respectively.

This was the status of our knowledge when the present study began. We had a reasonably complete faunal list, with some knowledge of the geographic distribution of species and races from various collections. Good studies had been made on the life history and ecology of two colonial species and rather incomplete data were available on two other species. Extrapolations were possible from studies in other states but little or nothing was known about relative abundance, seasonal movements, population structures, or habitats in Florida.

METHODS AND MATERIALS

Bats were collected by shooting at dusk, by purchase from Spanish moss gatherers, and by using hands and nets in colony roosts. A few were donated by the interested public who found them in a helpless condition or confiscated them from pets.

TABLE 1

BATS COLLECTED BY VARIOUS METHODS IN FLORIDA DURING THE STUDY

	Shooting	Moss	Colonies	Donated	Total
<u>Myotis austroriparius</u>	13	0	1535	2	1550
<u>Myotis grisescens</u>	0	0	203	0	203
<u>Myotis sodalis</u>	0	0	2	0	2
<u>Pipistrellus subflavus</u>	124	40	142	0	306
<u>Eptesicus fuscus</u>	6	0	6	0	12
<u>Lasiurus borealis</u>	108	2	0	0	110
<u>Lasiurus seminolus</u>	514	69	0	13	596
<u>Lasiurus cinereus</u>	0	1	0	0	1
<u>Dasypterus floridanus</u>	191	181	0	7	379
<u>Nycticeius humeralis</u>	188	3	5	2	198
<u>Tadarida brasiliensis</u>	71	0	1220	8	1299
<u>Eumops glaucinus</u>	0	0	0	3	3
Unknown Species (Unidentifiable)	7	0	1	0	8
Total	1222	296	3114	35	4667

Collection by Shooting

Shooting at dusk proved to be the most effective method for collecting the non-colonial species of bats. More than one hundred public bat shoots were organized by the Area Supervisors of the Game and Fresh Water Fish Commission. These shoots were held under conditions described below and produced ecological information as well as large samples of the bats flying at dusk at each shoot locality.

Each Area Supervisor, of which there were about 20 in the State, was asked to search for bats feeding in the two to four counties under his administration and to organize public shoots for those concentrations which could be shot. No attempt was made to hold shoots in every county. The basic collecting unit was the two to four county administrative area, four or five of which made up a region. Most supervisors selected one or two representative counties and spent all their efforts sampling bat concentrations in them.

The term aggregation is applied to most of these large feeding concentrations because some elements of social interaction were observed. Aggregations contain several species and are stable over long periods of time, if the supply of insects lasts. Heavy shooting does not appear to decrease the aggregation's size, apparently because many bats feed here for only a short time each evening and are replaced by newcomers as they leave. Thus an aggregation estimated to contain 40 bats may yield 100 or more to repeated shooting without an apparent decrease in size. This may be due to the attraction exerted by the volume of high frequency

TABLE 2
SEASONAL RETURNS FROM COLLECTING

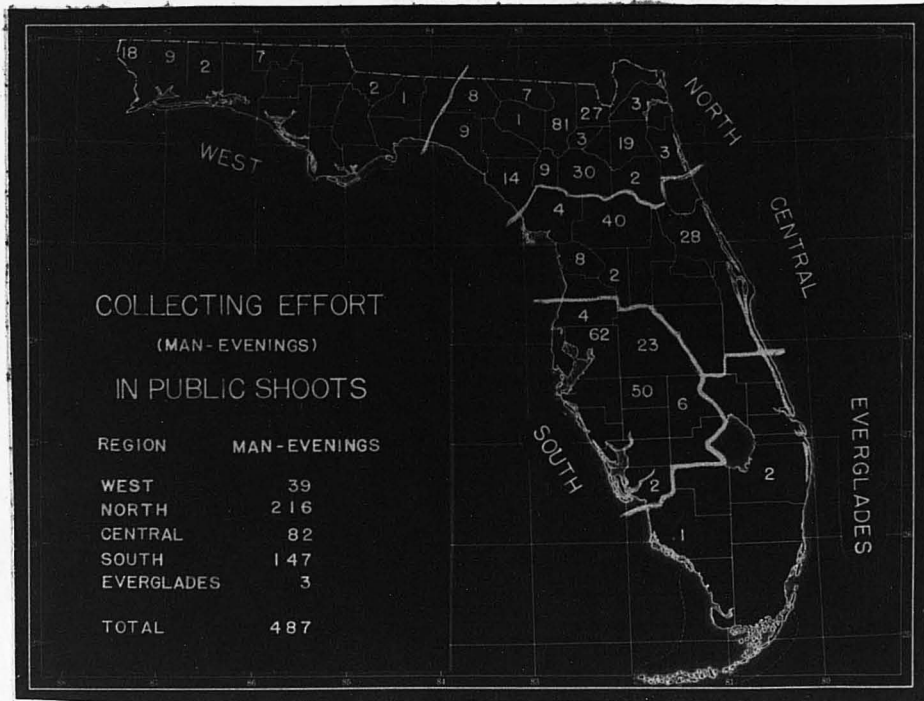
Month	Shooting	Moss	Colonies	Donated	Total
January	10	4	82	1	97
February	43	23	400	1	467
March	57	12	266	0	335
April	13	18	203	2	236
May	130	9	213	5	357
June	235	132	273	7	647
July	223	44	118	8	393
August	105	4	7	6	122
September	296	12	367	2	677
October	53	6	524	2	585
November	23	12	356	1	392
December	34	20	305	0	359
Totals	1222	296	3114	35	4667

sound produced by several feeding bats on others passing by. Griffin (1950) has pointed out that the noise level produced by one bat squeaking a short distance away exceeds that found in a boiler factory. The location of several dozen would appear to be broadcast over a great distance, indicating by permanence that a good supply of insects is found there.

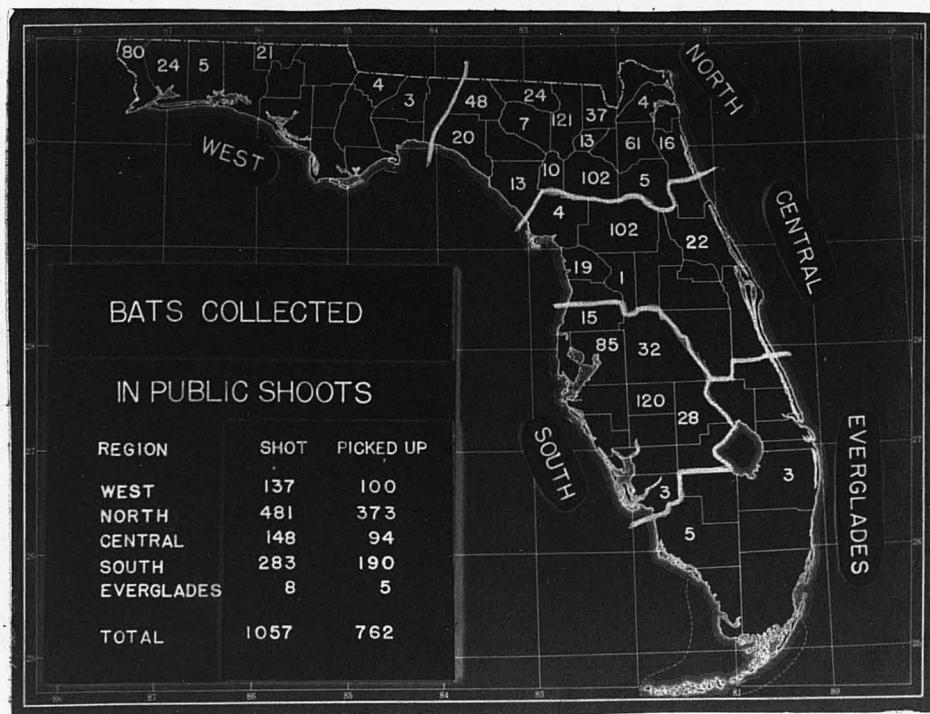
Ponds, fields, airports, pastures and other sites with open vegetation so bats could be seen flying, and sparse ground cover to facilitate recovery of downed bats were usually selected. After organizing the shooting party and holding a shoot each Area Supervisor filled out a shipping tag to accompany the bats giving the number of shooters, number of bats shot down but not found, weather, terrain, vegetation and other pertinent data. Most of these sites were later visited to check on the accuracy of terrain description. Of the shoots held under this system 93 were organized and recorded so that they could be considered standard public shoots.

Map 1 shows the effort expended in each county and administrative region in public shoots, expressed in units of man-evenings. This unit indicates the effort of one man, presumably an average hunter from the county, trying to shoot and pick up bats from the time the first feeding bats appear at dusk until it becomes too dark to shoot them effectively. The regions indicated on the map are administrative divisions of the Florida Game and Fresh Water Fish Commission, each containing four or five administrative areas supervised by an Area Supervisor.

Map 2 shows the number of bats recovered from these shoots in



Map 1. Collecting effort expended in public bat shoots in Florida expressed in man-evenings for the counties and regions where successful shoots were held.



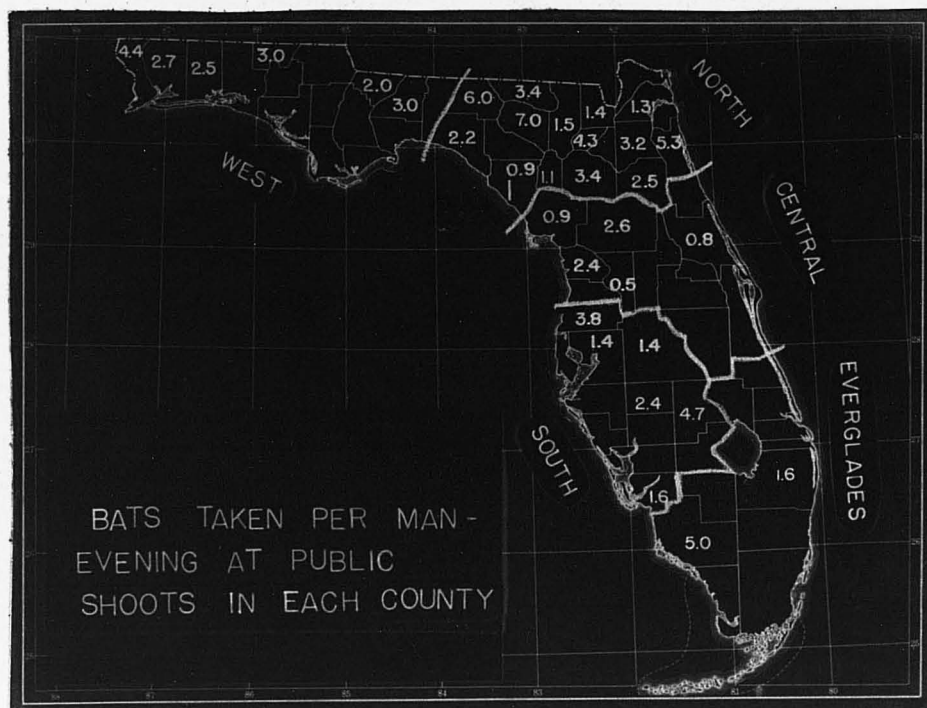
Map 2. Number of bats of all species taken by public bat shoots in the counties and regions where successful shoots were held. (Includes those bats reported as shot but not picked up.)

each county and administrative division of Florida. Successful shoots were held in 33 counties. Map 3 shows the return per unit of collecting effort in each county, based upon total number of bats of all species shot down, including those not picked up because of adverse terrain features.

TABLE 3
NUMBER OF PUBLIC SHOOTS HELD EACH MONTH

Month	Number	Month	Number
January	1	July	10
February	0	August	9
March	3	September	37
April	2	October	3
May	12	November	2
June	11	December	3
Total - 93			

Table 3 shows the number of shoots held each month. It is evident that bat concentrations are not common in winter when bats are only active during sporadic warm periods. During the five warm months bats were abundant and good concentrations were located regularly. The number of shoots held in September is a result of the increased population after young begin to fly as well as a greater tendency to aggregate



Map 3. Bats taken per man-evening of collecting effort at public shoots in each county where successful shoots were held.

when the mating season approaches. At that time concentrations are larger and more of them are encountered.

Table 4 shows the number of each species yielded by these shoots in each administrative region.

TABLE 4
NUMBER OF BATS COLLECTED BY PUBLIC SHOTS IN EACH REGION

Species Recovered	West	North	Central	South	Ever- glades	Total
<u>Pipistrellus subflavus</u>	4	29	19	5	0	57
<u>Lasiurus borealis</u>	32	44	7	5	0	88
<u>Lasiurus seminolus</u>	54	233	56	52	0	395
<u>Dasypterus floridanus</u>	1	29	2	99	0	131
<u>Nycticeius humeralis</u>	9	38	10	29	5	91
Total recovered	100	373	94	190	5	762
Bats not recovered	37	108	54	93	3	295
Total bats shot down	137	481	148	283	8	1057

Data from these shoots have been analyzed in two ways. First, it may be reasonably assumed that the Area Supervisors and their Wildlife Officers exerted a uniform effort over the state in an attempt to locate feeding bats. When these were located, the shooters necessary to adequately collect the feeding population were assembled. If this is true then the figures in Table 3 and Map 2 indicate the relative abundance of

feeding bats of each species at dusk in various sections of Florida.

On the other hand, it may be argued that for various reasons the intensity of collecting effort was neither random nor uniform over the whole state. If this is true then the abundance of bats feeding at dusk and the relative abundance of each species is indicated more accurately by the yield per man-evening of effort. Map 3 and Table 5 present these data by counties and by administrative regions. This presentation probably indicates the actual abundance most accurately because the first method of analysis over-emphasizes the abundance of the species which join large aggregations. Relative abundance in various habitats is indicated in the species discussions.

TABLE 5

BATS TAKEN PER MAN-EVENING OF EFFORT IN EACH REGION BY PUBLIC SHOOTERS

Region	Total Shot	<u>Pipistrellus</u> <u>subflavus</u>	<u>Lasiurus</u> <u>borealis</u>	<u>Lasiurus</u> <u>seminolus</u>	<u>Dasypterus</u> <u>floridanus</u>	<u>Nycticeius</u> <u>humeralis</u>	Bats Lost
West	3.5	.1	.8	1.4	.0	.2	1.0
North	2.2	.1	.2	1.1	.1	.2	.5
Central	1.8	.2	.1	.7	.0	.1	.7
South	1.9	.0	.0	.4	.7	.2	.6
Everglades	2.7	.0	.0	.0	.0	1.7	1.0

The tendency to seek large concentrations and therefore select in favor of the species which join feeding aggregations is an important factor affecting the accuracy of shoot data. Figure 1 presents a comparison of the yield per unit of effort (bats shot down per man) with total effort (total number of men shooting). This curve reflects two variables. First is the accuracy with which Area Supervisors estimated the number of shooters necessary to sample adequately the feeding aggregation. Observation of shoots in the field indicated that in few if any cases was the number of shooters excessively large when compared with the number of bats feeding in the vicinity. Although there was a general tendency for decreased return when ten or more shooters were used, this may not be significant due to the small number of such large shoots held. The significant drop in yield when six shooters participated is probably due to urging Supervisors to locate large concentrations which would justify employing this number. Perhaps in a few cases six shooters were used when not called for by the number of bats present.

A second variable is the tendency for some species of bats to join large aggregations more readily than others do. The curves in the species discussions indicate, for each species commonly taken by shooting, the yield per unit of effort in public shoots where various numbers of bats were shot down. Here it was assumed that the correct number of shooters was used to sample adequately the bats present. The number of bats taken is an indication of the size of the aggregation if this is true. It is evident that, of the species taken by shooting, all but Pipistrellus subflavus show a tendency to join aggregations of their

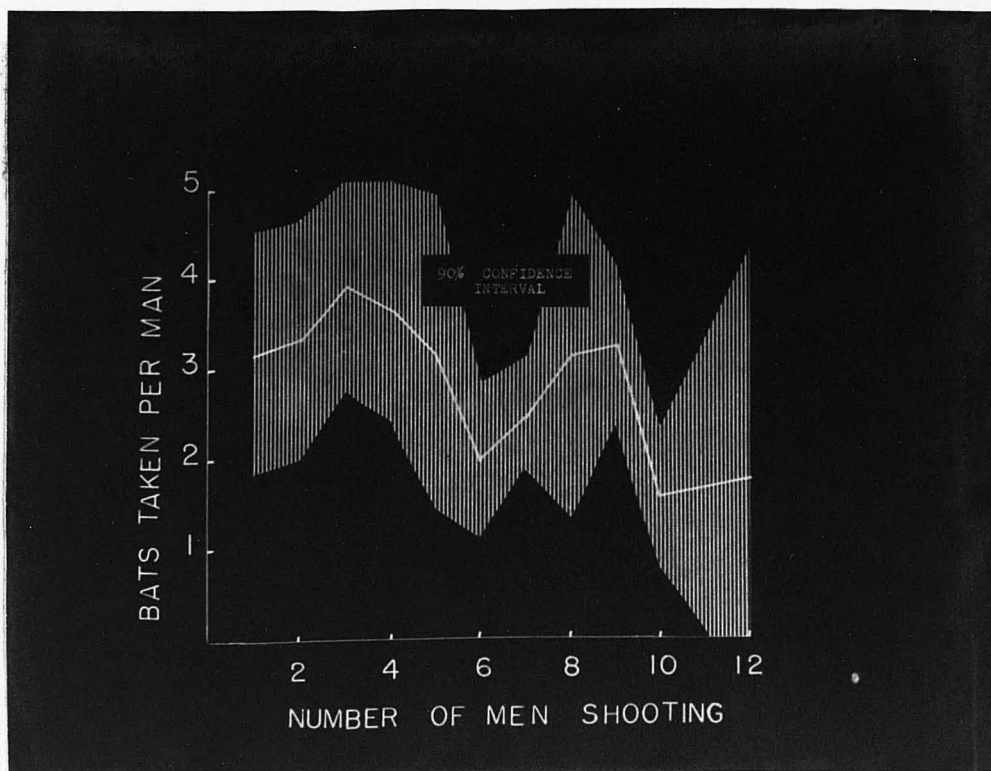


Figure 1. Number of bats taken per unit of collecting effort at public shoots of various sizes. (Bats reported shot down but not picked up were included in the tabulation.)

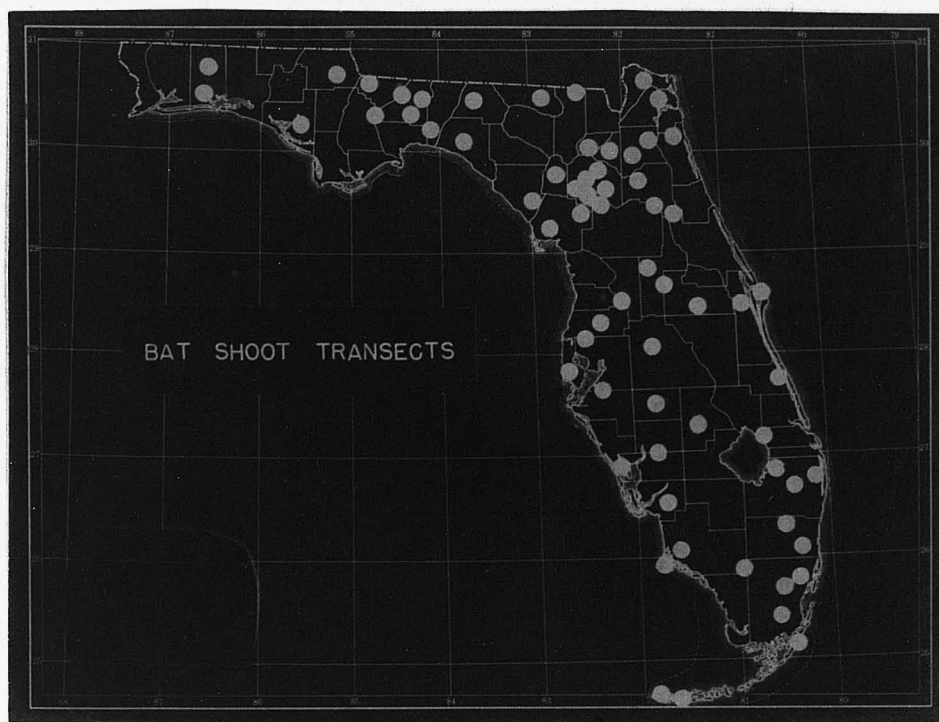
own or other species.

As data accumulated from shoots, certain sections of the state seemed to lack bat concentrations large enough to stimulate shooting by Area Supervisors. These areas were searched more intensively by driving slowly along roads through selected habitats, sometimes watching at ponds or other situations which seemed to offer good bat feeding conditions. Similar transects were run as controls in the North Florida Region where large samples had been taken by public shoots. These transects were run about 200 times in more than 50 localities (shown on Map 4) under conditions of weather, daylight and season favorable to bat feeding activity. The results generally upheld the previous indications of relative abundance from public shoots.

Bats shot in these searches were not included in the public shoot analyses. A comparison of species taken by the two shooting systems is presented in Tables 6 and 7.

The abundance estimated from shooting yields is indicated in two ways on maps accompanying the species discussions. Yield per unit of collecting effort at public shoots permits an estimate which is expressed in the terms abundant, common and few. These are assigned values according to the following scale:

- Abundant - usual yield more than one per man per shoot. (Three bats per man were often taken and eight was the maximum number reported for feeding aggregations.)
- Common - usual yield between one-half and one per man per shoot.
- Few - usual yield less than one-half per man per shoot.



Map 4. Location of the bat shoot transects used to supplement data from public shoots.

The estimated abundance was extrapolated to coincide with the range of plant communities in which shoots were held when a similar abundance in the community was indicated by transect observations, impromptu shooting, or other data.

Relative abundance, estimated from yields from all types of shooting and analyzed by county units, appears on a separate map, which also shows the locations where parturient females were collected. Here abundance in comparison with other species collected by shooting in the county is indicated, according to the following scale of values:

Predominant - the species made up one-half or more of the bats shot in the county

Subordinate - the species made up between one-tenth and one-half of the bats shot in the county.

In the counties where relative abundance is indicated, ten or more bats were shot. In half of these, between 25 and 150 bats were shot. Relative abundance reflects the frequency with which a species is encountered away from aggregations as well as its abundance in aggregations sampled by public shoots.

Census

A census technique designed to estimate the number of bats using a measured area was applied 460 times in 141 localities by some 30 of the technical personnel of the Florida Game and Fresh Water Fish Commission. The first year's results indicated that 70 per cent of the 316 randomly selected areas had no detectable use by feeding bats while more than half of the remainder were so heavily used that the randomness of their selection was suspect. The demonstrated tendency to

TABLE 6

BATS TAKEN IN FLORIDA BY PUBLIC SHOTS COMPARED WITH THOSE TAKEN ON
TRANSECTS

	Public Shoots		Transects	
	Number	Per Cent	Number	Per Cent
<u>Pipistrellus subflavus</u>	57	7	36	21
<u>Lasiurus borealis</u>	88	12	28	17
<u>Lasiurus seminolus</u>	395	52	65	39
<u>Dasyptherus floridanus</u>	131	17	18	11
<u>Nycticeius humeralis</u>	91	12	21	12
Total	762		168	

TABLE 7

BATS TAKEN IN THE NORTH FLORIDA REGION BY PUBLIC SHOTS COMPARED WITH
THOSE TAKEN ON TRANSECTS

	Public Shoots		Transects	
	Number	Per Cent	Number	Per Cent
<u>Pipistrellus subflavus</u>	29	8	33	22
<u>Lasiurus borealis</u>	44	12	24	16
<u>Lasiurus seminolus</u>	233	62	60	41
<u>Dasyptherus floridanus</u>	29	8	17	12
<u>Nycticeius humeralis</u>	28	10	13	9
Totals	373		147	

aggregate precluded any reasonable estimate of the total bat population with the resources available and so this activity was not carried beyond the field test stage.

