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## Notes on the natural history of *Plecotus rafinesquii*

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NOTES ON THE NATURAL HISTORY OF *PLECOTUS RAFINESQUII*By CLYDE JONES<sup>1</sup> AND ROYAL D. SUTTKUS<sup>2</sup>

*Plecotus rafinesquii* was referred to as one of the least known North American bats by Barbour and Davis (1969). A review of the taxonomy, distribution, and other aspects of natural history of this species was provided by Handley (1959). Some recent comments on distribution were presented by Michael and Birch (1967), Fessler (1971), and Baker and Ward (1967). Some limited data on reproduction and life history of *P. rafinesquii* were included in the reports by Hall (1963), Hoffmeister and Goodpaster (1963), Baker and Ward (1967), Lowery (1974), Barbour and Davis (1974), as well as Jones and Suttikus (1971), who also presented some information on flight. The phylogeny of this species in relation to other plecotines was discussed by Williams, Druecker, and Black (1970).

The purpose of this report is to present some data on colony structure and movements of *P. rafinesquii* and to provide some additional information on the natural history of this little known species.

## MATERIALS AND METHODS

Data were gathered from bats observed and obtained at two sites: the Riverside Campus of Tulane University, Plaquemines Parish, Louisiana; and 19.3 km west of Woodville, Wilkinson County, Mississippi. At the former

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study site bats were found beneath old ammunition storage bunkers; at the latter locality animals were in an abandoned house. More detailed descriptions of these roosting sites were provided by Jones and Pagels (1968) and Jones and Suttkus (1971, 1973).

Studies were carried out at the site in Louisiana from December 1965 to December 1973 and at the locality in Mississippi from June 1970 to April 1973. The procedures for studying bats were different for the two study sites. In Louisiana, several roosts were visited regularly and all sites were examined occasionally. For example, except for 1967 and 1968, when numbers of visits to roosts were reduced, a mean of 11 roosting sites were visited per month of study. In Mississippi, the roosting site was visited only at fairly long intervals throughout the study.

In Louisiana, most animals were taken by hand during the day from roosts, but some bats were captured in mist nets set over entrances to the roosts. In Mississippi, most bats were caught during the day in mist nets set inside the abandoned house where the animals roosted; some animals were caught by hand.

During the early phases of this study, some animals at each of the aforementioned localities were marked with bands furnished by the Fish and Wildlife Service. When bats were captured, data were recorded on site of capture, date, number, age, flight ability, sex, and weight. Weights of animals were taken with a triple beam balance.

Data on *P. rafinesquii* were taken from labels on specimens deposited in the vertebrate collections of Tulane University; the Mississippi Museum of Natural Sciences, Jackson, Mississippi; the Louisiana State University Museum of Zoology; the Museum, Texas Tech University; the Field Museum of Natural History; the American Museum of Natural History; the Florida State Museum; and the U.S. National Museum of Natural History. Also, some information was obtained from the files of the bat banding program in the National Fish and Wildlife Laboratory.

#### RESULTS AND DISCUSSION

*Roosting habits.*—At the study site in Louisiana, *P. rafinesquii* roosted beneath old ammunition storage bunkers in the spaces formed by removal of earth for construction of concrete footings. Openings near ground level in the fronts of the buildings provided entrances to the roosting sites. Concrete support beams located about two meters in from the fronts of the buildings

prevented light from entering the greater part of each roosting area. However, the front portions of the roosting areas were partially lighted.

From December through May most solitary animals roosted in the front portions of the aforementioned buildings. However, most single bats found during June through November were in the rear of the roosting sites. Of all the bats observed from December to May, 20 percent were in torpor; of animals seen at other times of the year, 3 percent were in torpor.

All clusters of *Plecotus* were observed in the partially lighted front parts of the roosts. For example, groups of more than 30 adults and their young were found clustered near the entrances to the roosts during June and July. Adult bats in groups of 2 and 4 were found in the same areas of the roosts in August to November.

At the study site in Mississippi, the bats inhabited rooms and attic portions of an abandoned house. Most rooms of the house were well lighted but the attics were very poorly lighted. The bats most often entered and exited through open doors and broken windows but also did so through holes in the siding and air vents beneath the eaves.

Most animals roosted in two rooms on the second floor and in adjacent spaces beneath the roof. In the former sites the bats hung in the corners; in the latter places they were found singly and in clusters along rafters and on inside walls. Occasionally, single animals were located roosting in corners of rooms in the ground floor of the house.

Movements of *P. rafinesquii* within a roost in Tennessee were correlated with air temperatures (Hoffmeister and Goodpaster, 1963); bats moved away from the entrance of the roost during winter and were near the entrance in summer. According to Barbour and Davis (1969), hibernating animals were found mostly in the twilight zones of caves and mines not far from the entrances.

Throughout its geographic range, *Plecotus rafinesquii* has been found most frequently roosting in partially lighted places in either buildings or other man-made structures (Barbour and Davis, 1969). However, the species has been observed in caves, trees, and other natural places, especially in the northern portions of the range.

*Reproduction.*—Specific knowledge about maternity colonies is poor. Colonies were reported previously in Tennessee and Kentucky by Barbour and Davis (1969, 1974), and Lowery (1974) told of a colony in Louisiana

mentioned in Vernon Bailey's field notes. Baker and Ward (1967) found a small nursery colony in Arkansas. Apparently only four or five extant nursery colonies are known for this species.

Copulation apparently takes place in the fall and winter (Barbour and Davis, 1969). Hoffmeister and Goodpaster (1963) observed bats of this species in February that might have been copulating.

Males with enlarged testes were detected from October to March at both study sites. Enlarged testes were recorded in *Plecotus* in North Carolina in January (Handley, 1959) and in Kentucky in August (Hall, 1963).

No enlarged testes were found in young males during the first year. However, marked young males more than one year old had testes indistinguishable in size from those of older animals.

Pregnant females were present at the study sites from April to June. On the basis of observations made during this study, as well as previous estimates (Jones and Suttkus, 1971), most of the young were born in late May. Lowery (1974) stated that young apparently were born in May and early June in Louisiana. Lactation in females was apparent from May to July. For weights of marked adult females that were measured in each of the aforementioned months, see Table 1.

*Seasonal weight changes.*—Our study did not yield data on weights of

TABLE 1. MEAN WEIGHTS OF ADULT *PLECOTUS RAFINESQUII*; RANGES ARE IN PARENTHESES.

Months	Females	Males
January	—	8.20 (6.9-9.5)
February	8.9	—
March	—	—
April	9.56 (8.0-12.0)	8.30 (8.3-8.3)
May	10.00 (7.0-13.6)	8.37 (8.2-8.5)
June	8.89 (7.1- 9.9)	8.70 (8.7-8.7)
July	8.56 (7.4-10.1)	8.10 (8.1-8.1)
August	9.10 (7.9-10.2)	8.45 (7.9-9.0)
September	9.1	—
October	8.44 (7.9- 9.0)	8.57 (8.3-8.9)
November	—	—
December	—	—

adult bats for each month, although some additional information on weights was obtained from labels on museum specimens. Weights of females averaged greater than weights of males; males heavier than females were found infrequently (Table 1). Weights of males were similar in each month for which data were available, with some slight weight increases indicated in the fall. Females, on the other hand, were heavy in the spring, light in the summer, and somewhat heavy again in early fall. Weight changes in females during spring and summer were apparently associated with pregnancy and subsequent lactation. Weight gains in the fall were probably related to cessation of lactation and abundance of food materials at this time of year. Some similar patterns of seasonal change in weights of *Tadarida brasiliensis cynocephala* in Louisiana were depicted by LaVal (1973).

*Growth of young.*—Growth in young *P. rafinesquii* is rapid, as is growth in several other species of bats that have been studied (Orr, 1970).

Very limited data were obtained on prenatal growth in *P. rafinesquii* (Table 2). Lengths of forearms of embryos ranged from 18 percent to 38 percent of the mean forearm length of newborn bats. For a review of prenatal growth in bats, see the work by Orr (1970).

Examination of the data available (Tables 1-2) revealed that the mean weight of neonates was about 28 percent of the weight of adults. Increases

TABLE 2. AVERAGE WEIGHTS AND FOREARM LENGTHS OF YOUNG *PLECOTUS RAFINESQUII*; RANGES ARE IN PARENTHESES.

Date	Weight (g)	Length of Forearm (mm)
Embryos		
27 April	—	3.20
29 April	—	6.75 ( 5.2- 8.3)
Neonates		
25 May	2.47 (2.3-2.6)	—
5 June	2.36 (2.3-2.5)	17.33 (17.0-18.0)
Young		
25 May	3.64 (3.3-4.2)	—
5 June	5.36 (3.5-6.8)	26.36 (17.0-37.0)
11 June	5.58 (5.2-6.2)	35.01 (33.4-36.9)
30 June	6.28 (5.5-6.8)	—
9 July	7.07 (6.5-8.2)	42.50 (41.8-43.7)

in weights of young during the first month after birth were about 34 percent of the adult weight. At three months of age, young bats weighed slightly less than adult animals.