Collecting by Purchase from Moss Plants

About 179 bats old enough to fly and 117 non-flying young were purchased by offering a bounty for live bats found roosting in Spanish moss, Dendropogon usneoides (L) Raf. This moss is processed commercially in the upper and middle peninsula for packing and upholstery materials. Seasonal workers gather moss during periods when other employment is not available, while a few people regularly engage in this work. The green moss is delivered to processing yards, of which there are two, one located at Apopka and the other at Bushnell. During the first year of purchases the Bushnell yard was moved in from Plant City. Table 8 shows the species received, separated by sex and age group. Table 9 compares the yield of flying age bats from moss yards with that obtained by shooting in the counties from which moss was purchased.

Collecting from Bat Colonies

Collections were made from the bat colonies located during an intensive search for colony roosts in caves and structures. Six species were taken by this method and four of these could be studied effectively only at their roosts. More than 25 caves were visited and eight Myotis colonies were located. Four of these were visited regularly over a three-year period.

TABLE 8

BATS TAKEN FROM SPANISH MOSS (COMMON SPECIES RECEIVED ALIVE ONLY)

Species	Total	Adults		" Babies "
		Total	Male Female	
<u>Pipistrellus subflavus</u>	40	25	7 18	15
<u>Lasiurus seminolus</u>	66	51	24 27	15
<u>Dasypterus floridanus</u>	161	98	41 57	63
<u>Nycticeius humeralis</u>	3	3	0 3	0

TABLE 9

GROWN BATS TAKEN FROM SPANISH MOSS COMPARED WITH THOSE SHOT IN THE SAME GENERAL AREA

Species	Moss		Shot	
	Number	Per Cent	Number	Per Cent
<u>Pipistrellus subflavus</u>	26	16	28	12
<u>Eptesicus fuscus</u>	0		1	
<u>Lasiurus borealis</u>	0		12	5
<u>Lasiurus seminolus</u>	51	28	116	49
<u>Lasiurus cinereus</u>	1		0	
<u>Dasypterus floridanus</u>	98	55	77	32
<u>Nycticeius humeralis</u>	3	2	4	1
Total	179		238	

Through numerous contacts about 35 bat colonies were located in structures such as houses, bridges, power plants, lumber mills, railway stations and storm sewers. Although some of these were not used more than once during the study it was usually possible to identify the resident bats. Only a few bats were observed while roosting outside established colony roosts and the details of these encounters are presented in the species discussions.

About 850 bats, taken by the Florida State Board of Health before the study began, were available for examination, although most of them lacked collecting data. Some valuable ecological notes were later extracted from this material and from the collectors.

Since these collections were intended for epidemiological study and zoological work was secondary, the condition of specimens and their fitness for examination should be described. All of the bats obtained by shooting and most of those collected in other ways were shipped to Jacksonville under refrigeration, many actually frozen. There they were thawed and the brains were taken out by removing the top of the skull. In most cases salivary glands and other attached tissues were also removed. The bodies were then preserved in a formalin-phenol-glycerin solution until identifications could be made. At this time they were transferred to 40 per cent alcohol.

These harshly shot insect feeders, subjected to the hazards of refrigeration in transit and inelegant surgery upon arrival, followed by delayed fixation, were often poor zoological specimens. They did yield data on reproduction, sex ratios and age. Spermatozoa did not

survive in recognizable form and were not found in preserved bats, although they were recovered, almost at will, in fresh material.

Tooth Wear and Age Estimation

It was considered desirable to develop a method for determining the approximate age of bats collected during the investigation. Such a technique would permit some insight into bat population structures and mortality rates.

Since almost all young bats of the species studied are born within a period of two months in May and June, it was possible to separate the females into two age groups rather easily at any time. Bats showing no evidence of having borne young could reasonably be assigned to the young of the year class, while those females which had enlarged mammae and uterine horns or placental scars could definitely be considered older than one year.

Tooth wear was investigated as a means for estimating age in the older group of bats, following the principles outlined by Anderson (1918). A trial was made with the yellow bat sample because of the number available which had been taken almost simultaneously and because of the conveniently large size of this animal. Females were separated into adult and subadult groups based upon morphological characters. Then the upper tooth row was extracted, mounted in plasticine clay and observed through a dissecting microscope equipped with an ocular micrometer. The following measurements were taken:

1. Incisor length - cingulum to tip.
2. Incisor wear face - maximum diameter of the face.

3. Canine length - cingulum to tip.
4. Canine wear face - maximum width of the wear face.
5. Premolar length - cingulum to tip, first premolar.
6. Premolar wear face - maximum width of wear face.
7. First molar wear face - length of wear face on infra-cone.
8. First molar wear face - width of wear face on postcone.
9. First molar wear face - length of wear face on postcone.
10. Second molar wear face - length of wear face on infra-cone.
11. Second molar wear face-width of wear face on postcone.
12. Second molar wear face - length of wear face on postcone.

Plane edges were used as wear boundaries rather than the edges of visible dentine.

These measurements were then graphed in pairs to test their constancy with each other and to help select the most useful ones. Most of the measurements showed some evidence of age correlated decrements. The two most promising ones, canine wear face and first molar wear face on the postcone, were tested further by plotting the wear measurement against month of collection. If the rate of wear is relatively uniform throughout life this procedure should result in a linear arrangement of the bats in order of their chronological age. If grouped into discrete wear classes, each one should correspond to a year class. A suggestion of this was obtained, but the grouping was not so clearly defined beyond the second year that actual wear-year correlations could be made. This portion of the sample was divided into arbitrary wear classes estimated to contain equal increments of wear. Much of the

overlap appeared to be due to more rapid wear during the summer and fall than during the winter months. The wear classes used here are arbitrary divisions of the wear observed and are not necessarily correlated with chronological age. Figure 2 shows the midranges of the various wear classes assigned to the molars of all species examined.

Wear classes were assigned to male yellow bats of two groups separated by testis size and these fitted the graph for females convincingly. Tooth wear is probably equal in the sexes.

Although it was not possible to separate bats older than one year into exclusive groups correlated with years of age, it was possible to estimate bat ages more accurately. A bat older than one year can be given an age relative to others of its group. This system permits estimates of comparative mortality at different ages and between the sexes. For the objectives of this study the use of these arbitrary tooth wear classes appeared to be satisfactory.

Summary

The materials examined included a large sample of the bat population segment feeding at dusk, with large samples from large feeding aggregations as well as bats collected where only a few individuals were seen. This sample was supplemented with collections made by taking advantage of the ecological adaptations of various species which permitted sampling population segments with different characteristics. Practically all of these bats were accompanied by reliable ecological data taken by the collectors and yielded more after they were examined

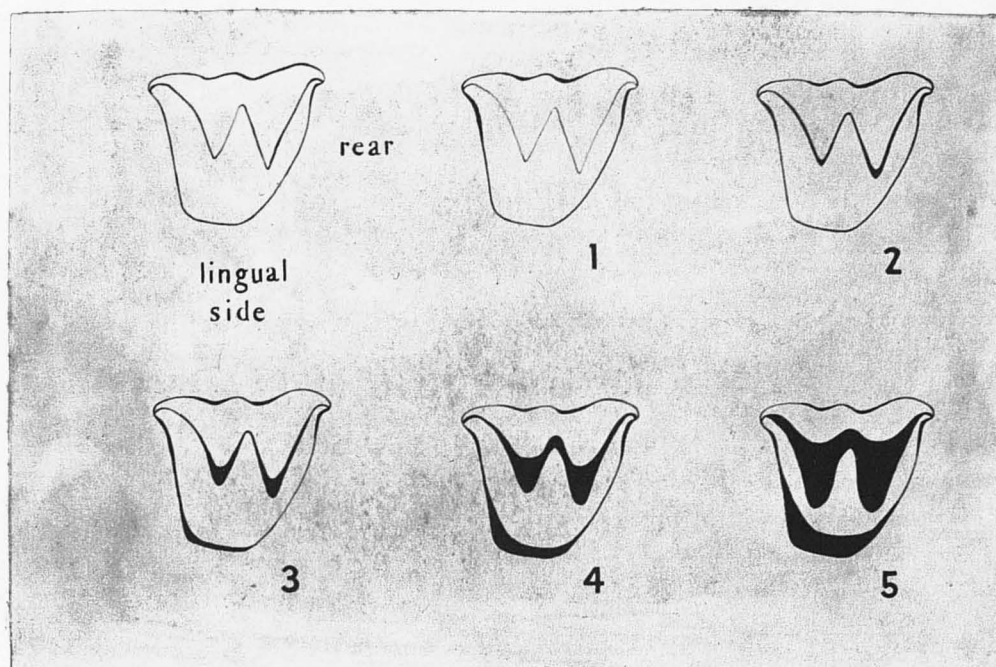


Figure 2. Wear stages of the first upper molar used to separate age groups of all bat species. (The amount of wear shown in each class example is approximately in the center of the range of wear assigned to the class.)

in the laboratory. Some other ecological information was obtained while observing flight habits and colony roosts, without collecting any bats. Interviews with collectors and observations of public shoots were also informative.

DISTRIBUTION OF BATS IN THE FAUNAL REGIONS OF FLORIDA

West Florida

Most of the region forming the panhandle of Florida is a reasonably homogenous unit with a continental climate. The plant communities fit easily into three natural groupings. In the northern half clay hills covered with pine or mixed pine and hardwoods are widespread. South of this community, rolling sandhills form a belt characterized by an open vegetation in which longleaf pine and turkey oak are dominant. In some areas pine flatwoods lie at lower elevations near the coast. In others the sandhills extend to the ocean or to sounds, which are protected by barrier islands off shore. Typically the strand vegetation is composed of the sand pine-dwarf oak community known as scrub throughout Florida.

Streams of various sizes penetrate these communities, some extending inland for many miles. Almost all of the larger ones are bordered with extensive floodplain swamps of cypress and mixed hardwoods. In the upper reaches there are low sandy areas usually covered with small cypress trees.

Civilization has brought little change to these communities. Timber and pulpwood, cattle grazing, tourism and large air force reservations are major categories of land use. They make little obvious change in the composition or extent of native vegetation. Agriculture is largely limited to the red clay lands and the low sandy areas near small stream heads. Here row crops and improved pastures

result in extensive clearings, but large areas of natural vegetation remain.

The common bats found here are:

Lasiurus seminolus

Lasiurus borealis

Pipistrellus subflavus

Nycticeius humeralis

Tadarida brasiliensis

The first four species were taken in all four plant communities but they were all scarce in flatwoods. The pine-hardwood covered red clay hills supported the largest concentrations of bats and yielded most of the specimens taken by shooting. Here Lasiurus borealis most nearly approached Lasiurus seminolus in abundance.

Tadarida colonies were common in buildings throughout the region and one of these yielded Eptesicus fuscus when the bats were shot as they emerged at dusk. Only two other species of bats have been taken in the region, Dasypterus floridanus and Lasiurus cinereus, and each is represented by a single specimen.

The Marianna - Appalachian Limesink Region

Near Marianna, Jackson County, and along the Chattahoochee-Flint-Appalachicola River system a region of large limestone caves and cool, deep ravines with steep sides serves as a refuge for elements of the northern biota. The trees suggest a northern mixed hardwood forest with beech and Trillium everywhere. Here also are two relics of earlier colder forests, the Florida yew, Taxus floridana Natt. and the stinking

cedar, Torreya taxifolia Arn.

It was in the caverns of this cool forest that Myotis keenii, Myotis grisescens and Myotis sodalis were found, roosting with Myotis austropiparius and Pipistrellus subflavus, some 200 miles south of the rest of their range. It was in this region that other bats with more northern ranges, Lasionycteris noctivagans, Lasiurus cinereas, and Myotis lucifugus, were expected to appear, but did not. The species common in nearby regions were scarce or absent here. It is not clear whether or not competition from the large numbers of cave bats excluded other species. The scarcity of surface water may have been influential. Lasiurus seminolus, Lasiurus borealis, Corynorhinus rafinesquii and Eptesicus fuscus have been taken here but they certainly were not common during the study and no public shoots were held. Seminole bats were abundant nearby, where clearings were made preparatory to damming the Appalachicola River. Further studies may yield interesting data on the fauna of this region where so many species reach the extreme southern limit of their range.

North Florida

North Florida, east of the panhandle and as far south as Marion County, closely resembles the West Florida region in climate, plant communities and bat fauna. The yellow bat is found in minor abundance and a cavern region similar to that near Marianna extends south in the western half. Trees of the mixed hardwood forest to the north gradually are replaced by broadleaved evergreen hardwoods until the distinctive hammock community of central Florida is predominant.

Major plant communities are hardwood forests known as hammocks, swamp, pine - turkey oak sandhills and pine flatwoods. Both hammock and swamp forests have closed canopies when undisturbed and bats were collected only where an edge of some kind was found. They were not observed to frequent unbroken stands of these communities while feeding, although Pipistrellus subflavus did enter under the canopy from a nearby edge. Several of Pearson's (1954) Corynorhinus rafinesquii were collected while roosting in deserted hunting shacks located inside an extensive hammock - swamp canopy, but no other evidence was gathered which indicated that the airspace within hammocks and swamps is utilized by feeding bats. Mist nets set here did not catch any bats. A similar situation exists for the area above the canopy, although most species taken near hammock edges sometimes sally out above the treetops for a short distance. Species collected by shooting in these communities were observed to confine their flight pattern almost entirely to clearings or their edges. Small ponds and clearings surrounded by a mile or more of unbroken forest canopy were not frequented by feeding bats. Since the feeding habitat of several of our bats, including Tadarida brasiliensis and Corynorhinus macrotis is not known, it would be unwise to postulate that this habitat, which was so extensive prior to the advent of western civilization, is not utilized. Perhaps further study will provide more definite evidence on this point.

Although all five species commonly collected by shooting were taken at edges in these two communities, Lasiurus borealis proved to be much less common than in West Florida while Dasypiterus floridanus

was more abundant here than anywhere outside of its principal range near Tampa. Dasypterus probably breeds here in limited numbers but conclusive evidence on birth and rearing of young was not obtained.

The pine - turkey oak community yielded few bats and no large feeding aggregations were found, but Pipistrellus subflavus, Lasiurus seminolus and Nycticeius humeralis were frequently collected along roads through it. Bats were not observed feeding under the canopy of mature stands of turkey oak, nor did the mist nets set here capture any. Lasiurus seminolus and Nycticeius humeralis were often observed feeding above this canopy however.

Several small feeding aggregations were encountered in the pine flatwoods community but all were restricted to clusters of mature pine trees or to cypress strands and bay heads. Bats were rarely observed feeding in the extensive open stands of pine trees. The few individuals collected here appeared to be in transit.

Colonies of Myotis austroriparius were found in caves and buildings in the western half of this region. Caverns are unknown in the eastern half and probably are necessary to the continued existence of colonies. Tadarida brasiliensis colonies were found in buildings throughout the North Florida region, as they were in the rest of the state.

The common bats found here are:

Myotis austroriparius

Pipistrellus subflavus

Lasiurus borealis

Lasiurus seminolus

Dasypterus floridanus

Nycticeius humeralis

Tadarida brasiliensis

Central and South Florida

Central and South Florida, or the region from Marion County through Brevard, Highlands and Lee Counties, have a similarity of climate, plant communities and bat fauna which makes it desirable to treat them as a single unit here.

The southern boundary approaches the subtropical in climate, including a narrow strip of that zone along the east coast, while the climate of the whole peninsula is tempered by the warm waters of the Gulf and Atlantic Ocean on either side. Numerous marshes and shallow lakes occur throughout, but especially in the eastern half and along the ridge which forms the central axis from north to south.

The vegetation of the ridge is primarily of pine - turkey oak community, with some admixture of scrub. An extensive area of scrub is found in eastern Marion County. To the eastward, the high sandhills of the ridge drop off to the broad valleys of the St. Johns and Kissimmee rivers. Open vegetational communities predominate here, with sandy prairie land, pine flatwoods and fresh water marches covering wide areas. Clumps and strips of hammock vegetation occur along streams, where sandy prairie land drops steeply into flood plains, and along the ridges of the coast. All species of bats found here appear to be

restricted to these small areas of hammock vegetation, since none were collected or observed in sandy prairie land, fresh water marsh land or the pine flatwoods of the east coast. Collecting was unproductive in the hammock areas of the east coast, but lasiurine bats were observed in several locations. Prevalence of high winds and the intensive real estate development restricted feeding aggregations to small size and made collecting difficult when bats were located. Observations indicate that Lasiurus seminolus, Dasypterus floridanus and Nycticeius humeralis probably occur commonly. Several Tadarida colonies were reported, but no occupied bat roosts were found. The scarcity of bats may have been more apparent than real, but here we find more plant communities, each covering an extensive area, that appear to lack bat populations.

West of the ridge a contrasting abundance of bats was observed. Here also the topography is low and flat, but with hammock and swamp vegetation bordering most of the rivers and streams and covering the submerged deltas near the coast. Low pine flatwoods cover most of the intervening areas but here, possibly due to the presence of large phosphate rock deposits, small clumps of hammock trees occur frequently. This area, and the adjacent portion of the central ridge constitute the range of the surprisingly abundant population of Dasypterus floridanus encountered during the study, while most other species are common, at least in the northern portion. Lasiurus borealis and Pipistrellus subflavus gradually disappear from collections in Hillsborough and Polk counties, while Lasiurus seminolus was not taken south of Highlands

and Hardee counties. The last two probably occur, at least sporadically, along the Peace and Caloosahatchee rivers, however. Nycticeius humeralis maintains its uniformly subordinate abundance southward through the region, at least along the coastal flatwoods strip.

Tadarida colonies occur commonly in buildings throughout the western half of the region. Myotis austroriparius probably reaches its southern range limits in the limestone caverns of Pasco and Hernando counties, with an isolated and sporadic occurrence in caverns near Apopka, Orange County. It has been taken in hollow mangrove trees in Tampa Bay and may breed in the vicinity, perhaps in buildings sheltering Tadarida colonies, but there is reason to doubt that this species of Myotis can maintain itself in regions where caves are not available.

Eptesicus fuscus osceola is confined to this region, and to the western half of the peninsula so far as is known.

This appears to be an ecologically critical region for bats and much remains to be learned about the occurrence of various species here. Certainly the species with northern affinities decrease in abundance and this appears to be correlated with the gradual disappearance of broad leaved forest vegetation.

Common bats of Central and South Florida are:

Myotis austroriparius

Lasiurus seminolus

Dasypterus floridanus

Nycticeius humeralis

Tadarida brasiliensis

Subtropical Florida

The southern tip of the Florida peninsula differs from the rest of the state vegetationally in having a narrow strip of tropical vegetation bordering a large inland marsh. The coastal strip has been described by Davis (1943) as a rim of higher land around the Everglades. On the east coast this rim is centered about a rocky ridge of Miami oolite covered with Southern slash pine-dominated Miami Pineland. This community has an open aspect. Seaward, narrow strips of scrub surmount the dune ridges while tropical hammocks, now largely replaced by tropical dooryards, occupy the lower, more fertile areas. Inland, open stands of cypress trees dominate the lower areas with cypress stands bordering natural waterways. Canals usually are bordered with Australian pine plantings, often with an understory of guava and other shrubs.

Bats were observed only in the tree-dominated communities. The tropical hammock areas have yielded Dasypiterus floridanus, Lasiurus seminolus, Eumops glaucinus and Tadarida brasiliensis during the study and earlier (Moore, 1949 and Schwartz, 1952). Nycticeius humeralis has been taken inland in the flatwoods and in the cypress strands.

Poor yields from the shoot organization and observations on transects indicate a sparse bat population south of Punta Gorda, Sebring and Vero Beach, although it is not uncommon to see Nycticeius circling about a clump of Australian pines or in the gap cut through a cypress strand by a highway. Schwartz (1952) reports this species roosting in hollow pines in typical Miami Pineland. Our efforts yielded none. The bats taken by the natives probably reflect intense human use of the bat habitat.

Both Lasiurus seminolus and Dasypterus floridanus breed in the region and young have been taken, although all of our specimens were found in a moribund condition in dooryards, usually beneath broad-leaved fruit trees. These tree-roosting species apparently reach their southern distributional limits in the broad leaved vegetation of residential areas near Miami and Fort Myers.

Distribution of the freetails is less well documented in the region. Eumops glaucinus is known from perhaps as many as 20 specimens, all taken in residential Miami, Coconut Grove and Coral Gables. Most of these were taken from buildings, low shrubbery or similar ruderal situations but under such conditions that it seems unlikely that they are the usual roosting places of the population as a whole.

Tadarida brasiliensis colonies are found throughout the region where suitable roost sites exist. Specific records include Opalocka and Marco Island (Schwartz, 1952) but numerous descriptions of large, odoriferous bat colonies were received. The more reliable reports were from Kendall, Fort Myers, Fort Bassinger, Okeechobee and South Miami. All of these colonies were located in buildings or similar structures.

Bats of all species are uncommon here.

The Florida Keys

The Florida Keys, which offer migrating birds a welcome pathway, leading to the tropics, apparently do not function in this way for bats. None were collected or reported from the area during the study despite an intensive search. More than 20 residents, bird watchers, nurserymen,

pest control specialists, and others were contacted, some of them repeatedly, over a period of three years. Transects were run in the town of Key West and at a large borrow pit filled with brackish water on Big Pine Key, the two localities which seemed to represent the most attractive habitat for bats. No bats were observed.

There is evidence for isolated occurrences of bats in the Keys. Maynard (1883) identified a drawing of bats he received there as Artibeus jamaicensis. He also reported seeing bats flying at dusk over Key West. Myotis austroriparius has been reported from Key West (Hamilton, 1943) although Rice (1947) was not able to substantiate this record in his study of the species in Florida, and considers this a record of an extreme wanderer.

John Curry recalls a bat found dead in Rock Harbor after a hurricane which was shown around town as a curiosity. He had visited the Bahamas several times and thought the dead one very similar to the bats found in caves there. Neither he nor his brother have ever seen bats in the Keys other than this one although both have lived there more than 50 years.

Stuart Whiting, past president of the Key West Audubon Society, reported having seen a bat on one occasion in 1950 at the Botanical Garden on Stock Island. Ralph Millner, United States Plant Quarantine Agent, resident in Key West more than 20 years, recalls seeing a bat long ago but has seen none in recent years.

At least 2500 bats, probably Tadarida brasiliensis from Texas, were released at Perky in 1929 as a mosquito control measure by Jack

Perky. The tower he constructed to house them and collect their guano still stands, although it held neither when the writer visited it in 1956. The present owner reports that he has never seen bats in the vicinity, or anywhere else in the Keys.