There were increases of about 40 percent in mean length of forearm in bats from birth to about a month of age (Table 2). Pearson, Koford, and Pearson (1952) and Jones and Suttkus (1971) showed that by a month of age measurements of forearms of young *Plecotus* were similar to those of adults and were unreliable for indicating age in young; wing areas, wing loadings, and flight abilities were similar also.

Bats less than about three months of age were identifiable by their dark pelage. By late August, young animals in both study sites had developed pelage closely resembling that of adults. A brief description of molt in *P. rafinesquii* was provided by Handley (1959).

*Dentition.*—In *P. rafinesquii* the complete number of deciduous teeth is expressed by the formula  $i\ 2/3, c\ 1/1, p\ 2/2 = 22$ . All the lacteal teeth were erupted completely in newborn bats.

The upper lacteal teeth are all trifold. The upper incisors have a central cusp slightly longer than the lateral cusps. The cusps are rounded, and the teeth are flattened on the lingual sides. The central cusps of the upper canines are longer than the other cusps, slender with sharp tips, and strongly recurved. The rounded lateral cusps are small, and sometimes appear as small bumps on the sides of these teeth. The upper premolars have sharp, slightly recurved central cusps. Lateral cusps appear as small rounded knobs near the gum lines. The second premolar is slightly larger than the first.

The lower deciduous teeth are all trifold also. The tips of all cusps on the lower incisors are about even with each other and are blade-like. The entire tooth is concave on the lingual side. The central cusps of the lower canines are slender, sharp at the tips, slightly recurved and larger than the lateral cusps. These teeth are flattened on the inner sides. The lower premolars have sharp, thick, conical central cusps. The lateral cusps are small knobs just above the gum lines. The second premolar is two to three times as large as the first.

The complete number of permanent teeth is expressed by the formula  $i\ 2/3, c\ 1/1, p\ 2/3, m\ 3/3 = 36$ . In the order of eruption of permanent dentition, the canines and premolars become apparent first, followed by the molars and incisors.

The presence of both deciduous and some permanent teeth was noticed in some of the specimens studied. For example, in some bats 15 to 18 days old, all permanent teeth except incisors were either erupted or clearly visible at the gum lines. However, other specimens of bats of this age exhibited no erupted permanent teeth.

*Colony structure.*—Numbers of *P. rafinesquii* banded at the study site in southern Louisiana in each year of this study are summarized in Table 3.

TABLE 3. NUMBERS OF *PLECOTUS RAFINESQUII* RECAPTURED EACH YEAR IN LOUISIANA.

Year and number banded	Year recaptured								
	1965	1966	1967	1968	1969	1970	1971	1972	1973
1965: 8( 5♂, 3♀)	1	3	0	0	0	0	0	0	0
1966: 30(15♂,15♀)		12	1	0	0	6	4	0	1
1967: 0			0	0	0	0	0	0	0
1968: 1( 1♂, 0♀)			0	0	0	0	0	0	0
1969: 4( 3♂, 1♀)					0	1	0	0	0
1970: 33(15♂,18♀)						9	14	3	3
1971: 9( 4♂, 5♀)							4	1	2
1972: 2( 1♂, 1♀)								0	1
1973: 4( 4♂, 0♀)									2
Totals: 91	1	15	1	0	0	16	22	4	9

Of the total number of animals marked at this site, about 70 percent were banded in 1966 and 1970. These peaks of banding activity reflected numbers of bats that were found in the area after the initial colonization in the winter of 1965. *Pipistrellus subflavus* moved into the same area at the same time. However, after the initial colonization in 1965 and 1966, numbers of this species did not increase significantly in later years (Jones and Suttks, 1973).

Fifty-nine *P. rafinesquii* were banded at the study site in Mississippi (Table 4). All bats were marked in 1971. No other banding activities were carried out, because of the sensitivity of this colony to various disturbances.

In the 9 years of study of *Plecotus* in southern Louisiana, 91 bats were banded; of the bats marked, 74.7 percent of the animals were recaptured at least once during the study (Table 3). Rates of recapture were 30.8 percent in the first year after banding and 23.1 percent in the second year after



TABLE 4. NUMBERS OF *PLECOTUS RAFINESQUII* RECAPTURED EACH MONTH IN MISSISSIPPI.

Total number of bats banded is given in parentheses for each month.

<i>Month banded</i>	<i>Month recaptured</i>										Totals
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	
Jan (15)	1	3	1	4	3	2	1	0	0	2	17
Feb (11)		0	6	8	6	3	2	0	0	1	26
Mar (11)			0	6	7	5	3	0	0	5	26
Apr (13)				0	10	3	3	0	0	3	19
May (5)					2	3	1	0	0	2	8
Jun (1)							0	0	0	0	0
Jul (1)							0	0	0	1	1
Aug (0)								0	0	0	0
Sep (0)									0	0	0
Oct (2)										0	0
Totals (59)	1	3	7	18	28	16	10	0	0	14	97

banding. Relatively few banded bats were recaptured three or more years after marking. Although the rates of recapture for *Plecotus* were lower than the rates for *Pipistrellus* (Jones and Suttkus, 1973), they showed a similar pattern of year-to-year decrease.

During the ten months of study of *P. rafinesquii* in southern Mississippi, 59 animals were banded (Table 4). Rates of recapture at monthly intervals after banding were: month I, 5.1 percent; month II, 47.5 percent; month III, 33.9 percent; month IV, 30.5 percent; month V, 20.3 percent; month VI, 10.2 percent; month VII, 6.8 percent; month VIII, 8.4 percent; month IX, 1.6 percent; month X, 3.4 percent. Six bats that were banded in 1971 were recaptured during a visit to this colony on 7 April 1973. Rates of recapture during the year of study perhaps reflected disturbances at the roosting site and dispersal of bats after the young animals were capable of flight.

In Mississippi, 25.4 percent of the animals marked were not recaptured; and in this group females were outnumbered by males 1:1.5 (Table 5). Of the bats recaptured one or more times (74.6 percent), males were outnumbered by females 1:6.33. The greater multiple recapture frequencies for females undoubtedly reflected their maternal behavior.

In Louisiana, 44.0 percent of the adult bats banded were not recaptured

(Table 6). Of this group, females were outnumbered by males 1:1.22. Fifty-six percent of the animals marked were recaptured one or more times. Slightly fewer males than females (1:1.14) were recaptured at least one time. Some young bats were marked at the study site in Louisiana. Among

TABLE 5. FREQUENCY OF RECAPTURE OF *PLECOTUS RAFINESQUII* IN MISSISSIPPI.

	Number of recaptures							
	0	1	2	3	4	5	6	7
Males	9	2	2	2	0	0	0	0
Females	6	10	11	7	4	4	1	1
Totals	15	12	13	9	4	4	1	1

TABLE 6. FREQUENCY OF RECAPTURE OF *PLECOTUS RAFINESQUII* IN LOUISIANA.

	Number of recaptures									
	0	1	2	3	4	5	6	7	8	9
Males	22	9	4	2	1	3	0	0	1	1
Females	18	12	5	5	1	0	1	0	0	0
Totals	40	21	9	7	2	3	1	0	1	1

those not recaptured, males and females were equally represented, but fewer females than males (1:3.0) were recaptured one or more times (Table 7). Examination of the data revealed that the long-term residents of this colony were mostly males. Adult and young females appear to have emigrated from the area more than adult and young males.

TABLE 7. FREQUENCY OF RECAPTURE OF YOUNG *PLECOTUS RAFINESQUII* IN LOUISIANA.

	Number of recaptures					
	0	1	2	3	4	5
Males	5	2	1	1	0	2
Females	5	1	1	0	0	0
Totals	10	3	2	1	0	2

Data on frequencies of recaptures of *P. subflavus* in the same roosts in Louisiana were presented by Jones and Suttkus (1973). Recapture rates of *P. subflavus* were similar to those of *P. rafinesquii*; 60.0 percent were recaptured one or more times. As in the case of *P. rafinesquii*, a few adult male *P. subflavus* were long-term residents in the area. In general, marked *P. subflavus* remained in the area longer and were recaptured more frequently than marked *P. rafinesquii*. On the basis of these data, we infer that *P. rafinesquii* may be more sensitive to disturbances than *P. subflavus*.

At the study site in Louisiana most individual *Plecotus* (82 percent) used more than one building for roosting (Table 8). Two was the number

TABLE 8. FREQUENCY OF MULTIPLE USE OF BUILDINGS BY ROOSTING *PLECOTUS RAFINESQUII* IN LOUISIANA.