These reports indicate sporadic introduction by various agencies without successful establishment, in recent years at least. Similar accidents are credited with the successful introduction of Eumops glaucinus into the Miami area and are probably responsible for the distribution of various bats in the Bahamas (Koopman et al., 1957).

Geographically, the Keys are at least as eligible for introductions from Cuba and the other Antilles as the Florida mainland or the islands of the Bahamas are. Establishment may be precluded by the absence of open bodies of fresh water suitable for drinking in flight and by the tourist boom which concentrates the demand for space and for mosquito control in the most attractive bat habitats. These eliminate vacant or delapidated buildings and most insects, to the obvious detriment of a potential bat population.

SPECIES DISCUSSIONS

Artibeus jamaicensis parvipes Rehn

RANGE - Cuba, perhaps extending to Key West, Florida. Races of the species are found from Brazil to southern Mexico, in the Antilles and Jamaica.

The Antillean fruit bat has been reported from Florida only once (Maynard, 1883). Dr. Harrison Allen identified a drawing of a bat brought to Maynard in Key West as this species. Maynard also reported seeing bats in flight over the Keys during the same period. Chapman (1894) commented: "It is doubtful if this species is more than an accidental visitant in Florida. Mr. Maynard speaks of seeing high-flying bats which he supposed were the same as the specimen brought him, but Artibeus is a forest-inhabiting fruit-eating bat and is rarely observed in the open even in localities where it is abundant."

During the study efforts to collect or observe bats in the Key West area were profitless. It seems doubtful that this species or any other is now resident in the Florida Keys.

Myotis austroriparius austroriparius (Rhoads)

RANGE - The Florida peninsula, southern Alabama and southwestern Georgia. Other races of the species occur in Louisiana, Arkansas, Illinois and Indiana.

The race of Myotis austroriparius found in Florida is abundant in the two cavern regions of the state and appears to be restricted to them. Maternity colonies and hibernating groups were also found in

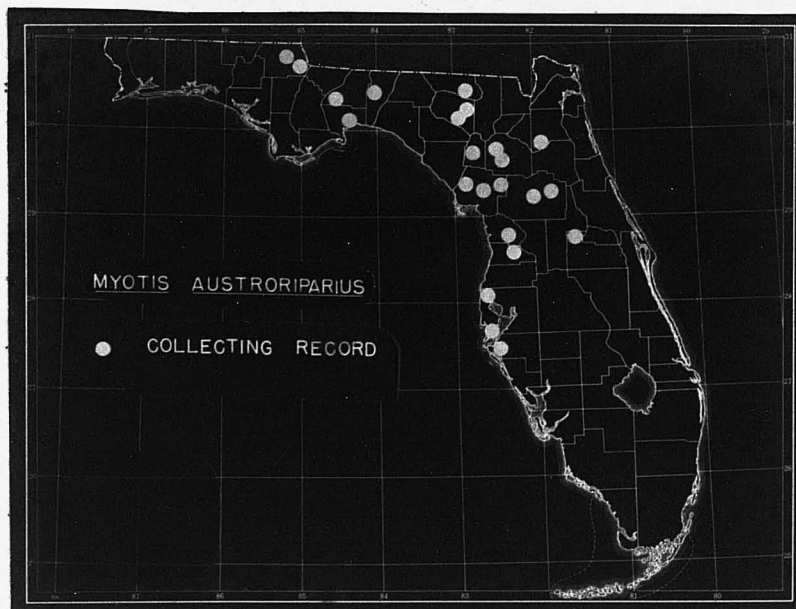
buildings and beneath bridges. Although this species was not taken by systematic collecting away from the immediate vicinity of caves or other colony roosts, feeding individuals were shot at will near Gainesville, weaving sinuously over the surface of pools of water. The feeding flight was never more than a foot above the water and usually began so late that a flashlight was necessary for shooting. At a cave about eight miles west of Gainesville, and about the same distance from open water, this bat fed over the adjoining pastures.

Map 5 indicates the location of collecting sites where this species has been taken in Florida. Most of these are colony roosts used during the study but some of them were not near known caves and could not be linked to any maternity colony.

Roosts and localities where this bat was taken are confined to the regions of karst topography and there seems to be no direct relationship with vegetation. Hammock and pine (Pinus palustris) - turkey oak (Quercus lacvis)* communities are characteristically found near caverns in Florida.

Rice (1957) reports an intensive study of this bat in Florida and presents the features of its ecology. In the peninsular cavern region maternity colonies are usually in large caverns containing water, although some have been located in attics and under bridges for many years. Water seems to be an important feature, since maternity colonies often abandon caverns when the water recedes, leaving the floor dry. In

*Names of trees from West and Arnold, The Native Trees of Florida. Gainesville, Florida: University of Florida Press, 1948.



Map 5. Localities where Myotis austroriparius has been taken in Florida.
The solid circles indicate colonies.

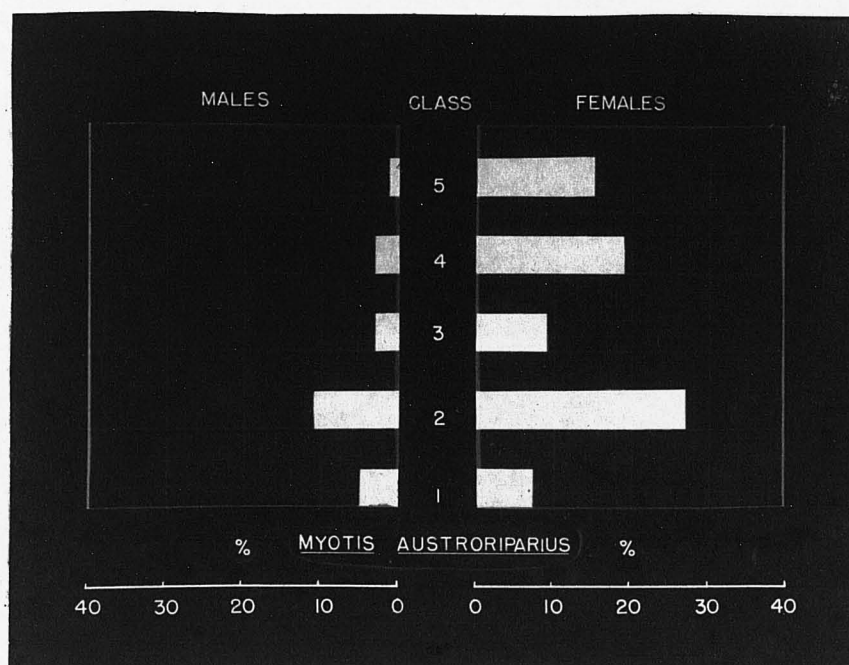


Figure 3. Sex and age distribution in 633 adult Myotis austroriparius examined.

these maternity colonies females predominate (more than 70 per cent) (Rice, 1957) and practically all of them are actively reproducing. Males apparently roost outdoors in summer. These caverns are uniformly warm, with temperatures averaging about 70°F, and successful hibernation is probably impossible in them. In winter both sexes leave the caves to roost in less temperate situations and become active during periods of warm weather.

In the Marianna cavern region the colder caves permit an activity pattern commonly found in northern climates, with both sexes hibernating in caves that serve as maternity colony roosts in summer. Males appear to roost outdoors during the summer in both regions.

Rice (op. cit.) has discussed thoroughly the ecological significance of two young per litter, found in this species, rather than the single one born to northern species of Myotis. The habit of roosting outdoors much of the year and remaining active during the mild winter probably results in increased mortality in Florida. Evidence of predation by rat snakes, opossums and owls was secured during the study. Most of the caverns available are not used for roosts and so maternity roosting sites probably are not a limiting factor.

Rice's estimate of 155,000 individuals, or one bat per 8.3 acres of habitat in the peninsular cavern region, is unique and no comparison with other species is possible.

It is estimated that males may constitute as much as 40 per cent of the population but often they are present in smaller numbers, probably because their roosting habits differ from those of females.

Data from Rice (op. cit.) on this species and Stegeman on Myotis lucifugus (1956) showing estimates of age composition in their samples, based on banding data in the first case and tooth wear in the latter, are presented in Table 10. From these comparisons it is clear that age distribution and mortality rates in cavern dwelling bats merit further study. It appears, however, that these are relatively long-lived bats with higher mortality rates in the juveniles and young adults. Data gathered during this study are presented in Figure 3.

TABLE 10

COMPARISON OF AGE DISTRIBUTION IN MYOTIS POPULATIONS

Age in years	<u>Myotis austroriparius</u> (Rice, 1957)	<u>Myotis lucifugus</u> (Stegeman, 1956)
	per cent	per cent
1	47	33
2	18	36
3 plus	35	31

Males evidently have higher mortality rates and shorter life expectancy than do females due to roosting outdoors in more exposed situations. In females the heavy mortality appears to be in the first year, with long life expected for those surviving the first winter.

TABLE 11
NUMBER OF MYOTIS AUSTRORIPARIUS COLLECTED EACH MONTH

Month	From Colonies in Caves and Structures		Month	Number
	Number			
January	1		July	103
February	135		August	0
March	109		September	69
April	6		October	446
May	165		November	349
June	50		December	102
Total 1535				

Tooth wear is slower in Myotis austroriparius than it is in the non-colonial species. Recoveries of banded individuals indicate that bats more than four years old may be common in the population. The tooth wear classes in Figure 3 probably contain decrements representing more than one year of wear. For this reason the data are not comparable with other species and are only intended to permit comparison of the age structures and indicate differences in mortality rates between the sexes.

Myotis grisescens Howell

RANGE - Cavern areas from southern Indiana and Illinois south to Tennessee, Georgia, northwestern Florida and central Alabama west to southwestern Missouri and northern Arkansas.

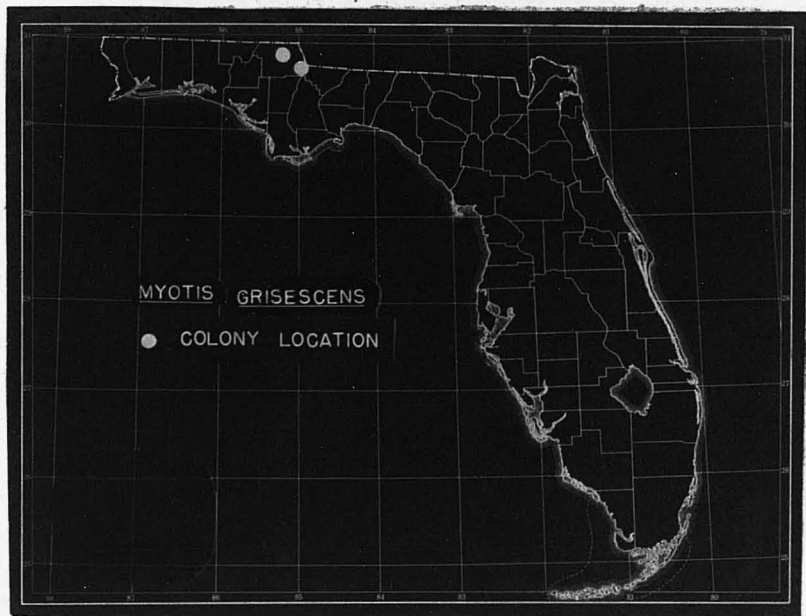
The status of our knowledge of the Florida population of Myotis grisescens has been accurately summarized by Rice (1955). An additional cave used as a breeding site was located during the study, but the field work generally substantiated Rice's observations.

The known Florida population of this species does not exceed 8000 adult individuals just before young are born in May, assuming a 50:50 sex ratio (Smith, 1957). Band returns indicate that bats banded in one cave may appear in any of the other caves frequented by this species, all of which lie in the cavern region of Jackson County.

Males older than a few months are rarely found in the nursery caves but more than 2000 of these, together with about 800 females, were found in Old Indian Cave in October 1956. Adult females are in the minority in the hibernating caves but apparently roost elsewhere during the winter since I have never found more than 800 hibernating females of this species.

These features seem consistent with those expected in a stable population resident in Florida and relatively isolated from the Tennessee-Alabama population some 200 miles to the north. Limited winter banding of hibernating bats has not produced any returns to indicate migration across the intervening coastal plain, but larger banding efforts will be necessary before the degree of isolation can be determined.

Old Indian Cave has unique features not found in most Florida caverns and these probably account for Myotis of several species hibernating in it alone of the numerous caverns available. The most important difference from other caverns is in elevation, since it is a



Map 6. Location of Myotis grisescens colony roosts in Florida.

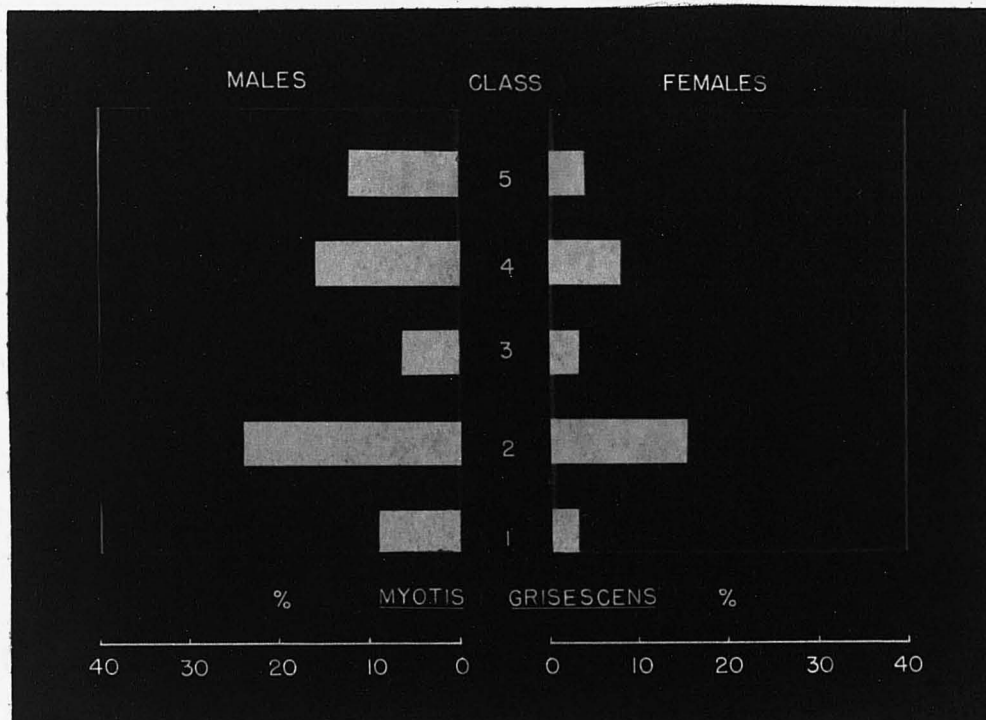


Figure 4. Sex and age distribution in 155 adult Myotis grisescens examined.

hollow chamber in a hill of limestone covered with northern forest trees. Three entrances lead to the bat chamber through passages of different lengths and permit a flow of air with almost every wind. In winter this produces temperatures at least as low as 46°F in the bat chamber, almost unknown elsewhere in Florida caverns, which average from 68° to 73° in all seasons. This one physical characteristic may be responsible for the establishment of Myotis grisescens in Florida. Perhaps it also is responsible for the records of two other species, known only from hibernating individuals collected in Old Indian Cave.

Myotis keenii septentrionalis (Trouessart)

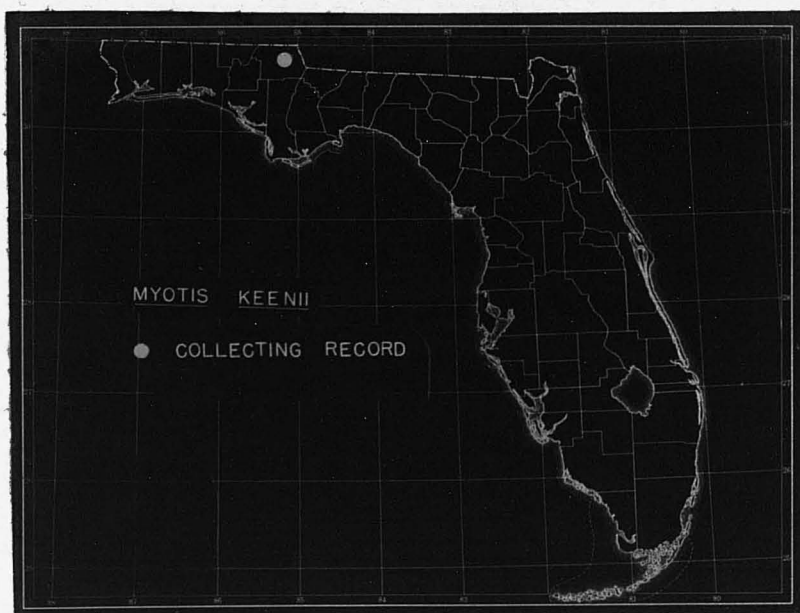
RANGE - Eastern North America west to Manitoba, North Dakota, Nebraska, Missouri and Arkansas and south to Tennessee, Georgia and Florida.

The sole Florida specimen of Myotis keenii septentrionalis was taken in Old Indian Cave, Jackson County by Rice (1955). He emphasizes the single occurrence among the many bats he examined in the area. Subsequent collections during the winter months have failed to yield additional specimens and indicate the probability that the one taken was a wanderer, not a representative of a local population restricted to the Marianna cavern region.

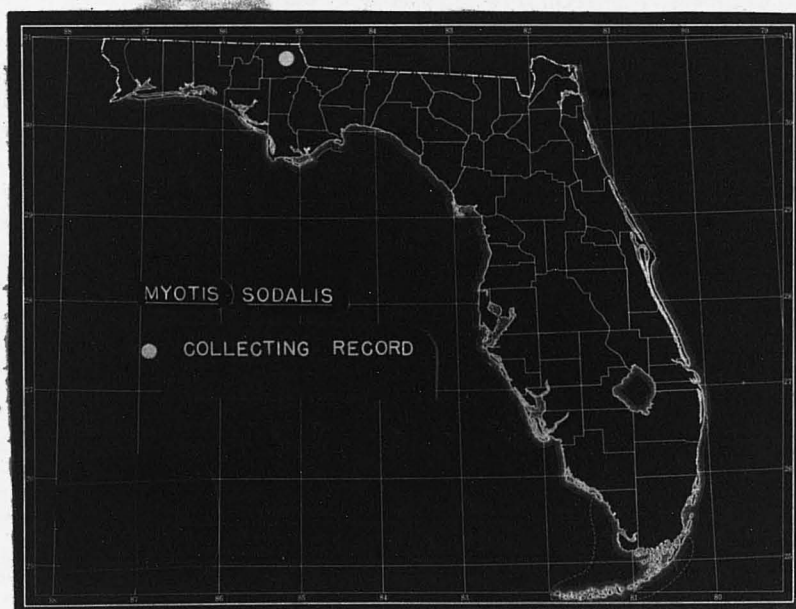
In its usual range this is a cavern-roosting colonial bat, most often encountered in small groups, or singly in caves with colonies of other species. It appears to breed outside of caves (Hamilton, 1943).

Myotis sodalis Miller and G. M. Allen

RANGE - Eastern United States from Arkansas and Missouri to western New



Map 7. Locality where Myotis keenii has been taken in Florida.



Map 8. Locality where Myotis sodalis has been taken in Florida.

England and south to northern Alabama.

This bat has been taken once in Florida as a winter hibernant in the Marianna cavern region of Jackson County (Jennings and Layne, 1956). Two specimens were taken from Old Indian Cave on October 14, 1955. Both were females, one an adult with sperm in the uterus and the other, recognized after an extended period in preservative, apparently a young of the year from which sperm were not recovered.

More than twenty trips to bat caves in Jackson County did not produce any other specimens although more than a thousand Myotis were examined critically. Nor did Rice collect any in his careful study of Myotis austroriparius in this area, although he did collect the only Florida specimen of Myotis keenii septentrionalis from this same cave (Rice, 1955). This isolated occurrence in a cave previously demonstrated to shelter bats with northern affinities implies that Myotis sodalis occurs in Florida only as an irregular visitor in winter and not as a functional species population like that of Myotis grisescens. The peculiar ecological features of Old Indian Cave are discussed elsewhere.

Pipistrellus subflavus subflavus (F. Cuvier)

Pipistrellus subflavus floridanus Davis

RANGE - Pennsylvania to Kansas south to Florida and Texas. The Florida race is restricted to peninsular Florida and southeastern Georgia.

In Florida the pipistrel occurs commonly throughout the northern half of the state and it was taken as far south as Hillsborough and Polk counties. In this study about 10 per cent of the bats collected

by shooting were pipistrelles. Of 306 examined, 46 per cent were taken from caves, 40 per cent were shot while feeding and 13 per cent came from Spanish moss plants. Cave collections were made only during fall and winter. Table 12 illustrates the seasonal variation in returns from the collecting methods that yielded pipistrelles. This species was taken by shooting in almost every month when weather warm enough to permit activity occurred. Seasonal alternation in use of roosting sites varying between hibernation in caves during winter and sleeping in foliage and other non-cave situations in warmer weather is characteristic of this bat.

Although usually found wherever bat shoots yielded reasonably large samples as a rule, pipistrelles were present only in small numbers. About 4 per cent of the bats taken at public shoots were of this species while it made up 16 per cent of the bag from impromptu shoots. The curve in Figure 5 indicates the tendency of this species to be found widely but thinly distributed, never flocking to join large aggregations containing feeding bats of several species. Table 13 illustrates the thin, evenly dispersed nature of the pipistrel population in Florida and compares the yield of pipistrels in various regions with that of semiole bats from both public and impromptu shoots.

It is notable that pipistrelles are comparatively less abundant than Semioles in large aggregations everywhere, even in the South Florida region where the number of Semioles in feeding flocks is overshadowed by the abundance of yellow bats. This scarcity is less manifest when collecting isolated feeding bats and in samples from small,

TABLE 12

NUMBER OF PIPISTRELLUS SUBFLAVUS COLLECTED EACH MONTH BY PRODUCTIVE METHODS

Month	Shooting	Per Cent	Moss Plant	Per Cent	Cave
January	0	0	0	0	21
February	27	60	2	9	85
March	7	11	0	0	0
April	1	7	5	28	13
May	20	15	2	21	0
June	33	14	20	15	0
July	12	5	9	20	0
August	4	0	1	25	0
September	12	4	0	0	1
October	6	11	0	0	18
November	2	9	1	8	3
December	<u>0</u>	0	<u>0</u>	0	<u>0</u>
Total	124		40		141

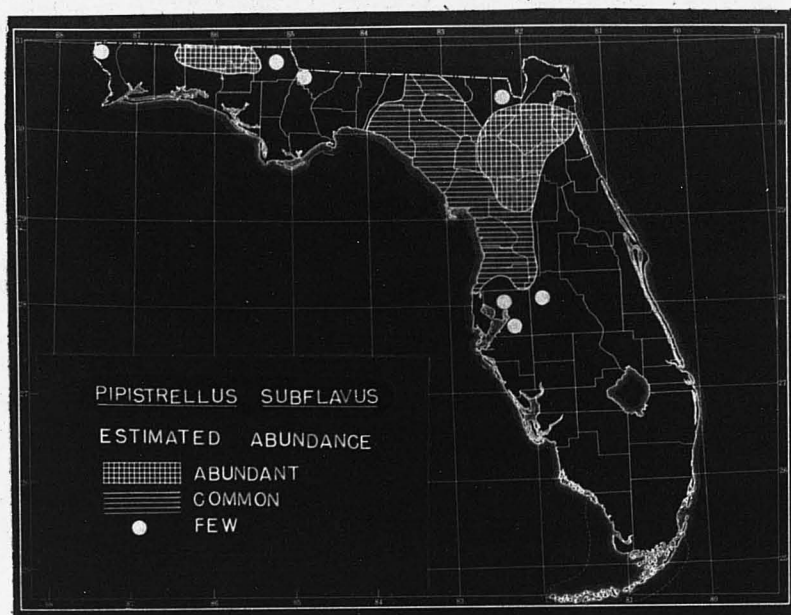
TABLE 13

RELATIVE REGIONAL ABUNDANCE OF PIPISTRELLUS SUBFLAVUS IN FLORIDA

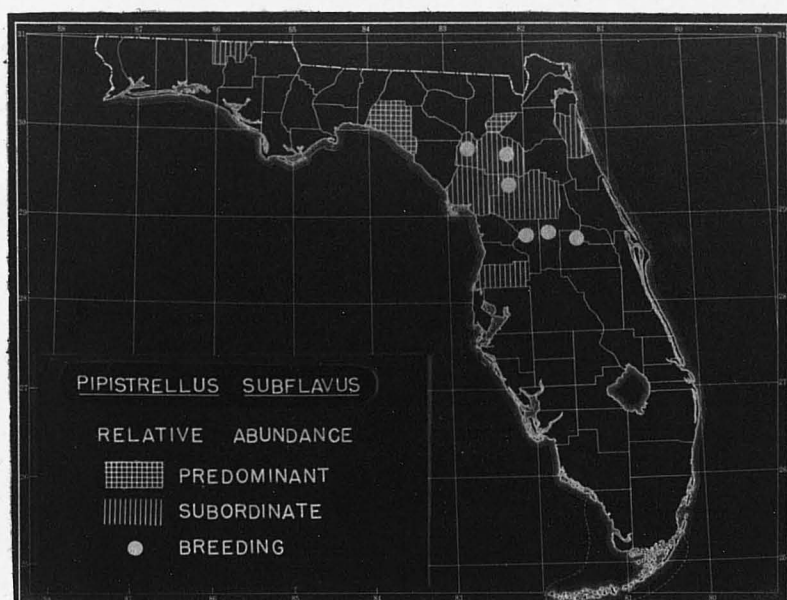
	Number Taken	Per cent of All Bats Shot	Ratio of <u>Pipistrellus</u> per 100 <u>L. seminolus</u>	
			Public Shoots	Impromptu Shoots
West	26	12	7	60
North	61	13	12	128
Central	37	22	34	18
South	5	2	9	0
Everglades	0	0		
	124			

impromptu shoots. There is no obvious restriction of pipistrel activity to cave environs in summer, but they were shot in greater relative abundance in the regions where caves are common.

Pregnant and lactating pipistrelles were taken by shooting and by purchase from moss plant collectors. Copulation was observed in caves in November. Map 10 indicates the localities where breeding females, including those with embryos large enough to be considered full term and those obviously newly lactating, were collected. Although a restricted breeding range is indicated, it is probable that mating and rearing of young occur throughout the known range of the species in Florida. Breeding records are scarce because these bats were taken in small numbers by shooting during the season of birth and, although



Map 9. Range and estimated abundance of Pipistrellus subflavus in Florida.



Map 10. Relative abundance of Pipistrellus subflavus in Florida.
Breeding localities are shown.

usually considered a cave bat, parturition is not recorded from a cave anywhere in the range of the species.

Births begin during the last week or two in May and probably continue through most of June. Full term embryos were common after May 21 and were last recorded June 18. Newly lactating females were collected as early as May 21, and were in the majority among females examined by the first week of June. Newborn young, weighing about 2.5 gm. and with forearms measuring 13 or 14 mm. were received from moss plants or born in the laboratory June 4, 6, 8, and 21. Flying young with forearm measurements of 25 mm. were collected as early as June 19, so it appears that about a month of development is required before adult size and flying ability are attained. Each of the nine litters examined contained two embryos.

Collecting data show a close relationship with water, which lay inside the flight pattern of 49 per cent of the pipistrelles taken by shooting. A similar correlation was noticed with broad leaved forest vegetation, 47 per cent of the pipistrelles shot coming from hammock communities. Although 10 per cent of those in our sample were shot in flatwoods, almost all of these were found where highways crossed cypress strands or stream border vegetation of broadleaved trees. This bat usually flies low and may enter the canopy of dense hammock. Two pipistrelles were observed one warm December evening near Gainesville, feeding beneath a large live oak which formed a part of a hammock canopy some 30 yards from the edge of a small lake. The entire feeding area of these bats was inside the hammock canopy. Most of their flying was

confined to the open space below the lowest limbs of the dominant trees and above the tops of the lower, scattered shrubs. They were not observed to take insects from foliage at any time, but apparently fed on flying insects.

Pipistrel roosting habitat varied with the season, as was indicated above. During the winter months they were found in caves, with numbers varying from a few to as many as 50 or 60 in a chamber. They hung singly or in pairs, never with bats of another species, and almost every cave contained at least one pipistrel during the coldest months. Several accounts describe the hibernating habits, emphasizing the relative immobility of hibernating individuals, often seen gleaming with the moisture which condenses on their fur, causing them to sparkle like jewels in the glare from a headlight. By late March most pipistrelles left the caves in Florida and they were not found roosting in them during the summer months. Summer roosts included Spanish moss and the drainpipes through bridges, but foliage roosts and crevices were probably also used. Young were reared in Spanish moss.

The seasonal use of caves by pipistrelles is almost exactly the reverse of that observed in Myotis austroriparius in Florida. Only in the colder caves of Jackson County were both found roosting in a cave during the winter. Perhaps the tendency to roost in the cool twilight zone of caves permits pipistrelles to hibernate successfully in central Florida caves that are thought to be too warm for Myotis in winter.

Figure 6 illustrates the sex and age class composition of the pipistrelle sample, as revealed by analysis of tooth wear. Only in

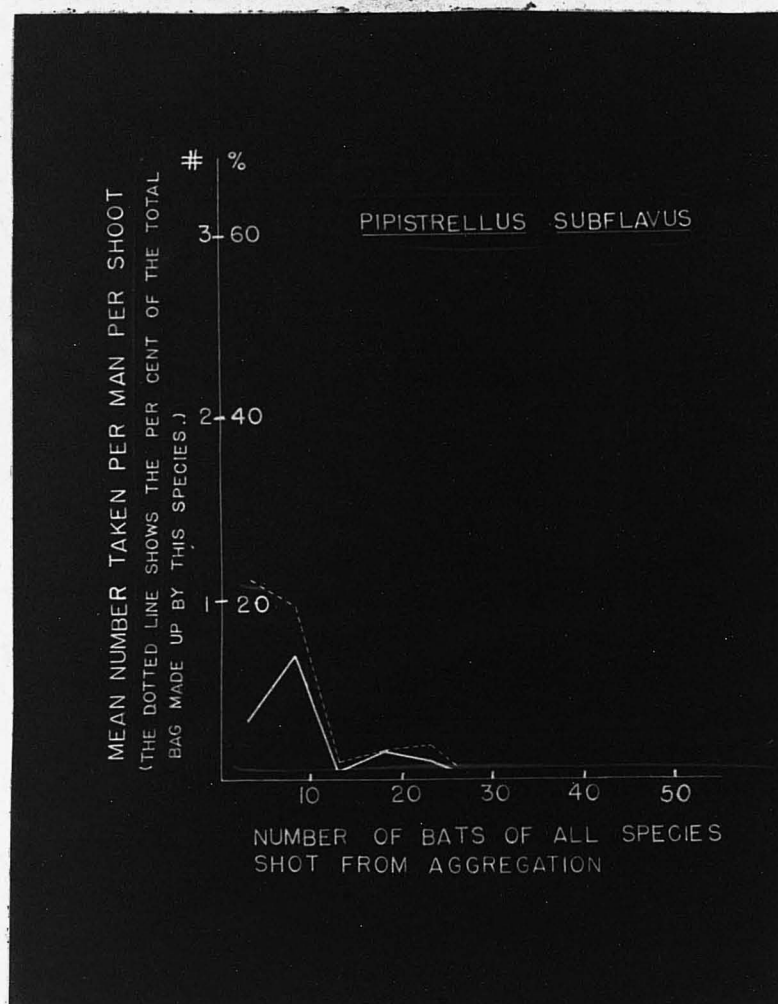


Figure 5. Aggregation response in Pipistrellus subflavus.

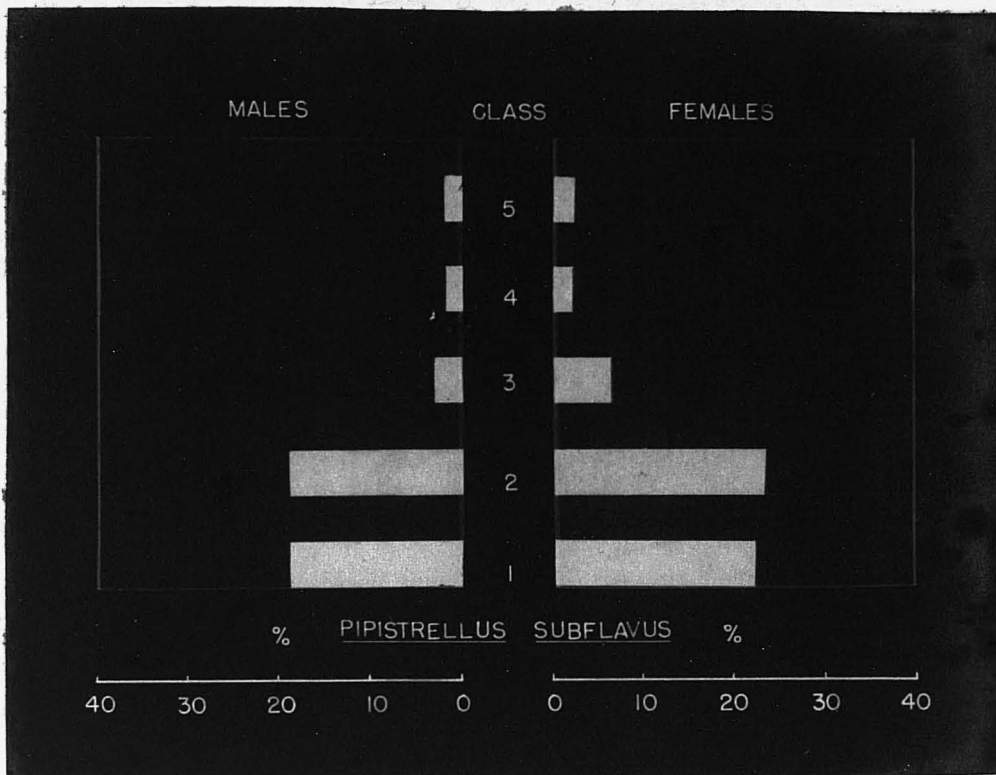


Figure 6. Sex and age distribution in 248 adult Pipistrellus subflavus examined.

this species and in Tadarida brasiliensis was there no indication of a significant difference in mortality rates between the sexes. Here also males made up 45 per cent of the adult bats collected, the highest proportion observed in non-colonial species taken throughout the year. It appears from these data on mortality and seasonal variation in roosting habits that roosting singly and outdoors is correlated with high mortality rates during the first winter of life. Higher mortality associated with roosting outdoors at any season might be inferred from comparison of the difference in litter size between colonial and non-colonial species of bats. In roosting habits and mortality rates pipistrelles are unique among Florida bats.

Eptesicus fuscus fuscus (Palisot de Beauvois)

Eptesicus fuscus osceola (Rhoads)

RANGE - Eastern North America from central Quebec, Ontario and Manitoba south to northern Florida and Nuevo Leon, Mexico. The Florida race, osceola, is known only from the southern part of the peninsula.

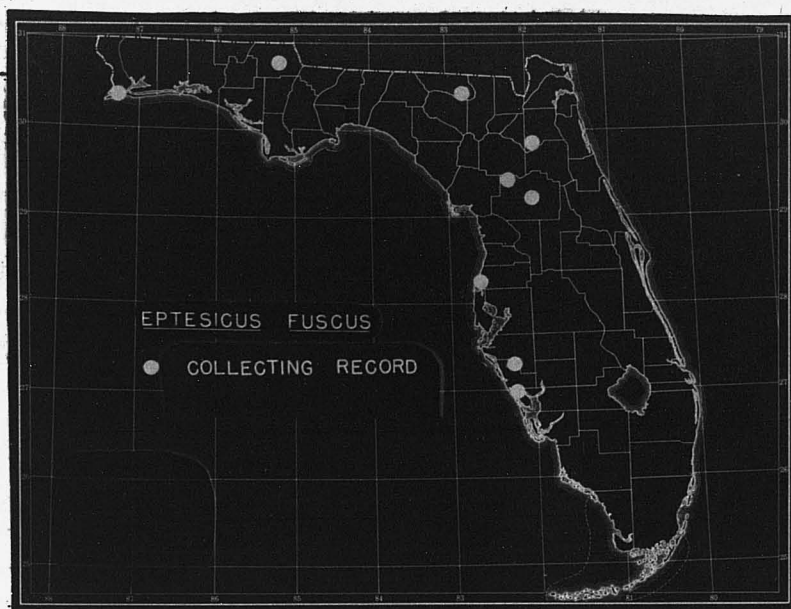
Of the 12 Eptesicus examined during the study, six were shot while feeding, although none were taken by public shoots. Four were shot near an Escambia County beach flying outside a building containing a Tadarida colony and they presumably roosted in the building. The other two were feeding over the edges of lakes bordered with hammock type vegetation in Marion and Clay Counties.

Four of the specimens taken from colonies were netted in a large Tadarida roost in an abandoned school building in Hamilton County. Three of these were lactating females, taken on June 22, 1955 as they

flew out at dusk. Another taken in March of the following winter was a young female. About 100 Tadarida and some 30 Myotis austroriparius were taken with the first three females netted. The surrounding area was a wooded residential section in a bend of the Suwannee River. Another, a young male, entered a Marion County barn hayloft with about 70 Tadarida after 9:00 p.m. September 23, 1955. He attached himself to a crack in the planks sheathing the hip roof about 20 feet from the nearest group of resting Tadarida. This hayloft was not frequented by any bats during the day at that time, but served as a midnight roost, often for large numbers of Tadarida.

These observations indicate that Eptesicus occurs in the northern portion of Florida, primarily associated with colonies of Tadarida, roosting and rearing young in buildings. This affinity for buildings has been commented on elsewhere (Hamilton, 1943). Absence from Florida caves probably is due to their damp walls and high humidity since this bat is reported to inhabit only the drier caves in the North (Hamilton, op. cit.).

Examination of our specimens shows that all lie within the range of color variation exhibited by fuscus. The race osceola described by Rhoads (1902) from near Tarpon Springs is reported from most of southern Florida but our collections from shoots and Tadarida colonies did not yield any. Since only one skin of osceola was available for comparison it is impossible to comment on the relationships of our Marion County specimens. Eptesicus does not appear to be abundant anywhere in southern Florida, and is scarce everywhere in the state away from Tadarida colonies.



Map 11. Localities where Eptesicus fuscus has been taken in Florida.

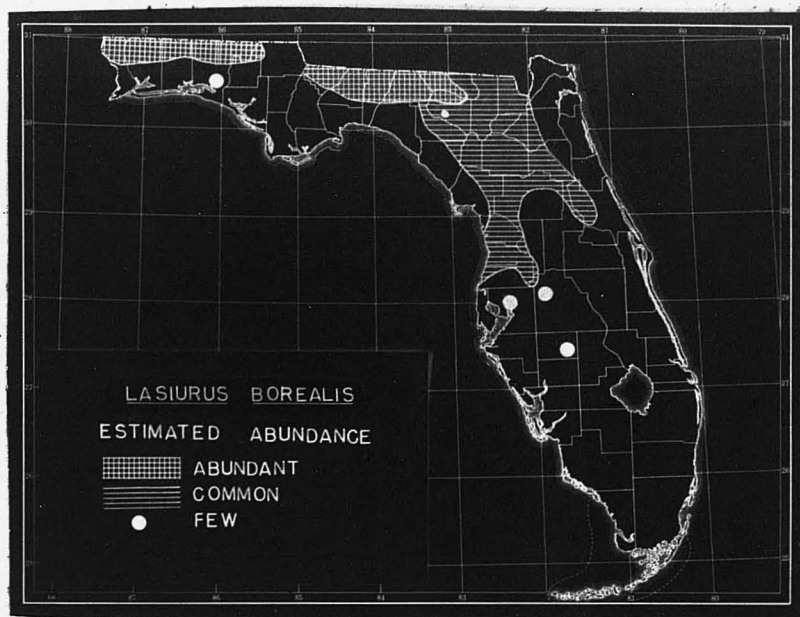
Lasiurus borealis borealis (Muller)

RANGE -- The eastern United States and southern Canada south to Florida; in the west to eastern Texas, eastern North Dakota and Colorado. Recorded from Bermuda.

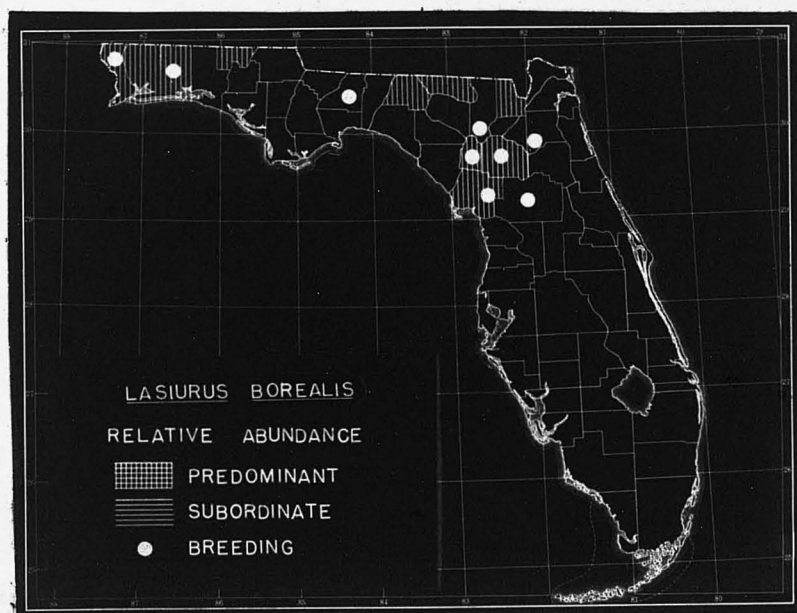
The red bat is relatively common in northern Florida whenever closed forest canopies are found. About 9 per cent of the 1222 bats collected by shooting were of this species. Map 12 shows the area in which it was taken and indicates abundance as reflected by return per unit of collecting effort. It is obvious that red bats are taken less frequently in the peninsula and that collecting returns decrease as one moves to the south. Table 15 indicates the relative abundance of this species compared with others taken by shooting.

Red bats are taken in decreasing proportion to other species toward the east and south. This is especially true with reference to the Seminole bat, and in shoots of larger aggregations. The more variable data furnished by impromptu shoots indicate that red bats show less tendency to join large feeding aggregations. More frequent appearance in collections from small impromptu shoots indicates a dispersed distribution for the species. It was rarely found to be as abundant as the common and uniformly distributed Seminole bat.

Map 13 shows the breeding range in Florida as revealed by the pregnant and lactating females collected. Young too small to fly were not taken and this species did not roost or rear young in Spanish moss. Only two specimens, both hibernating adults, were purchased from moss plants.



Map 12. Range and estimated abundance of Lasiurus borealis in Florida.



Map 13. Relative abundance of Lasiurus borealis in Florida. Breeding localities are shown.

TABLE 14

NUMBER OF LASIURUS BOREALIS COLLECTED EACH MONTH BY PRODUCTIVE METHODS

Month	Shooting		Moss Plants	
	Number	Per Cent	Number	Per Cent
January	1	10	0	0
February	1	2	2	9
March	2	4	0	0
April	0	0	0	0
May	10	8	0	0
June	21	9	0	0
July	15	7	0	0
August	6	6	0	0
September	38	13	0	0
October	7	13	0	0
November	2	9	0	0
December	5	15	0	0
Total	108		2	

Table 14 shows the seasonal distribution in numbers of red bats collected by various methods and indicates the relative proportion represented by this species in the monthly samples taken by each method. This collection gave some indication of seasonal shifts in population. Red bats are known to migrate southward in winter (Allen, 1939, Cockrum,

1952). They were not taken during colder weather but were collected in every month except April. Increased relative abundance in feeding aggregations in the fall suggests an influx from some source.

Notes on the vegetation in which red bats were collected while feeding reveal an affinity for the edges of closed tree canopies. Highways and clearings through hammocks, clumps of trees in more open situations, and forest bordered streams and lakes were especially productive of this species. Many individuals were observed flying along the edge of a tree canopy, apparently patrolling an invisible path near the foliage, and almost never flying beyond the range of vision. This feeding pattern is shared with the closely related Seminole bat and it is almost impossible to distinguish between the two under the light conditions that are usually encountered. The high, spiraling flight noted in other parts of the range during the early part of evening activities was not observed in Florida.

Of the red bats collected while feeding, 51 per cent were in hammock communities, 24 per cent were in turkey oak, and 11 per cent were in scrubby flatwoods while the remainder were scattered almost singly among other plant communities. Open water of some kind lay within the area patrolled by 55 per cent of the red bats collected by shooting.

Features of life history of the local red bat population are probably similar to those reported elsewhere (Palmer, 1954). Since young were not reared in moss, leafy vegetation is probably used for roosting sites. The ten pregnant females collected had a mean litter

size of 3.4 and five of them contained four embryos at nearly full-term, with forearm lengths between 6 and 12 mm. Seven pregnant females with embryos within this size range were collected between May 16 and June 9. Twelve lactating females were taken between June 7 and June 27, while a young male just learning to fly was shot June 23. Although this species is reported to carry the young while feeding, we obtained no young bats from shoots.

Sex ratios of the large embryos were 12 males: 8 females or 133 males per 100 females. In the adult sample of 101 examined, a sex ratio of 38 males per 100 females was encountered.

Figure 8 presents the age groups indicated by tooth wear classes for each sex. If these classes accurately represent years of life, then a median age for the spring population of about 21 months is indicated. It is clear that all individuals pass out of the first wear class before they are a year old. The annual increment based on our sample of 23 specimens taken in the fall is roughly 44 per cent, although adult males probably do not appear in the sample in their true abundance.