	Number of buildings roosted in					
	1	2	3	4	5	6
Males	6	10	2	3	0	1
Females	2	12	7	1	1	0
Totals	8	22	9	4	1	1

of buildings most frequently chosen, but bats with only one or as many as three roosting sites were well represented. No significant differences between males and females were apparent with regard to roost specificity.

Data on maternity groups were not included in Table 8. Clusters of females with clinging young were routinely located in the same building. These groups were smaller and more dispersed in the area during August to November than in earlier months. These changes in cluster sizes and roost specificities presumably were correlated with growth and the development of flight abilities of young bats.

*Sex ratios.*—There were no significant differences in the sex ratios of *Plecotus* banded in any of the nine years of this study in Louisiana. For the total number of females and males banded, the ratio was 1:1.12. These data seem to imply that the sexes have equal roles in colony formation. In Mississippi, however, more females than males were banded. For the total number banded, the ratio of males to females was 1:2.93. Seasonal differences in sex ratios of *Plecotus* in Louisiana were significant at the 5 percent level as tested by Chi-square. In winter (November to March) females were outnumbered by males 1:3.54; in summer (April to October) males were out-

numbered by females 1:4.68. These seasonal differences in sex ratios reflected movement of animals in relation to reproductive activities. Females assembled at the roosts in spring to form maternity colonies and to bear young; males accumulated in the area in the fall and overwintered. These seasonal differences in sex ratios of *P. rafinesquii* were the converse of seasonal sex ratios for *P. subflavus* in the same area (Jones and Pagels, 1968; Jones and Suttkus, 1973).

Seasonal sex ratios of the *Plecotus* studied in Mississippi were slightly different from those for the bats in Louisiana. In winter (November to March) the ratio of males to females was 1:2.43, and in summer (April to October) males were outnumbered by females 1:8.31. At the study site in Mississippi, fewer males overwintered and fewer males were associated with maternity colonies than in the area studied in Louisiana.

*Longevity.*—Several young *P. rafinesquii* were marked in 1970 in order to gather longevity data in the future. An adult male banded in Louisiana on 22 June 1966 was recaptured in the same area on 28 January 1973. Several males and females were frequently found here during a five-year period. Paradiso and Greenhall (1967) reported an adult female with a life span of 10 years and 1 month.

*Relationships with other species.*—Except for one *Myotis austroriparius* found on 2 January 1971 in a cluster with 13 *Plecotus*, no other species were found with *P. rafinesquii* at the roosting site in Mississippi. Species obtained either in mist nets set over a pond or shot in the adjacent cleared area about 100 meters from the aforementioned roost included *Lasinus borealis*, *Eptesicus fuscus*, *Nycticeius humeralis*, and *Pipistrellus subflavus*.

In Louisiana, *P. subflavus* and *Myotis austroriparius* occurred under the same buildings as *Plecotus*. During the studies there 303 *Pipistrellus* and 56 *Myotis* were observed and marked. These three species were not in close contact; *P. rafinesquii* either occurred in clusters or did not roost in the same places within the buildings as the other species. Information on the formation and structure of the colony of *P. subflavus* at the study site in Louisiana was presented by Jones and Pagels (1968) and Jones and Suttkus (1973).

*Status.*—Review of the limited information available led to some confusion with regard to the numerical status of *P. rafinesquii*. For example, Barbour and Davis (1969) stated that "It is nowhere abundant, but is readily available for study at many localities." Indications of reductions in popula-

tions of *P. rafinesquii*, as well as several other species, throughout most of the geographic ranges were presented by Jones (1971). Lowery (1974) reported the species as common in Louisiana, and examined a total of 105 specimens from the state. Barbour and Davis (1974) listed the species as uncommon in Kentucky, but ". . . perhaps as common in Kentucky as anywhere."

Examination of data from labels of specimens in museums revealed that *P. rafinesquii* has been found in small numbers at scattered localities. We found that most museum collections included a few specimens of this species, but in most cases this material had been accumulated over a long period of time.

Our impression is that *P. rafinesquii* is not found in large numbers, at least in abundance comparable to that of many other species of bats. For example, in the maternity colony at the locality in Mississippi, an average of 13.92 bats per visit and 15.8 per month was found. However, in Louisiana, the average was 4.75 animals per visit (0.43 bats per roosting site) and 25.75 bats per month.

Because of the locations of roosting sites, the vulnerability of maternity colonies, and the sensitivity of these bats to disturbances, it seems that *P. rafinesquii* is fairly vulnerable to a wide array of human activities.

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