The Florida sample of Lasiurus borealis indicates that the red bats found in the state belong to a relatively stable breeding population and occupy the local plant communities that are southern extensions of those found in the remainder of their range. Although not as abundant as the closely related Seminole bat, they occupy similar ecological situations. The range of red bats does appear to be somewhat less extensive and they may be entirely absent from the subtropical portions of the state. This decline in abundance to the southward is more

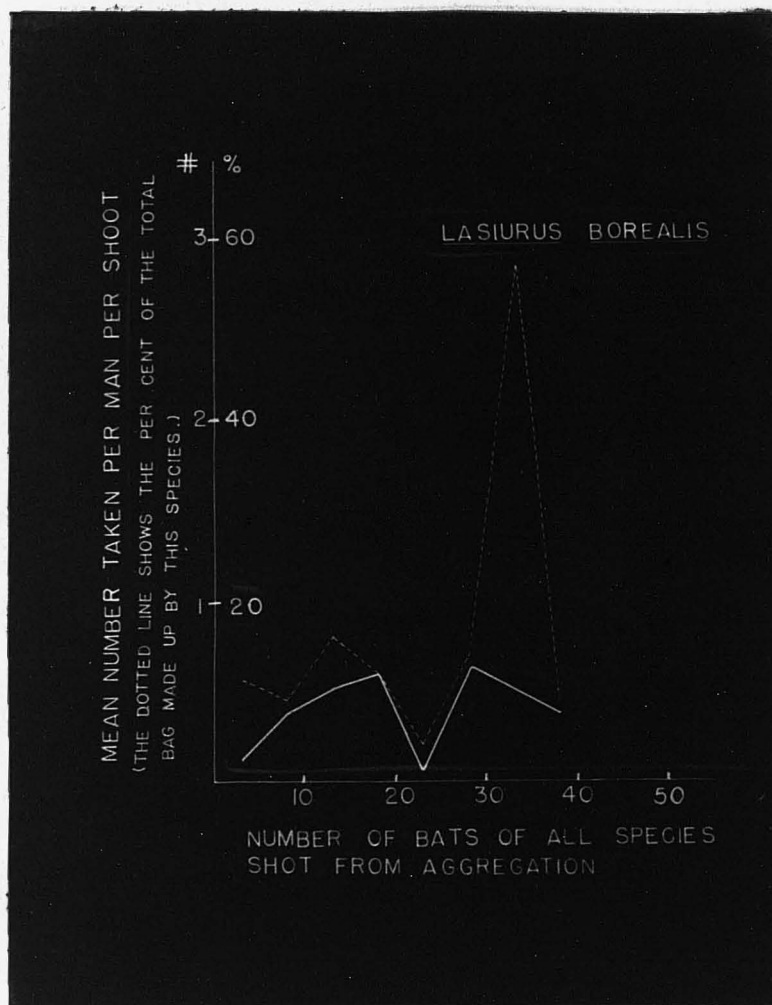


Figure 7. Aggregation response in Lasiurus borealis.

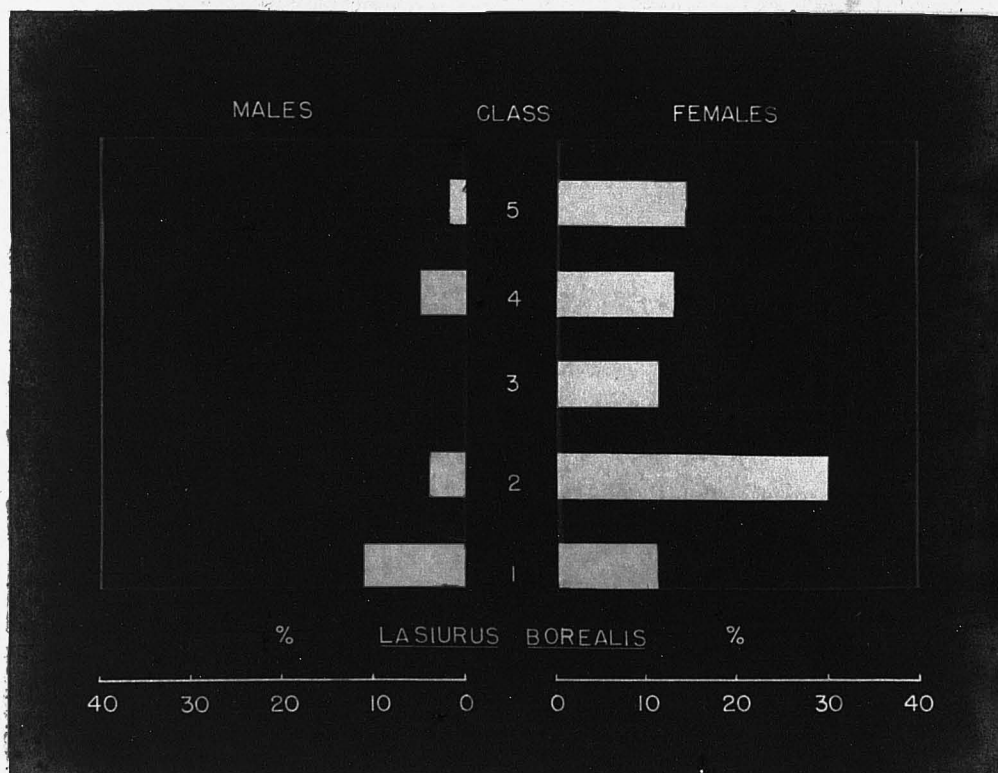


Figure 8. Sex and age distribution in 56 adult Lasiurus borealis examined.

rapid than would be inferred from observation of the gradual replacement of broad leaved forest communities with those of the tropics.

TABLE 15

RELATIVE REGIONAL ABUNDANCE OF LASIURUS BOREALIS IN FLORIDA

	Number taken	Per cent of all bats shot	Ratio of <u>L. borealis</u> per 100 <u>L. seminolus</u>	
			Public shoots	Impromptu shoots
West.	42	19	60	28
North	46	10	19	8
Central	12	7	13	13
South	8	3	10	11
Everglades	0	0		
Total	108			

Lasiurus seminolus (Rhoads)

RANGE - South Carolina to Florida and west to southern Louisiana. Recorded also from Brownsville, Texas and New York.

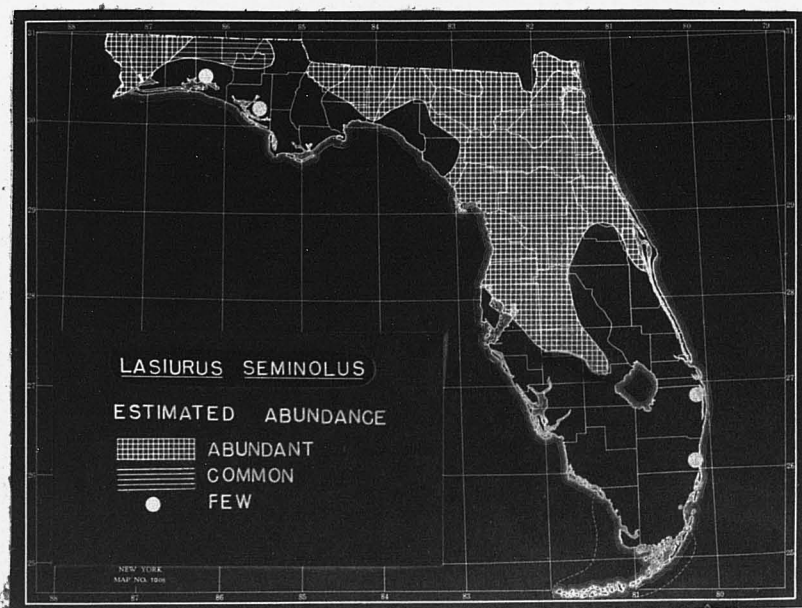
In Florida the Seminole bat is the one most commonly collected by shooting. It made up 42 per cent of all the bats collected by shooting and 52 per cent of the bag from public shoots.

Validity of the species has been questioned but some data gathered during the study support the genetic isolation indicated

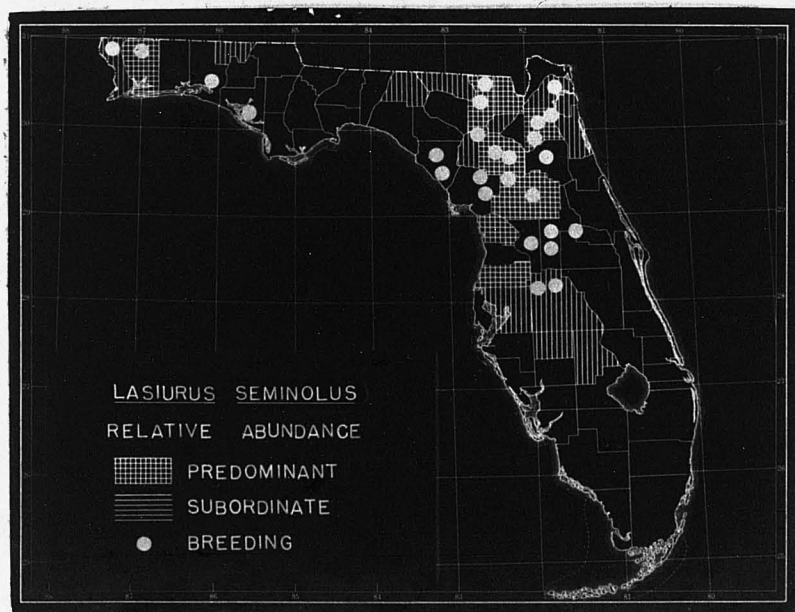
previously by Barkalow (1948) and Coleman (1950). Lasiurus borealis and Lasiurus seminolus both occur in the same regions of Florida. They usually were taken together in large samples from feeding aggregations, with seminolus invariably in the majority. None of our specimens exhibit intermediate stages of color although the wide color variation shown in borealis is well represented in the collection. Nor were litters of young seminolus observed to have lighter colored members, indicative of inter-grading or multiple color phases. Further, ecological differences were found in roosting habits, since seminolus habitually roosts and often rears young in Spanish moss, features never observed in borealis. For these reasons, the two are treated as separate species here.

Map 14 shows the sites in Florida where Seminole bats were collected and reflects their abundance as indicated by returns per unit of effort in public shoots. It is readily apparent that this animal is abundant throughout its principal range and is almost uniformly distributed. In the north half of the state it is the majority member of the larger feeding aggregations. Of 66 bats shot at the Lake City airport in August of 1955, 90 per cent (59) were Seminole bats. It is uncommonly encountered south of the Vero Beach, Sebring, Punta Gorda area as are most bats, but a few records do exist. Specific localities where Seminole bats were collected are Miami (Schwartz, 1952) and West Palm Beach.

Breeding records exist for the localities shown on Map 15 which also indicates relative abundance among the bats collected by shooting.



Map 14. Range and estimated abundance of Lasiurus seminolus in Florida.



Map 15. Relative abundance of Lasiurus seminolus in Florida. Breeding localities are indicated.

TABLE 16

NUMBER OF LASIURUS SEMINOLUS COLLECTED EACH MONTH BY PRODUCTIVE METHODS

Month	Shooting		Moss Plants	
	Number	Per Cent	Number	Per Cent
January	9	90	3	75
February	6	14	10	43
March	23	40	9	75
April	2	15	6	33
May	25	18	2	22
June	103	44	21	16
July	108	48	0	0
August	61	58	0	0
September	113	38	0	0
October	22	42	3	50
November	17	74	6	50
December	25	73	9	45
Total	514		69	

Table 17 indicates the proportion of the bats collected in each region identified as this species.

This table indicates a uniformly high relative abundance in general. In the South Florida region it is obvious that the overwhelming numbers of yellow bats in the larger aggregations tend to reduce

the proportion of the bag made up by Seminole bats but this does not indicate that Seminoles are less abundant there.

Table 16 shows the seasonal returns obtained by various collecting methods used for Seminole bats.

TABLE 17
RELATIVE REGIONAL ABUNDANCE OF LASIURUS SEMINOLUS IN FLORIDA

	Number taken	Per cent of all bats shot	Per cent by type of shoot taken in	
			Public shoots	Impromptu shoots
West	90	40	54	29
North	258	54	63	24
Central	96	56	60	52
South	70	28	27	43
Everglades	0	0	0	0
Total	514			

An obvious decrease in the proportion of Seminole bats taken in impromptu shooting during August and September reflects the tendency for this species to aggregate in large feeding concentrations with other species at this season. Its absence from Spanish moss collections in July, August and September may be a phenomenon correlated with weather, with non-random distribution or with adaptations to the rearing of the young at that time. Certainly there is no decrease in the

number present, and the proportion of Seminole bats in samples from large aggregations reaches a maximum at this period.

There is a tendency for this bat to feed near water and at edges of closed canopy forest communities. Of 514 collected by shooting, and for which habitat data were available, 49 per cent were taken in or at the edges of hammock vegetation and 30 per cent were taken in flatwoods mostly near clumps of oaks or along streams. Some were shot while flying around the crowns of large pine trees. Turkey oak vegetation yielded 14 per cent of the Seminole bats collected by shooting. Water was located within the flight pattern of 44 per cent of the feeding Seminole bats collected.

In general a correlation between feeding Seminole bats and the foliage of trees was noticed. In June of 1957 a Seminole bat was observed at Cedar Key as it fed at dusk on insects attracted by a flower spike of a cabbage palm, Sabal palmetto. It circled continually, but each time it passed the palm it landed for a few seconds on a convenient horizontal frond and quickly captured one of the insects gathering nectar. On several occasions this species was observed swooping regularly into a gap in the tree canopy, obviously feeding from a swarm of insects hovering in this sheltered location. Most of the feeding Seminole bats observed flew at the level of the tree canopy, rarely over the top of it and never beneath it.

The tendency to feed upon a single swarm of insects, using a tight circular flight pattern, was observed often under street lights. This gave some data on the feeding periods of Seminole bats. Probably

a few red bats were involved in the same activity but the light cast by the mercury arc made color distinctions in flight impossible.

Most collectors have found bats with their stomachs full of insects early in the evening. Some colonial species even return to the roost and rest during the middle part of the night, foraging again before dawn. This has led to a general speculation that most bats emerge early and are thus available for collecting by shooting. The data in Figure 10 show the frequency with which bats were seen under street lights through the night of April 27, 1957. The unit of measurement is the instant of time after the observer looks away and then looks again into the cone shaped, light flooded area. The presence or absence of bats was recorded for 100 of these observations to yield one of the tabulated frequency indices of bat activity. Figure 9 presents the curve obtained by plotting these results. There is an obvious increase in the amount of bat activity under the light between 8:00 p.m. and midnight, while activity decreased about 1:00 a.m. Activity increased again shortly before 2:00 a.m. but gradually diminished about 2:30 a.m. as the air temperature reached 60°F and relative humidity rapidly approached 90 per cent.

Observations on 40 evenings during cool weather revealed that bats seldom flew when the air temperatures dropped as low as 55°F and activity was much reduced below 64°F. Humidity apparently had less influence but when the dew point was reached all flight activity ceased, so far as could be determined. High winds and rain also reduced bat activity. It was not clear whether these weather features act directly

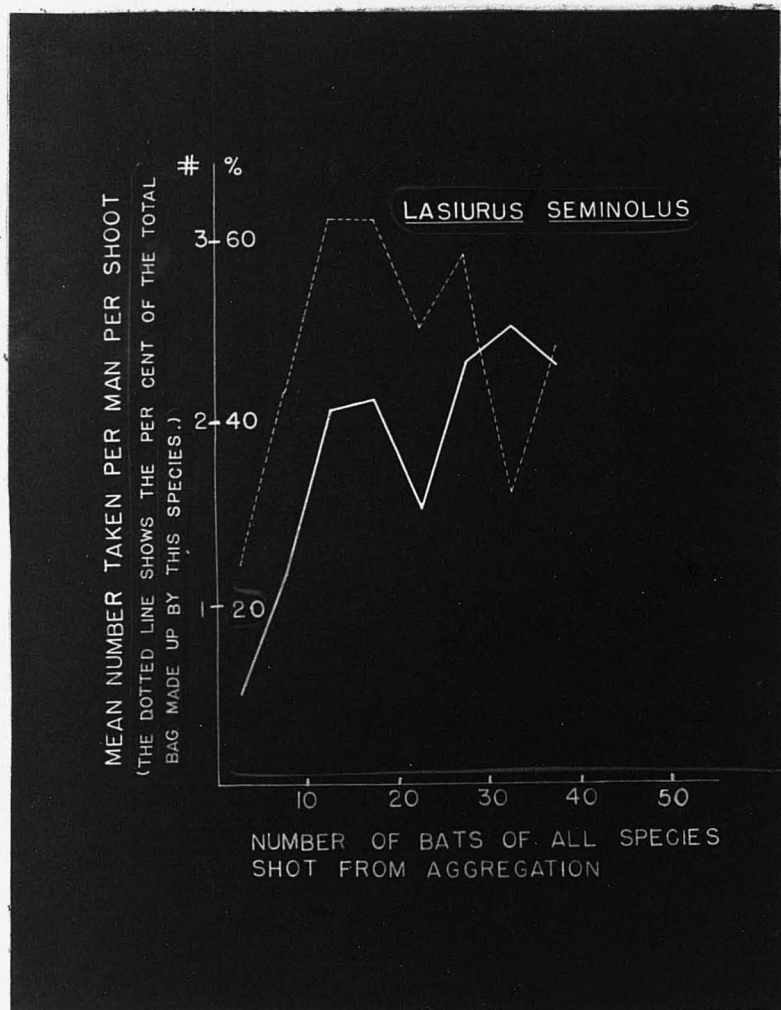


Figure 9. Aggregation response in Lasiurus seminolus.

upon the bats or upon their insect prey.

Seminole bats probably roost in foliage as red bats usually do, but they also roost in Spanish moss. Of 180 adult bats purchased from moss plants, 28 per cent were of this species. Males and females used this roosting habitat in approximately equal numbers (24 males to 27 females or 89 males: 100 females). Although a few litters were found, the small number bought at moss plants is good evidence that Seminole bats do not rear young in Spanish moss in as great numbers as do yellow bats.

The sex ratio observed in 588 Seminole bats collected by various methods was 38 per cent males or 61 males: 100 females. Litter size averaged 3.3 in litters containing 70 large embryos, with ten litters of four and nine of three young each. The sex ratio of these young was 123 males: 100 females.

New born young were taken on June 12, but embryos about full term were common between May 21 and June 18, with most of the births probably occurring before the second week in June. Of 26 females shot in Alachua and Levy counties on June 7 and 8, 1955, 23 were obviously lactating while the other three appeared to have given birth shortly before. Young of the year were feeding on the wing in large numbers during July.

Figure 11 presents the age classes established by tooth wear examination for adult bats only, contrasting males and females. There appears to be a markedly greater mortality rate for males than for females with a lesser mean life expectancy for males. This might explain the disproportionate sex ratios encountered in this and other non-colonial species.

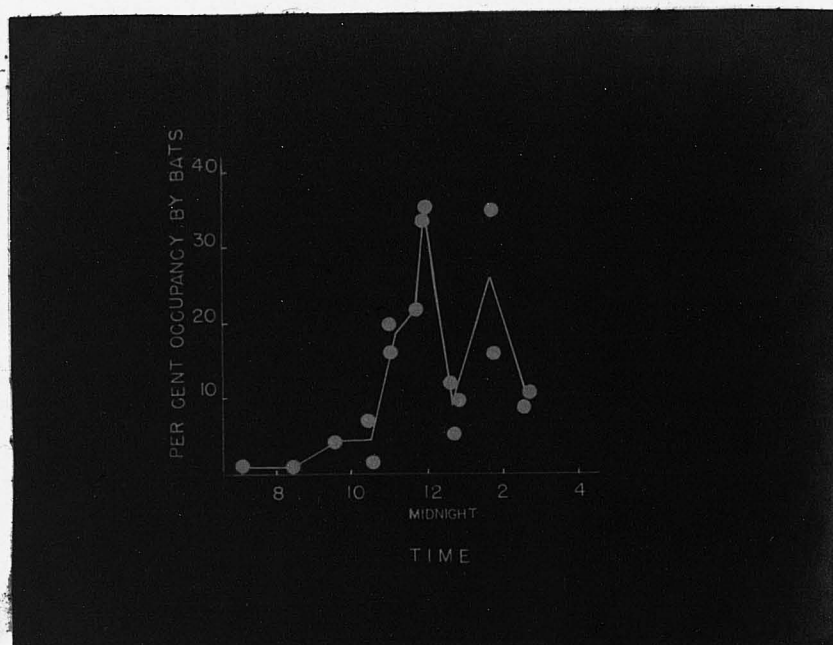


Figure 10. Nocturnal activity of Lasiurus seminolus and some other bats.

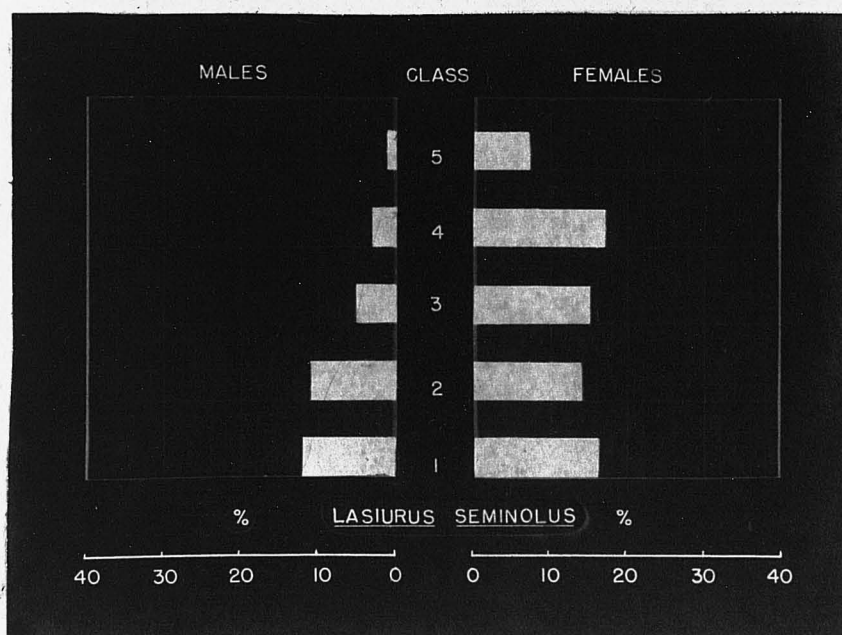


Figure 11. Sex and age distribution in 413 adult Lasiurus seminolus examined.

Lasiurus cinereus cinereus (Palisot de Beauvois)

RANGE - Northern United States and Canada, migrating south as far as northern Florida, central Chihuahua and northern Michoacan, Mexico.

The hoary bat is known in Florida from three specimens, all probably wide ranging migrants since they were taken in fall and winter. A similar seasonal occurrence is seen in those collected in neighboring states also (Cooley, 1954). Hamilton (1943) states that this bat is only a winter resident in the south.

Hoary bats were not taken by shooting during our study but most of the shooting effort was expended in the summer and fall, before migrants could be expected to appear according to the data from previous collections in the South. Solitary habits and a late flight period also reduce the proportion of our collecting effort which would be likely to yield a specimen.

One was purchased at a Spanish moss plant near Apopka on January 24, 1955. It was a young male, roosting through the day in the moss (Sherman, 1956). Cooley's specimen from Santa Rosa Island was found dead October 26, 1952 on the strip of beach and dune scrub which is similar to that found bordering both Florida coasts in long stretches. Ecological data are not available for the individual collected near Gainesville in February, 1891 (Chapman, 1891).

Intensive collecting during warm winter evenings might be expected to yield additional specimens of this magnificent bat.

Dasypterus floridanus Miller

RANGE - Florida and the Gulf Coast west to eastern Texas and north to the southern coast of Virginia and to Arkansas.

The Florida yellow bat, once considered to be the most uncommonly encountered species breeding in the state, was taken in real abundance by shooting large bat concentrations in the central part of the peninsula. In this section, including Polk, Hillsboro, Hardee, and Highlands counties, the yellow bat made up 52 per cent of the bats taken by shooting. At many shoots this species made up 90 per cent or more of the bats taken. Map 16 indicates this area of maximum abundance and other areas where the species was taken in the state. The range used by less dense populations of this species extends south along the east coast ridge to Miami (Moore, 1949) where it evidently breeds. Young too small to fly were collected by residents of West Palm Beach and Fort Lauderdale.

North of the area of maximum abundance the range extends over the whole of the northern part of the state, but yellow bats were rarely encountered west of the Aucilla River. Of 206 bats taken by shooting in the western panhandle, only one was a yellow bat. Since this species is reported to be common in Louisiana (Lowery, 1943) this thinly populated intervening strip more than 200 miles wide may prove to have taxonomic significance.

In the area of maximum abundance most concentrations of feeding bats contain large numbers of adult females and young of this species. Despite careful searches earlier, large feeding aggregations were not

located before the June and July period when young were first flying. As many as 100 females and flying young have been shot over a concentration area in a single evening. It was quite common to find favored feeding areas where from 20 to 50 of these bats were collected in one night by a group of experienced bat shooters.

Adult male yellow bats are scarce in these maternity aggregations, but they, too, show a tendency to aggregate. This was noticed in February of 1956 when a bat feeding area in Jefferson County yielded 23 bats taken in two nights of shooting. Seventeen of them were yellow bats and all were males. About the same time a collection of eight bats taken in Alachua County proved to be males of this species. By contrast, of 130 yellow bats taken in a series of shoots in feeding aggregations near Tampa in July, 1953 only nine were adult males. Young males of the year were present in numbers about equal with young females.

It seems doubtful that any of these aggregations are manifestations of mating behavior since mating probably occurs during the fall months. Sherman (1945) found sperm in a February male but males collected during this study had enlarged epididymides from July until at least as late as December. Two females, taken in mid-December and examined in fresh condition contained many sperm in the uterus. Tooth wear and mammary development indicated that one of these was in the first year of life. W. J. Riemer captured a copulating pair, which fell in the road before him on November 23, 1957. No aggregation of yellow bats composed of equal numbers of both sexes was discovered in the fall months during our study.

In its principal range this species characteristically feeds over open areas with few shrubs and only scattered tree clumps. Grassy situations such as airports, improved pastures, golf courses and lake borders were favored. Many bats were shot over water, but yellow bats were never abundant unless an open grassy area was immediately adjacent. Although scattered individuals were taken in open areas surrounded by hammock vegetation with a closed canopy, feeding aggregations were characteristically near roosting areas, usually found in two distinct communities of the peninsular flora.

In the lake region of the central Florida ridge a mixture of pine and turkey oak originally covered wide areas. Although most of this community in the region has been converted to orange groves or improved pastures, some stands of longleaf pines, thickly festooned with Spanish moss, are still to be found. Stands and patches of mature turkey oak trees inherited dominance in this community after the pines were timbered off and are more common in the region. They also are characteristically shrouded with Spanish moss. It was in this moss that yellow bats were found to roost and bear their young.

A similar community is common in the lower and flatter areas of the phosphate rock mining region, but the turkey oaks were absent as a rule and thick clumps of live oaks, covered with moss, serve as roosting and nursery sites.

All of the roosting yellow bats collected during the study came from Spanish moss but a few individuals were found in a moribund condition under trees without any moss. All of the flightless young examined

during the study were taken from moss.

Observations of ten pregnant females with nearly full term embryos indicate that average litter size at birth may approximate 3.5, since five litters had three young and five had four. These young had forearm lengths from 8 mm. to 16 mm., which was the length found in three newborn young with the umbilical cord still attached. These newborn young weighed approximately 3 gms. each.

High postnatal mortalities might be expected in mammals with a litter size this large but the available data do not indicate that this occurs before the first winter. In young with forearms less than 25 mm. of which six litters were observed, average litter size was 2.7 with two litters of two and four litters of three babies each. Only three litters were observed with larger young and these had one, three and four young each. An over-all mean litter size, before young are able to fly of 2.7 is estimated.

Newly born young were taken in mid-June but some young could fly short distances at that time. It is most likely that the interval from the last week in May through June is the period at which most births occur. One young bat was shot while feeding as early as July 3, while one taken from a litter on July 20 had nothing but milk in its stomach.

Young of the year made up about 74 per cent of the sample of 89 yellow bats from nursery aggregations shot in August and September, a proportion which allows an estimate of 2.8 for the average litter size represented in these aggregations. About 45 per cent of all yellow bats shot between July and December were young of the year.

Data were not gathered on mortality factors affecting baby yellow bats, but two of 24 examined were rabid. Observations of roosting mothers and litters indicate that, while Spanish moss offers excellent concealment and the plant community usually selected for the nursery roost reduces the probability of discovery by most carnivorous vertebrates, discovery of the litter by a predator probably results in death of all its members. It is obvious that the fibrous tangle of moss, especially when pressed or grasped, forms an impenetrable net which effectively prevents any member of the litter from escaping. This type of predation, by destroying all members of a family, would not affect the ratio of young to adults and could not be detected in the analysis of this ratio.

It is doubtful that the mother carries her young while feeding at any time since 84 lactating females were shot while feeding without securing any young too small to fly. Mothers of three captive litters confined on a screened porch left their young sleeping quietly in moss used as roosting material when they flew at dusk. When disturbed during the day, however, all mothers carried their young with them as they fled. Moss gatherers reported observing this on a number of occasions. Flightless young were never received from moss plants unaccompanied by their mothers.

Although these bats roost singly as adults, there is a tendency for a number of them to roost in the same vicinity. In one instance a moss gatherer reported capturing about 20 yellow bats, including mothers and young, from a live oak grove less than an acre in extent. He

lamented the escape of more than 30 adult bats, many of them carrying young, which were disturbed here during the same time. Later in the season, during July, August and September, when shooting feeding aggregations, it was usual to see yellow bats flying over, directly and very high, all in the same direction and all obviously leaving the same grove of moss covered trees.

TABLE 18

NUMBER OF DASYPTERUS FLORIDANUS COLLECTED EACH MONTH BY PRODUCTIVE METHODS

Month	Shooting		Moss Plants	
	Number	Per Cent	Number	Per Cent
January	0	0	1	25
February	5	12	8	35
March	16	28	3	25
April	1	8	6	33
May	5	9	5	60
June	30	13	90	68
July	77	34	35	80
August	17	16	3	75
September	31	10	12	100
October	7	13	3	50
November	0	0	5	42
December	2	6	10	50
Total	191		181	

TABLE 19

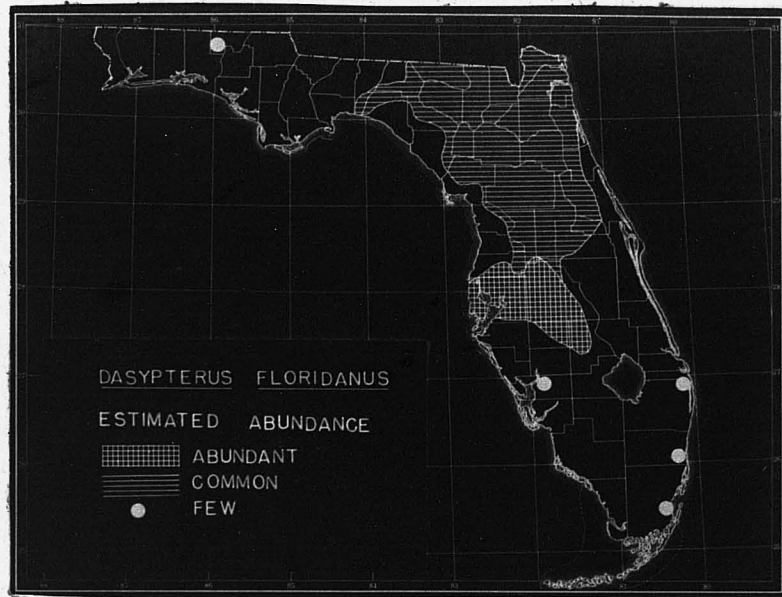
RELATIVE REGIONAL ABUNDANCE OF DASYPTERUS FLORIDANUS IN FLORIDA

	Number taken	Per cent of all bats shot	Ratio of <u>Dasypterus</u> per 100 <u>L. seminolus</u>	
			Public shoots	Impromptu shoots
West	1		2	0
North	38	8	12	36
Central	11	6	4	23
South	140	57	190	15
Everglades	0	0		
	190			

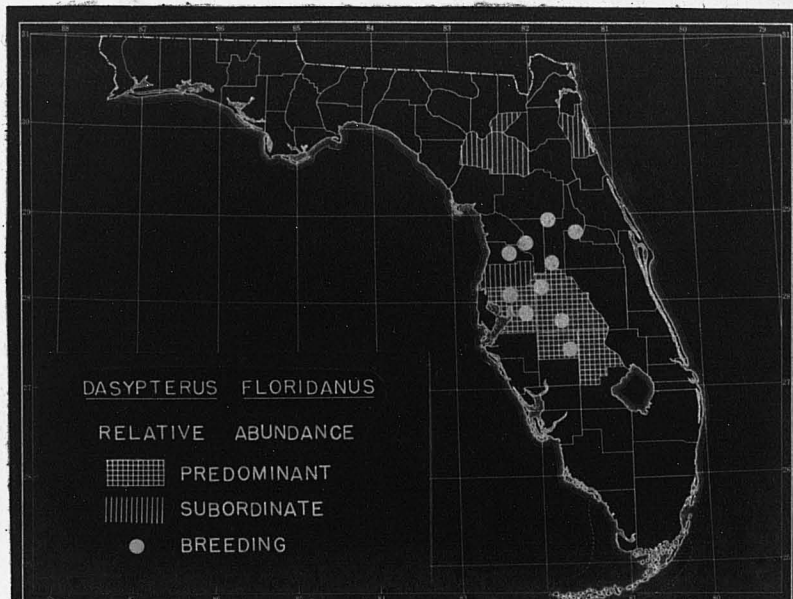
TABLE 20

SEASONAL DISTRIBUTION OF AGE GROUPS IN DASYPTERUS FLORIDANUS

Age Class	July - December		January - June	
	Number	Per Cent	Number	Per Cent
1	59	46	3	11
2	17	13	8	29
3	28	22	3	11
4	13	10	8	29
5	11	9	6	21
	128		28	



Map 16. Range and estimated abundance of Dasypterus floridanus in Florida.



Map 17. Relative abundance of Dasypterus floridanus in Florida.
Breeding localities are shown.

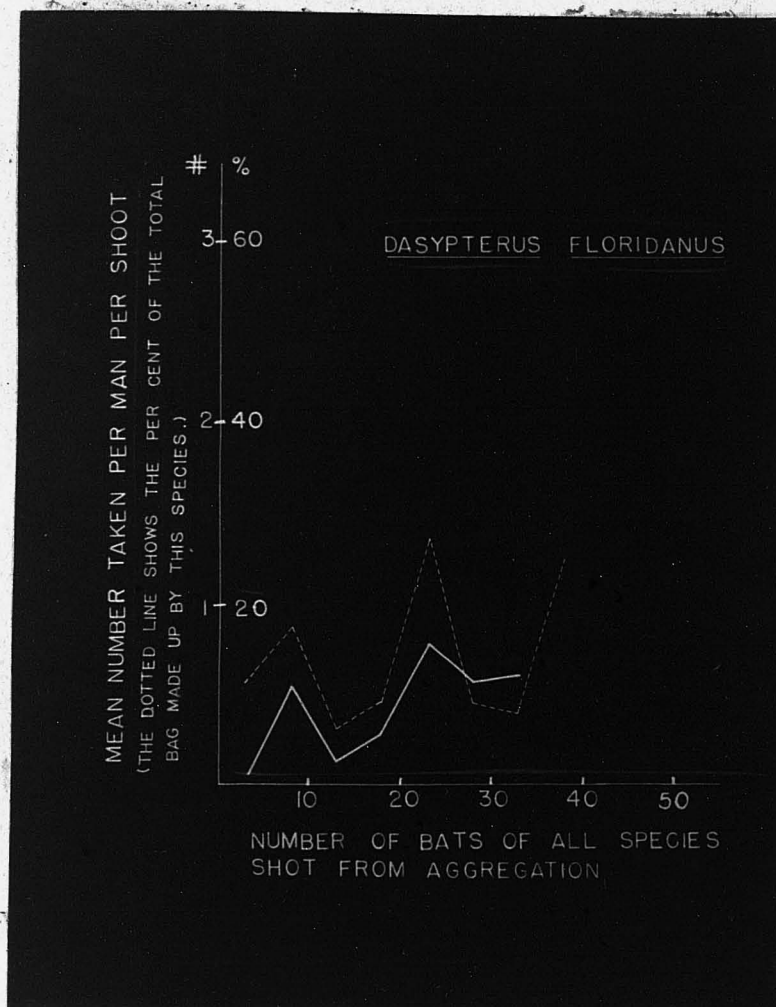


Figure 12. Aggregation response in Dasyptherus floridanus.

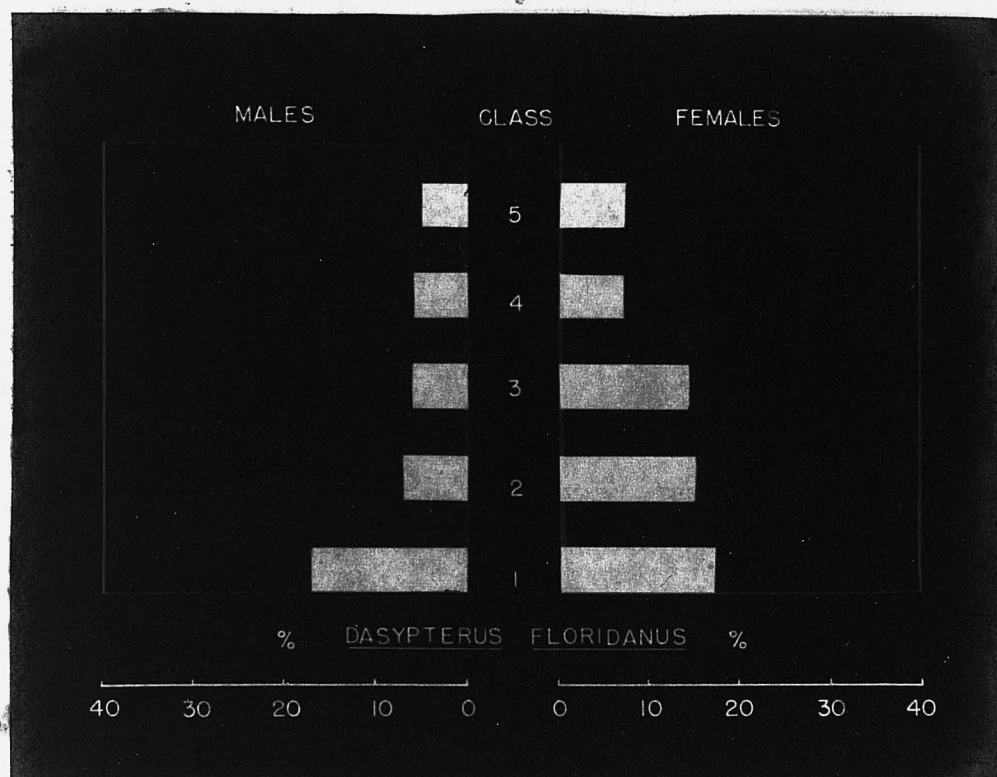


Figure 13. Sex and age distribution in 273 adult Dasypterus floridanus examined.

Nycticeius humeralis humeralis (Rafinesque)

Nycticeius humeralis subtropicalis Schwartz

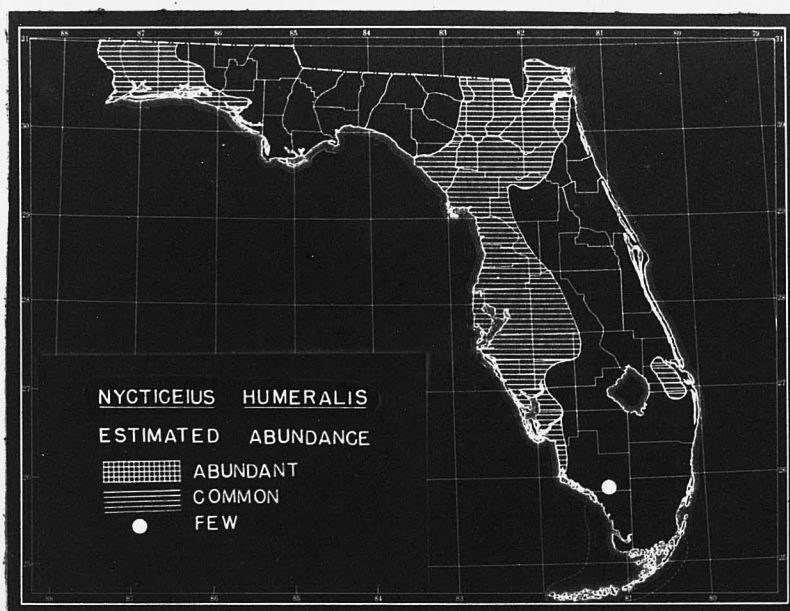
RANGE - Eastern United States, north to southwestern Ontario and southwestern Michigan, south through Florida, Alabama, Louisiana and southern Texas, west to northeastern Kansas. The Florida race, subtropicalis, is restricted to the southern tip of the peninsula, but our sample is not adequate to define the range limits.

In Florida the evening bat was found throughout the mainland portion of the state. Map 18 shows the localities where it was collected and indicates the abundance revealed by returns from public shoots. Map 19 shows the breeding localities recorded during the study and indicates relative abundance, compared with all other species collected by shooting. Nycticeius lives and breeds throughout the state where bats are found and probably is the only bat commonly seen flying in the southern peninsula.

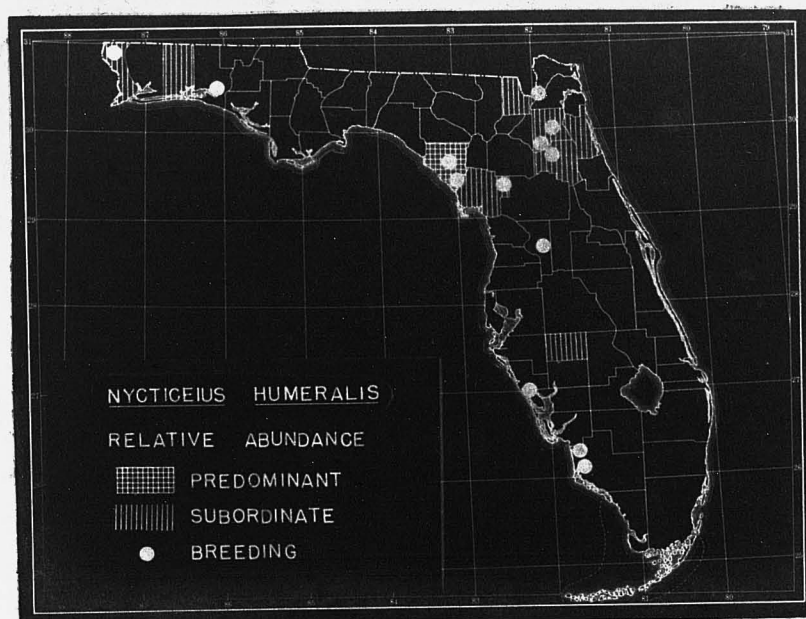
Of the 196 Nycticeius collected during the study, 38 per cent were shot at public shoots, 58 per cent came from impromptu shoots and 2 per cent came from moss plants. The remainder were taken from Tadarida colonies in buildings or as they emerged from them. Table 20 indicates the monthly returns from each of the collecting methods.

It appears that the evening bat occurs more frequently as isolated individuals or in small feeding groups than does any other species (Figure 14) but it also joins large feeding aggregations, though in smaller numbers than yellow and Seminole bats.

Collecting data for the 188 evening bats taken by shooting, where



Map 18. Range and estimated abundance of Nycticeius humeralis in Florida.



Map 19. Relative abundance of Nycticeius humeralis in Florida.
Breeding localities are shown.

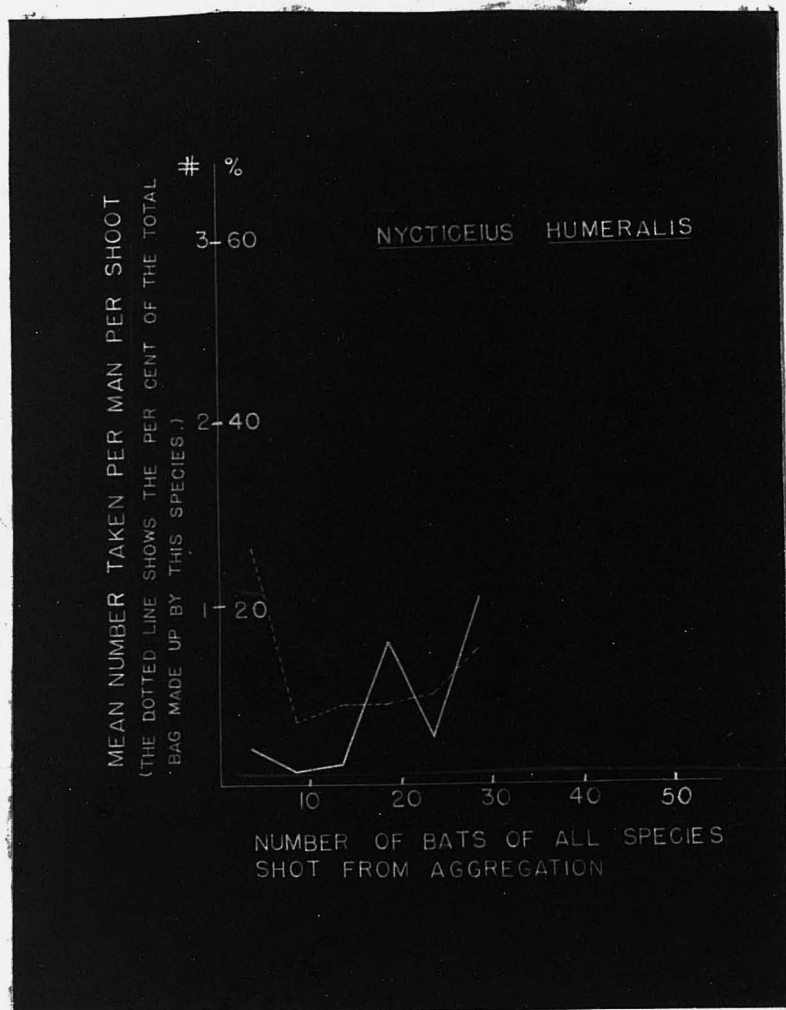


Figure 14. Aggregation response in Nycticeius humeralis.

habitat is known, indicate that 30 per cent were taken in hammock communities, 30 per cent were in scrub and 30 per cent came from flatwoods including cypress strands and ponds. Only 10 per cent were shot in turkey oak vegetation. Water was in the flight pattern of 31 per cent of the Nycticeius taken while feeding. These data are biased to a large degree because at least two shoots, inadvertently held near Tadarida colonies, yielded large numbers of Nycticeius. This causes a decrease in the apparent importance of water and an increase in the take in scrub vegetation. Harper (1927) has indicated the affinity this species exhibits for cypress trees and for water in the Okefenokee Swamp of Georgia. This is the common bat near cypress strands everywhere in Florida.

Nycticeius was found roosting under loose bark of pine trees, in buildings housing Tadarida colonies, in exterior crevices of houses, in hollow mangrove trees and, rarely, in Spanish moss. Three adult females were received from moss plants and a check indicated that this moss was gathered from cypress trees bordering a central Florida lake. Lactating females were netted inside a building housing a large Tadarida colony.

Newborn young were not collected during the study. Young are reared in tree crevices, under bark, and in buildings. Gates (1941) reported on a large breeding colony of this species in the attic of a church in Auburn, Alabama.

The young, typically two in number, are born in May and perhaps as late as mid-June. Litters of nearly full term embryos were collected May 17, 22, 23, and 26. Newly lactating females were collected May 14

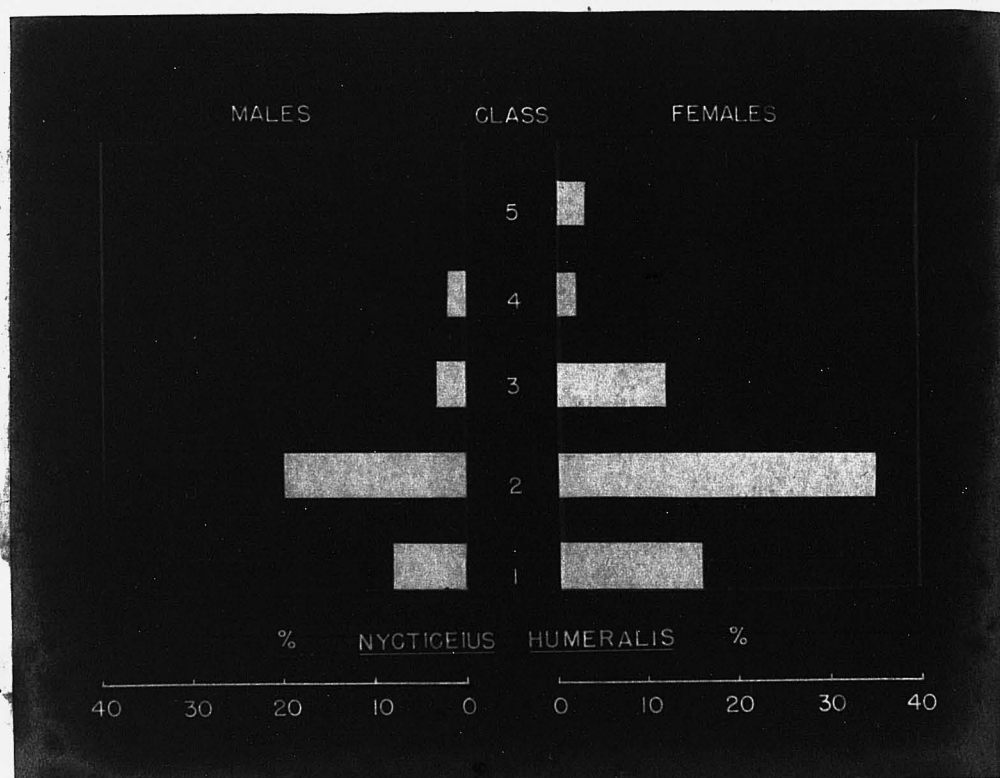


Figure 15. Sex and age distribution in 174 adult Nycticeius humeralis examined.

and 30 and June 5, 9 and 11. Of 18 litters examined, 17 had two embryos and one had three. The embryos in the latter were approximately half the size of full term young and had forearms measuring about 7 mm.

TABLE 21

NUMBER OF NYCTICEIUS HUMERALIS COLLECTED EACH MONTH BY PRODUCTIVE METHODS

	Shooting		Moss Plants	
	Number	Per cent	Number	Per cent
January	0	0	0	0
February	4	9	0	0
March	0	0	0	0
April	8	60	1	6
May	26	20	0	0
June	30	12	1	1
July	7	3	0	0
August	17	16	0	0
September	90	30	0	0
October	5	9	0	0
November	1	4	0	0
December	0	0	1	5
Totals	188		3	

The sex ratio observed in 174 Nycticeius shot while feeding was 32 per cent males or 47 males per 100 females. Figure 15 illustrates the sex and age distribution in the adult sample. Here again the structure is as would be expected if the males have a higher mortality rate and a shorter life expectancy than do females. A collecting phenomenon is reflected in the apparent small number of young of the year in the first class. This is due to the small number of Nycticeius taken during July and August and may also reflect a faster rate of tooth wear. This would result in many of the young of the year reaching a stage of wear which would cause them to be placed in age class two by September or October.

TABLE 22

RELATIVE REGIONAL ABUNDANCE OF NYCTICEIUS HUMERALIS IN FLORIDA

	Number taken	Per cent of all bats shot	Ratio of <u>Nycticeius</u> per 100 <u>L. seminolus</u>	
			Public shoots	Impromptu shoots
West	64	28	17	153
North	73	15	16	140
Central	15	9	18	13
South	28	11	56	0
Everglades	8	100		
Total	188			

Corynorhinus rafinesquii (Lesson)

RANGE - Southeastern United States, from West Virginia to northwestern Tennessee west to Arkansas and south as far as central Florida and probably eastern Texas.

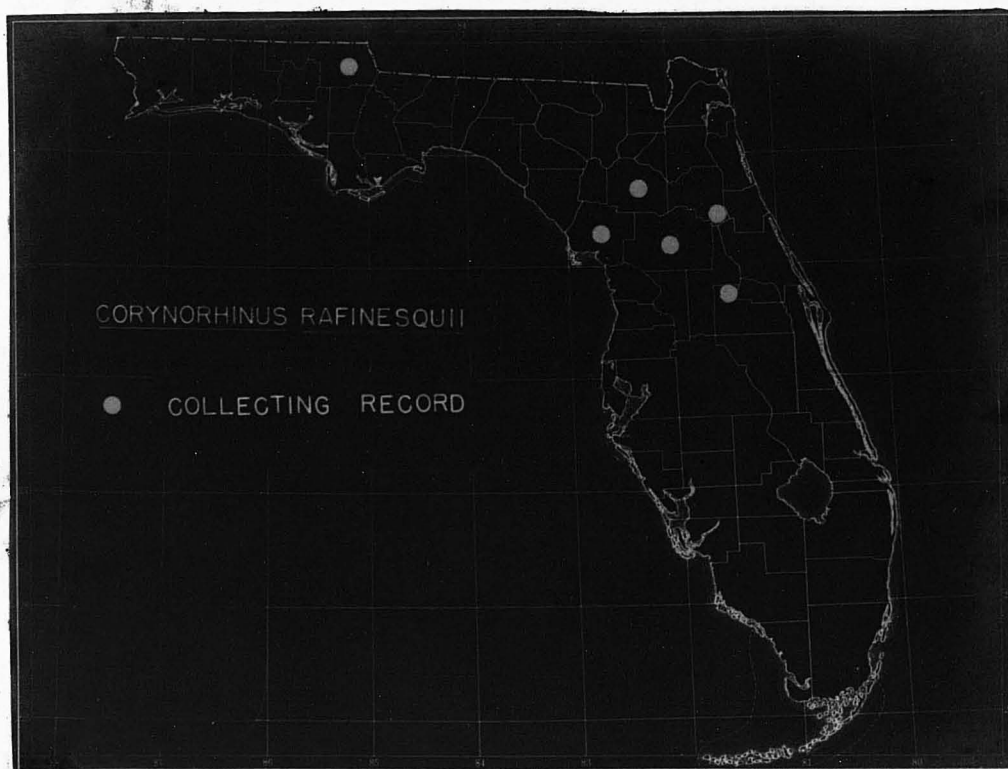
The eastern lump-nosed bat, although not taken by the collecting organization during our study, appears to be fairly common in suitable habitat in Florida. It is recorded from Micanopy, Alachua County (Allen 1893), Marianna, Jackson County (Sherman, 1945), Zellwood, Orange County (Moore, 1949), Satsuma, Putnam County (Moore, 1949b), Silver Springs, Marion County (Neill, 1953) and various localities in Levy County (Pearson, 1954).

Ecological data furnished with four of these collections indicate that roosts are used repeatedly, often by several individuals. These roosts combine semi-darkness with high humidity in situations such as culverts, basements, hunting shacks and artificial grottoes, usually located in hammock type vegetation. Similar situations are found in roosts reported from other parts of the range. Goodpaster and Hoffmeister (1952) described a roost in Tennessee used regularly for at least ten months, located in a cistern reaching a depth of 20 feet below ground surface. It had an entrance two and one-half feet in diameter three feet above ground. Parturition was not recorded in this roost.

Florida records are from the months of June, July, September, October and November. Although most of the specimens were males, females were taken in June, September and November. Birth of the single young

has never been recorded in Florida, nor is the feeding habitat known. It is not surprising that bats of this species were not taken at shoots since they habitually leave the roost after dark (Palmer, 1954) and shooting is a poor collecting method for them. It seems likely, however, that this species may emulate Corynorhinus townsendii, hovering about low vegetation or even alighting on it in search of soft bodied prey. The ability to hover in flight and maneuver in close quarters is probably an adaptation for this type of activity (Hamilton, 1943).

It is somewhat disturbing that this bat, with a propensity for selecting roosts having the characteristics furnished by so many Florida caves, has not been recorded from them, despite the intensive speleological activity of the last few years. A breeding record is needed before Corynorhinus can be definitely considered to have a functional population in the state, although the number and seasonal distribution of the records now available indicate that the species is certainly more than an occasional wanderer visiting Florida.



Map 20. Localities where Corynorhinus rafinesquii has been taken in Florida.

Eumops glaucinus (Wagner)

RANGE - Colombia, Ecuador and Brazil north through Central America to Yucatan and Morelos in Mexico; Cuba and Jamaica in the West Indies and Miami, Florida.

The mastiff bat, not abundant anywhere in its circum-Caribbean range, was first noticed in Miami in 1936 (Barbour, 1936). Since that time a total of about 20 have been taken. Collecting data indicate that only injured, young or confused individuals fall into the hands of the informed citizens of greater Miami who save them for collections.

The range in Florida is limited to parts of Coral Gables, Coconut Grove and Miami intensively developed as residential areas, with lush growths of tropical flowers and shrubs. Some individuals were taken in low shrubbery by gardeners, some flew into houses at dusk and other isolated individuals were taken under conditions indicating injury of some kind.

Through the generosity of Mr. Owre of the University of Miami, who is accumulating specimens for a careful study of this species, the writer was able to examine three freshly collected Eumops, one a sub-adult male which was taken alive in June of 1955. This individual was still in the dark juvenile coat but could already fly short distances.

It appears that Eumops is encountered more often by the natives than are other bat species known to frequent the area. Although this may indicate a denser population, it seems more likely that the habits of this species are more conducive to its discovery by man.

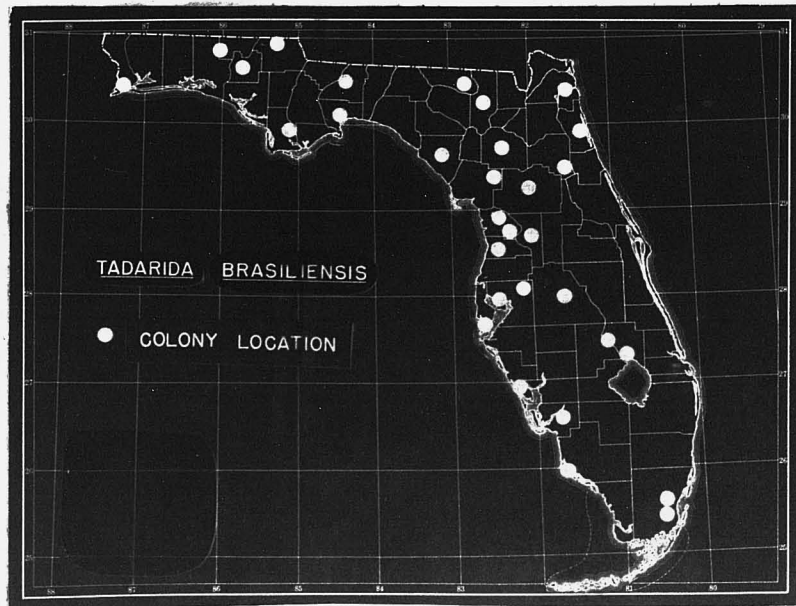
Tadarida brasiliensis cynocephala (LeConte)

RANGE - Louisiana, the coastal plain in Mississippi, Alabama, Georgia and South Carolina and all of the Florida mainland. The species range covers the Caribbean islands and includes the area from southern Brazil and Chile to Oregon and Nebraska.

The freetail bat, Tadarida brasiliensis cynocephala is abundant throughout the Florida mainland but has not been taken in the Keys. Breeding colonies were found only in man-made structures such as houses and bridges. Colonies estimated to have 50,000 individuals are common and some may be much larger. The number of roosts located during the study make it obvious that almost every town with abandoned buildings may shelter a Tadarida colony. Tadarida may be the most abundant bat in Florida.

This bat was not taken while feeding and was never shot during the study away from the immediate vicinity of a colony roost. It was not observed in caves and has never been recorded from a cave in the southeast. This is in marked contrast to the closely related Tadarida brasiliensis mexicana, which is also found in houses but characteristically roosts in caves in western North America. Map 21 shows the colony roosts located during the study.

Of 31 roosting sites located during the study, 25 were in walls and attics of houses, barns, power plants, railway stations, lumber mills or similar roofed buildings. Two were beneath the timbers and in cracks of bridges. The remainder were in more exposed places, behind window blinds, signboards or ornamental parts of buildings. Mr.



Map 21. Location of Tadarida brasiliensis colonies in Florida.

Lester Piper described a bat, probably of this species, roosting in the concave underside of a telephone insulator. All of these sites are products of human development.

Hamilton (1941) has described an incident when bats which he identified as this species were frightened from inside the thatch formed by dead and drooping fronds sheathing the trunk of a Washintonia palm in Fort Myers. Mr. E. B. Chamberlain, Jr. told the writer of a similar observation he had made in Punta Gorda. Although the trees were exotic species found only in cities in Florida, this may furnish a clue to one type of natural roost. Fargo (1929) described roosts of this species in hollow mangroves on Old Indian Key in Tampa Bay. Subsequent to the introduction of the roof rat and destruction of the mangroves by hurricanes the bats disappeared. Since that time, although hollow trees in this and various other localities have been watched and examined, Tadarida have not been found.

All of the breeding colonies of Tadarida known in Florida are in situations that did not exist 500 years ago. Apparently human structures were so admirably suited to the living requirements of this bat that natural breeding sites were entirely abandoned. While it may be that houses are merely a superior substitute for hollow trees, it may be reasonably argued that changes in the fauna following the advent of western civilization made the original breeding sites untenable.

Whatever the reason may have been for abandonment of natural roosts, a parallel may be seen in the habits of some other species. Myotis austroriparius, primarily a cave breeder, has also accepted

buildings as a substitute for natural roosts. If a comparison of the amount of predator sign seen in caves with that in buildings can be accepted as an indication of predation rates, this change in habits may have been beneficial. Nycticeius humeralis and Eptesicus fuscus, originally roosting in tree cavities in Florida, have also accepted buildings as breeding sites. It is common to find at least one of these species breeding in buildings containing a Tadarida colony.

Of the nine Tadarida colonies examined closely for other species, either by shooting during the evening flight or by setting mist nets across exits, three contained Myotis, three Nycticeius, four Eptesicus and two contained only Tadarida. Only Myotis were found in Tadarida colonies in large numbers. The other two species when present were represented by a few individuals. One colony contained breeding females of three species. Nycticeius and Eptesicus were not found roosting in buildings without a Tadarida colony, but two Myotis colonies of the four found in man-made structures contained no Tadarida.

Twenty-two of the roosts located were in structures in hammock vegetation, usually in residential areas. This may indicate nothing more than a tendency for humans to build in this plant community. One colony was located in a house in scrub vegetation bordering a beach, one in a boathouse well out in a salt marsh and three were in pine flatwoods. The most surprising roost locality was under a bridge crossing a mangrove bordered salt creek.

In only two instances were Tadarida roosts located over water. This is in marked contrast to Myotis austroriparius which usually roosts over water and commonly deserts a breeding cave if it becomes

dry. It may be that the high relative humidity, usually 100 per cent, keeps Tadarida from using Florida caves as roost sites.

Observations on the sex and age groups in roosts at various seasons indicate that Tadarida populations have a number of auxiliary roosts. Females outnumber males in breeding colonies, but up to 42 per cent of the colony may be males. Small groups of from 30 to 100 males may be found at auxiliary roosts at any season, but these may contain a few females also. Breeding roosts are usually deserted in cold weather but sometimes a small remnant of the colony may be found hibernating in a protected crevice.

Recovery of banded individuals indicated that tooth wear is slower than it is in non-colonial species and that the five age classes recognized by this character probably cover an age span much longer than four years. Samples from one large maternity colony after the young were completely independent indicated that those born in the current year may make up 43 per cent of the colony, with as many as 51 per cent of the females being young of the year. Since only one young is born per year and the sex ratio is very nearly even, it is probable that the adult females leave the roost after weaning their young. Practically all of the females in a colony in May and June are either pregnant or lactating. Only 8 per cent of 120 examined in one instance showed no evidence of breeding activity.

Study of the age distribution in Figure 16 indicates that Tadarida like Pipistrellus subflavus, may have no differential mortality between

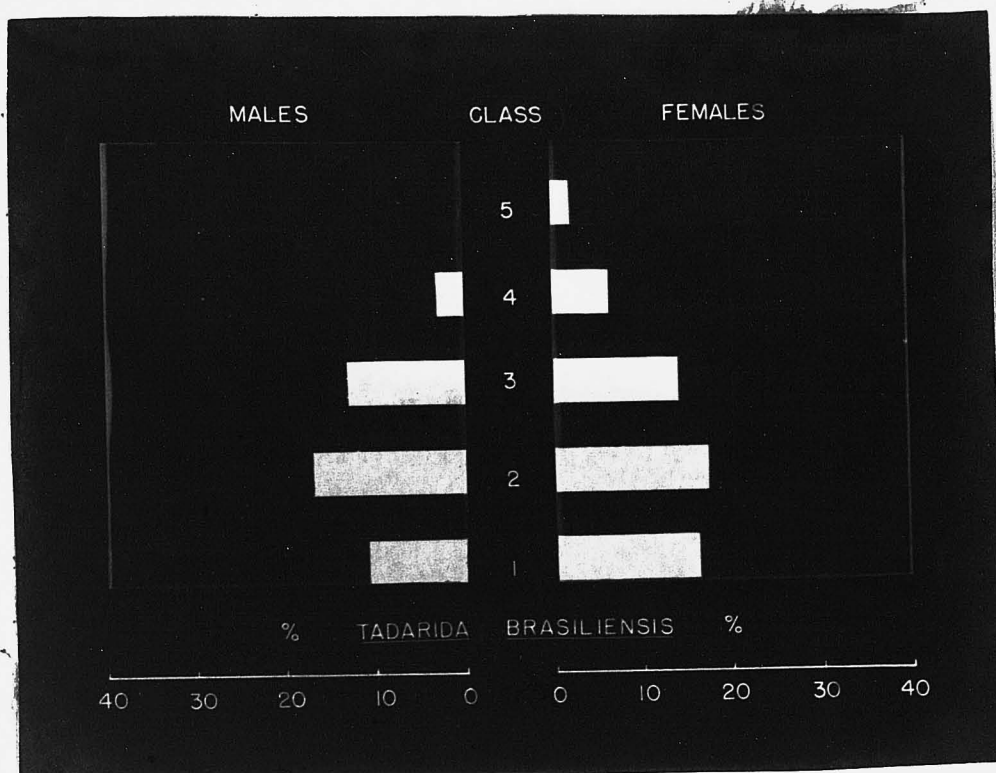


Figure 16. Sex and age distribution in 311 adult Tadarida brasiliensis examined.

sexes. In this species alone the available data indicate uniform mortality, without regard for sex or age, after maturity is attained. This characteristic, considering the low birth rate and the flourishing population in Florida, probably reveals the benefits attained by rapid adaptation to the changes of civilization.

DISCUSSION AND SUMMARY

The Florida bat fauna is composed of 15 species and 18 races. Four species appear to be accidental or seasonal visitors, not breeding in the state. Of these, Artibeus jamaicensis has a tropical range, while the others, Myotis keenii, Myotis sodalis and Lasiurus cinereus appear to be irregular winter visitors to the northern half of the state from more northern populations. One species, Corynorhinus rafinesquii, is not known to breed here, but the number and dates of collecting records suggest that a functional population does exist, and that it has habits which make the usual collecting methods ineffective, especially for parturient females. Ten species are known to occur as breeding populations in Florida but the ranges of two, Eumops glaucinus and Myotis grisescens, are small and they appear to be restricted to isolated and ecologically unique habitats.

The eight species remaining have breeding populations found over a large portion of the state. Four of them, Myotis austroriparius, Lasiurus borealis, Lasiurus seminolus, and Pipistrellus subflavus are associated with the hammock communities, which are similar ecologically to the deciduous hardwood forests of the North. Tadarida brasiliensis is not limited by hammock community distribution and its abundance probably is influenced more by the availability of roosts than by the type of plant community. Nycticeius humeralis is common in cypress swamps and in pine flatwoods, both typically Florida communities, but

it also occurs in moderate abundance in hammock communities. Dasypterus floridanus is abundant only in the open parkland communities of the central peninsula, which are also typically Floridian. These three species have related forms ranging to the west and south and, at least in their principal abundance, are restricted to the lower austral life zone, occurring sparsely in the deciduous forest biome. Eptesicus fuscus probably has an equally wide range in Florida, but was not well represented in the bats collected. It may have habits which shield it from the collecting methods employed.

Four species, Myotis austroriparius, Pipistrellus subflavus, Eptesicus fuscus and Nycticeius humeralis, have recognized races restricted to Florida or the immediately adjacent areas of the Coastal Plain.

Two distinctive and widespread plant communities which appear to lack a bat population are the fresh water marsh and sandy prairie communities, both of which are level, open areas devoid of trees. They are poorly drained and become covered with water during the rainy season. When dry there is a striking superficial resemblance to dry prairies of the west.

It is germane to mention here some of the species not collected in Florida, but whose range and ecology make it possible for them to appear, at least as wanderers, in the future. The most promising source of new species is in the north, which has so many species already represented in the state, has other likely candidates, and is not isolated by barriers to bat movement.

Myotis lucifugus and Lasionycteris noctivagans have already been mentioned. Both range over wide areas and have been taken within 200 miles of Florida. Winter collections in the northern and western parts of the state may eventually yield specimens.

To the south, Cuba and the Bahamas have tropical species probably adapted to the southern coasts of Florida. Absence of caves and of rain forest vegetation preclude establishment of most of these if they appear, but individuals may cross the narrow intervening stretch of water at any time, although this seems to be a formidable barrier when present distributions are considered. Most of the bats of the southwestern United States are cave roosting species adapted to arid conditions.

Different collecting methods gave divergent impressions of occurrence and abundance of several species. Tadarida brasiliensis, although quite abundant and widely distributed, was not taken by shooting away from the roosting sites. This was also true of Myotis austroriparius until the late flight, low and well out over the surface of ponds and lakes, was discovered. In contrast, most other species only appeared to be abundant when collecting was by shooting, although Lasiurus seminolus and Dasypterus floridanus were taken in considerable numbers from the Spanish moss in which they roosted. Pipistrellus subflavus was taken effectively from roosting sites in caves and Spanish moss and also by shooting, but did not seem abundant by any of these methods when compared with the numbers of other species taken. Corynorhinus rafinequii and Eptesicus fuscus did not appear to be abundant when collected by

any method, although the latter demonstrated a tendency to roost and breed in buildings housing Tadarida colonies. A species combining the roosting habits of Lasiurus borealis or Nycticeius humeralis with the flight and feeding habits of Tadarida brasiliensis would certainly appear to be scarce, if it were collected at all. Corynorhinus rafinesquii is the only Florida bat which appears to approach these conditions.

The caves of Florida influence the distribution of several bat species to a remarkable degree. There are two cavern regions, one in Jackson County and the other in the western half of the peninsula, between Hamilton and Hernando counties. Florida caverns are characteristically warm and humid, with almost constant temperatures of from 68° to 73°F, and humidity uniformly near the saturation point. The high temperatures apparently make successful hibernation impossible because energy loss through metabolism is too great. Some more exposed caves may have lower temperatures, but in general Myotis austroriparius, in the southern cavern region at least, roosts outside caves in winter. Most Pipistrellus subflavus hibernate in caverns but they usually select roosts near the entrance, where temperatures fluctuate over a wider range, allowing successful hibernation in cold weather and feeding flights during warm periods. In the Marianna region one large cavern, Old Indian Cave, has three entrances exposed so that winds from almost any quarter pass fresh air from outside through the bat chamber, producing rapid changes and temperatures approaching the 40° mark in cold weather. Here five species of bats, Myotis austroriparius, Myotis grisescens, Myotis keenii, Myotis sodalis and Pipistrellus subflavus have been found hibernating.

The high humidity in all these caverns seems to be the factor excluding other species, especially Eptesicus fuscus and Tadarida brasiliensis, which roost in drier caves in other parts of the country.

The species which roost singly or in small, inconspicuous groups, dispersed in vegetation or in small crevices, were collected by shooting the population segment feeding at twilight. It does not necessarily follow that this method produces a representative sample of the non-colonial bats, but this was the only productive source for some of them. A few species, particularly Pipistrellus subflavus, Lasiurus seminolus, and Dasypterus floridanus, were collected from Spanish moss processing plants because they use this material as a roosting site and it is gathered in quantity by a labor force which responded to minor economic stimulation.

When feeding aggregations were found standard collecting methods were employed, using volunteer shooters, so that large samples which could be duplicated were obtained. The bats of each species taken per unit of effort were computed and these figures were used as indices to their abundance. Bats were also collected by shooting where only one, or a few, were found in flight. Comparison of these with the collections of bats from public shoots revealed information about the tendency to aggregate, or to avoid aggregations.

It was obvious that Lasiurus seminolus and Dasypterus floridanus were especially inclined to join aggregations, while Lasiurus borealis and Nycticeius humeralis were less so. Pipistrellus subflavus did not appear to join aggregations at all and may avoid them.

Lasiurus borealis was found to be limited in abundance to the northern border region of Florida, while Pipistrellus subflavus and Lasiurus seminolus decreased concurrently with the hammock vegetation. Dasypterus floridanus was only abundant in the western half of the central peninsula, where it outnumbered all other species in large aggregations, while Nycticeius humeralis was almost uniformly common in all forested parts of the state.

The data on life history available in the sample were presented in the species discussions.

Tooth wear was measured in eight species, six of which were collected in sufficient numbers to yield reliable information about population age composition and mortality rates. These data permit evaluation of the status of the populations in the state and the effects of different roosting and hibernating habits on survival. Precise correlation of various stages of wear with chronological age proved to be impractical beyond the first year. Individuals of each species were grouped into five classes of wear, based upon observation of the first upper molar, and the results were reduced to per cent of the sample observed, separating sexes. Most interpretations from these data were based upon comparison of the results observed between the sexes assuming an even wear rate throughout life similar in both sexes. Bats with extreme amounts of wear were unusual. Apparently most Florida bats do not attain the physiological life expectancy indicated by completely worn-out teeth.

Observation of the data presented in the tooth wear charts

revealed information about mortality rates. There was no significant difference in age composition of the male and female Tadarida brasiliensis and Pipistrellus subflavus samples. Tadarida roost and hibernate in colonies, usually in buildings, and mortality appears to be uniform, without regard to age or sex. Pipistrellus, however, hibernate in caves in winter and roost outdoors in foliage during the summer. Although similar for the sexes, high mortality rates occur, apparently in the first summer and fall of adulthood, with very low mortality rates thereafter. It appears, therefore, that when the sexes have similar roosting and hibernating habits, mortality is about equal. Roosting outdoors seems to increase mortality, probably through increased predation while the bats sleep during the day. A contrasting situation was observed in Myotis austroriparius, in which most males roost outdoors all year while females join large cavern colonies to bear and rear young in summer. Here males have a higher mortality rate which appears to be independent of age, while females have a very low one, also independent of age. It seems, therefore, that summer is the season of highest mortality for bats which roost outdoors.

Female Lasiurus seminolus and Dasypterus floridanus, which roost outdoors all year, have low mortality rates increasing late in life, while males appear to have higher ones, and earlier in life than the females do. In male Dasypterus the critical period is the first winter, with good survival afterward until very old age, while males of Lasiurus seminolus seem to have a uniform mortality rate, without regard for age. It is not clear how differences between the two species, if significant,

can be explained by the known differences in habits, the most promising of which is the tendency for each sex of Dasypterus to aggregate in separate groups, some of which may move about over wide ranges.

Nycticeius humeralis, roosting mostly outdoors, but in small groups containing both sexes in sheltered places, has a high mortality rate for both sexes during the first summer as an adult. It decreases thereafter in both sexes.

Data on length of life were not obtained for the non-colonial species with large litters and heavy mortalities, but banding indicated that Tadarida brasiliensis and Myotis austroriparius spend more time, possibly as much as two years, in each of the earlier wear classes and hence live longer. The correlation between litter size and roosting habits is very close. Tadarida, having low mortality rates and roosting indoors all year has one young per litter. Myotis austroriparius and Pipistrellus subflavus, roosting outdoors at least half of the year have two young, while Lasiurus seminolus and Dasypterus floridanus, roosting outdoors all year have three or four young per litter.

Nycticeius humeralis, with two young per litter, probably illustrates the benefits of the cover offered by crevice type shelters on mortality rates. It is significant that species of Myotis which hibernate in caves in northern states typically have but one young per litter.

CONCLUSIONS

1. Data gathered during a study of more than five thousand bats collected in Florida reveal that the fauna contains 15 species, four of which occur irregularly. Only ten species are known to breed in the state.

2. Maps showing geographical variation of abundance for non-colonial species indicate a correlation with the distribution of plant communities. Four species are common only in broad-leaved forest communities. The distribution of Tadarida brasiliensis is not correlated with vegetation. At least two important plant communities apparently lack a bat fauna.

3. Six of the species breeding in Florida roost in colonies, three of them usually in caves, while four species roost in buildings. Myotis austroriparius, Myotis grisescens, Myotis keenii, Myotis sodalis, and Pipistrellus subflavus roost in caves in Florida and the first two rear young in them. Myotis austroriparius, Nycticeius humeralis, Eptesicus fuscus, Tadarida brasiliensis and Corynorhinus rafinesquii roost in buildings and all but the last species rear young in them. Eptesicus fuscus, Corynorhinus rafinesquii, and Tadarida brasiliensis roost outside caves in Florida although they are typically cave bats in other parts of their ranges. Florida caverns are warm and damp. Hibernation is limited to a few colder ones which shelter large numbers of bats.

4. Pipistrellus subflavus, Dasypterus floridanus, Lasiurus seminolus, Lasiurus borealis, and Lasiurus cinereus roost in foliage and the

first three commonly roost and rear young in Spanish moss.

5. Four of the five species usually collected by shooting at dusk join feeding aggregations of bats. Pipistrellus subflavus alone ignores or avoids aggregations of other species.

6. Population structures and mortality rates, estimated from tooth wear, reveal a good correlation between mortality rates, litter size and roosting habits. Species which roost in caves and buildings have smaller litters, lower mortality rates and greater life expectancy than those which roost in foliage. Mortality rates are greater in summer, in younger adults and in species which roost singly in foliage. When both sexes have similar roosting habits mortality rates are equal for males and females.

7. Availability of suitable roosting and hibernating sites is an important feature which may determine whether or not a population of any bat species can maintain itself in a plant community or faunal region.

8. The only indication of seasonal migration is in the species found to the north. Bats from the tropics and from western North America reach Florida irregularly and probably accidentally.

BIBLIOGRAPHY

- Allen, Glover Morrill 1939. Bats. Cambridge, Mass.: Harvard University Press, x, 368 pp.
- Allen, Harrison 1893. A monograph of the bats of North America. U. S. Nat. Mus. Bull. No. 43, ix, 198 pp.
- Anderson, K. 1918. On the determination of age in bats. Jour. Bombay Nat. Hist. Soc., 25: 249-259.
- Barbour, Thomas 1936. Eumops in Florida. Jour. Mamm., 17 (4): 414.
- Barkalow, Fred S. Jr. 1939. The LeConte free-tailed bat in Alabama. Jour. Mamm., 20 (3): 370.
- Barkalow, Fred S. Jr. 1948. The status of the Seminole bat, Lasiurus seminolus (Rhoads). Jour. Mamm., 29 (4): 415-416.
- Barrington, Burness Austin 1949. Mammals of a north Florida flatwoods. Unpublished Ph.D. dissertation, University of Florida.
- Black, J. D. 1936. Mammals of northwestern Arkansas. Jour. Mamm., 17 (1): 29-35.
- Blair, W. Frank 1935. The mammals of a Florida hammock. Jour. Mamm., 16 (4): 271-277.
- Brimley, C. S. 1923. Breeding dates of small mammals at Raleigh, North Carolina. Jour. Mamm., 4 (4): 263-264.
- Burt, William Henry 1939. The rafinesque bat in Michigan. Jour. Mamm., 20 (1): 103.
- Chapman, Frank M. 1894. Remarks on certain land mammals from Florida, with a list of the species known to occur in the state. Bull. Amer. Mus. Nat. Hist., 6 (Art. 14): 333-346.
- Cockrum, E. Lendell 1952. Mammals of Kansas. Univ. of Kansas Publs., Mus. of Nat. Hist., 7 (1): 1-303.
- Coleman, Robert H. 1940. Dasypterus floridanus in South Carolina. Jour. Mamm., 21 (1): 90.
- Coleman, Robert H. 1948. Some mammal notes from South Carolina. Jour. Mamm., 29 (3): 293-294.

- Coleman, Robert H. 1950. The status of Lasiurus borealis seminolus (Rhoads). Jour. Mamm., 31 (2): 190-192.
- Conner, Jeanette Thurber 1927. Jean Ribaut, the whole and true discoverer of Terra Florida. DeLand, Florida: Florida State Hist. Soc. XIV, 139 pp.
- Cooley, R. 1954. Second record of the hoary bat in Florida. Jour. Mamm., 35 (1): 116-117.
- Dalquest, Walter W. 1947. Notes on the natural history of the bat, Myotis yumanensis, in California, with a description of a new race. Amer. Midl. Nat., 38 (1): 224-247.
- Davis, John H., Jr. 1943. The natural features of southern Florida. Fla. State Geol. Surv. Bull., 25: 311 pp. illus.
- Davis, Wayne H. 1957a. The status of the seminole bat, Lasiurus seminolus (Rhoads). Proc. Biol. Soc. of Wash., 70: 181-182.
- Davis, Wayne H. 1957b. A new subspecies of the eastern pipistrelle from Florida. Proc. Biol. Soc. of Wash., 70: 213-216.
- Dellinger, S. C. and J. D. Black. 1940. Notes on Arkansas mammals. Jour. Mamm., 21 (2): 187-191.
- Fargo, William G. 1929. Bats of Indian Key, Tampa Bay, Florida. Jour. Mamm., 10 (3): 203-205.
- Frum, W. Gene 1948. Corynorhinus macrotis, big-eared bat, in West Virginia. Jour. Mamm., 29 (4): 418.
- Frye, O. E. Jr. 1948. Extension of range of two species of bats in Florida. Jour. Mamm., 29 (2): 182.
- Gates, William H. 1941. A few notes on the evening bat, Nycticeius humeralis (Rafinesque). Jour. Mamm., 22 (1): 53-56.
- Goodpaster, Woodrow W. and Donald F. Hoffmeister 1952. Notes on the mammals of western Tennessee. Jour. Mamm., 33 (3): 362-371.
- Griffin, Donald R. 1950. Measurements of the ultrasonic cries of bats. Jour. Acoust. Soc. of Amer., 22 (2): 247-255.
- Guthrie, Mary J. 1933. Notes on the seasonal movements and habits of some cave bats. Jour. Mamm. 14 (1): 1-19.

- Hamilton, W. J. Jr. 1930. Notes on the mammals of Breathitt County, Kentucky. Jour. Mamm., 11 (3): 306-311.
- Hamilton, W. J. Jr. 1941. Notes on some mammals of Lee County, Florida. Amer. Midl. Nat., 25 (3): 686-691.
- Hamilton, W. J. Jr. 1943. The Mammals of eastern United States. Ithaca, N. Y.: Comstock Publishing Company.
- Harper, Francis 1927. The mammals of the Okefenokee Swamp Region of Georgia. Proc. of the Boston Soc. of Nat. Hist., 38 (7): 191-396.
- Hooper, Emmet T. 1939. Notes on the sex ratio in Nycticeius humeralis. Jour. Mamm., 20 (3): 369-370.
- Howell, Arthur H. 1909. Description of a new bat from Nickajack Cave, Tennessee. Proc. Biol. Soc. of Wash., 22: 45-48.
- Howell, Arthur H. 1921. A biological survey of Alabama. North Amer. Fauna No. 45. 88 pp.
- Howell, Arthur H. 1932. Florida bird life. New York: Florida Dept. of Game and Fresh Water Fish etc. xxiv + 579 pp.
- Jennings, William L., and James N. Layne 1957. Myotis sodalis in Florida. Jour. Mamm. 38 (2): 259.
Koussman et al?
- Layne, James N. 1955. Seminole bat, Lasiurus seminolus, in central New York. Jour. Mamm., 36 (3): 453.
- Lawrence, Barbara 1943. Miocene bat remains from Florida, with notes on the generic characters of the humerus of bats. Jour. Mamm., 24 (3): 356-369.
- Lewis, John B. 1940. Mammals of Amelia County, Virginia. Jour. Mamm., 21 (4): 422-428.
- Lowry, George H. Jr. 1943. Check-list of the mammals of Louisiana and adjacent waters. Occ. Pap. Mus. Zool. Louisiana State Univ., No. 13: 213-251.
- Maynard, Charles Johnson 1872. Catalog of the mammals of Florida with notes on their habits, distribution, etc. Bul. Essex Institute, 4: 135-150.
- Maynard, Charles Johnson 1883. The mammals of Florida. Quart. Jour. Boston Zool. Soc., 2 (1): 1-8, (2): 17-24, (3): 38-43, (4): 49-50.

- Miller, Gerrit S. Jr. 1897. Revision of the North American bats of the family Vespertilionidae. North American Fauna No. 13: 135 pp.
- Miller, Gerrit S. and Glover M. Allen 1928. The American bats of the genera Myotis and Pizonyx. U. S. Nat. Mus. Bull. No. 144: VIII and 1-208 pp.
- Miller, Gerrit S. and Remington Kellog 1955. List of North American recent mammals. U. S. Nat. Mus. Bull. No. 205: XII and 1-954 pp.
- Mohr, Charles E. 1932. Myotis grisescens and Myotis sodalis in Tennessee and Alabama. Jour. Mamm., 13 (3): 272-273.
- Moore, Joseph C. 1946. Mammals from Welaka, Putnam County, Florida. Jour. Mamm., 27 (1): 49-59.
- Moore, Joseph C. 1948 (1949). Range extension of two bats in Florida. Quart. Jour. Fla. Acad. Sci., 11 (1): 50.
- Moore, Joseph C. 1949. Putnam County and other Florida mammal notes. Jour. Mamm., 30 (1): 57-66.
- Moseley, E. L. 1928. The number of young red bats in one litter. Jour. Mamm., 9 (3): 249.
- Neill, Wilfred T. 1953. A Florida specimen of LeConte's lump-nosed bat. Jour. Mamm., 34 (3): 382-383.
- Odum, Eugene P. 1949. Small mammals of the Highlands (North Carolina) plateau. Jour. Mamm., 30 (2): 179-192.
- Palmer, Ralph S. 1954. The Mammal guide. Garden City, N. Y.: Doubleday. 384 pp.
- Pearson, Paul G. 1954. Mammals of Gulf Hammock, Levy County, Florida. Amer. Midl. Nat., 51 (2): 468-480.
- Penney, J. R. 1950. Distribution and bibliography of the mammals of South Carolina. Jour. Mamm., 31 (1): 81-89.
- Pournelle, George H. 1950. Mammals of a north Florida swamp. Jour. Mamm., 31 (3): 310-319.
- Pournelle, George H. and B. A. Barrington 1953. Notes on mammals of Anastasia Island, St. Johns County, Florida. Jour. Mamm., 34 (1): 133-135.
- Quay, W. B. 1949. Notes on mammals of Thomas County, Georgia, with two new state records. Jour. Mamm., 30 (1): 66-68.

- Rageot, R. H. 1955. A new northernmost record of the yellow bat, Dasypterus floridanus. Jour. Mamm., 36 (3): 456.
- Rand, A. L. and Per Host 1942. Results of the Archbold expeditions. No. 45, Mammal notes from Highland County, Florida. Bull Amer. Mus. Nat. Hist. LXXX (Art. 1): 1-21.
- Rehn, James A. G. 1902. Three new American bats. Proc. Acad. Nat. Sci. Philadelphia, 54: 638-641.
- Rhoads, Samuel N. 1897. A new southeastern race of the little brown bat. Proc. Acad. Nat. Sci. Philadelphia, 49: 227-228.
- Rhoads, Samuel N. 1901. On the common brown bats of peninsula Florida and Southern California. Proc. Acad. Nat. Sci. Philadelphia, 53: 618-619.
- Rice, Dale W. 1955. Status of Myotis grisescens in Florida. Jour. Mamm., 36 (2): 289-290.
- Rice, Dale W. 1955b. Myotis keenii in Florida. Jour. Mamm., 36 (4): 567.
- Rice, Dale W. 1957. Life history and ecology of Myotis austroriparius in Florida. Jour. Mamm., 38 (1): 15-32.
- Romans, Bernard 1775. A concise natural history of east and west Florida. New York: XXXIX and 342 pp.
- Sanborn, Colin Campbell 1923. The bats of the genus Eumops. Jour. Mamm., 13 (4): 347-357.
- Schwartz, Albert 1951. A new race of bat (Nycticeus humeralis) from southern Florida. Jour. Mamm., 32 (2): 233-234.
- Schwartz, Albert 1952. The land mammals of southern Florida and the upper Florida Keys. Unpublished dissertation, University of Michigan.
- Schwartz, Albert 1955. The status of the species of the brasiliensis group of the genus Tadarida. Jour. Mamm., 37 (1): 106-109.
- Sherman, H. B. 1934. The occurrence of Myotis grisescens in Florida. Jour. Mamm., 15 (2): 156.
- Sherman, H. B. 1936. List of the recent wild land mammals of Florida. Proc. Fla. Acad. Sci., 1: 102-128.
- Sherman, H. B. 1937. Breeding habits of the free-tailed bat. Jour. Mamm., 18 (2): 176-187.

- Sherman, H. B. 1939. Notes on the food of some Florida bats. Jour. Mamm., 20 (1): 103-104.
- Sherman, H. B. 1944 (1945). The Florida yellow bat, Dasypterus floridanus. Proc. Fla. Acad. Sci., 7 (2-3): 193-197.
- Sherman, H. B. 1956. Third record of the hoary bat in Florida. Jour. Mamm., 37 (2): 281-282.
- Sherman, H. B. 1957. General biotic relations of the Florida mammal fauna. Quart. Jour. Fla. Acad. Sci., 20 (3): 149-173.
- Smith, Elizabeth, 1957. Experimental study of factors affecting sex ratios in the little brown bat. Jour. Mamm., 38 (1): 32-39.
- Stegeman, LeRoy C. 1956. Tooth development and wear in Myotis. Jour. Mamm., 37 (1): 58-63.
- Van Doren, Mark (editor) 1928. Travels of William Bartram. Dover Publications. 414 pp.
- Williams, John Lee 1827. A view of West Florida, embracing its geography, topography, etc. Philadelphia: 178 pp.
- Williams, John Lee 1837. The territory of Florida: or sketches of the topography, civil and natural history of the country, the climate, and the Indian tribes from the first discovery to the present time. New York: A. T. Goodrich. VI and 304 pp.
- Wimsatt, William A. 1945. Notes on breeding behavior, pregnancy and parturition in some vespertilionid bats of the eastern United States. Jour. Mamm., 26 (1): 23-33.

BIOGRAPHICAL INFORMATION

William Lamar Jennings was born in Powder Springs, Georgia, April 4, 1926. He attended primary and secondary schools there and entered the Georgia School of Technology in June, 1942, receiving the degree Bachelor of Civil Engineering in June, 1947. The period from February, 1943 through July, 1945 was spent in the United States Naval Reserve. He entered the University of Florida in January, 1949 and received the degree Master of Science in September, 1951. Studies leading to the degree of Doctor of Philosophy were begun in September, 1954.

He is a member of Phi Sigma, the American Society of Mammalogists, the Ecological Society of America, the Wildlife Society, and the American Association for the Advancement of Science.

This dissertation was prepared under the direction of the chairman of the candidate's supervisory committee and has been approved by all members of that committee. It was submitted to the Dean of the College of Arts and Sciences and to the Graduate Council, and was approved as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

June 9, 1958

C. F. Byers
Dean, College of Arts and Sciences

Dean, Graduate School

SUPERVISORY COMMITTEE:

Benjamin B. Leavitt
Chairman

John H. Davis

William B. Bernal

James H. Payne

Arvid B. Grohn