# STUDIES ON THE INCIDENCE OF GASTRIC

# AND INTESTINAL HELMINTHS OF

# *Tadarida brasiliensis mexicana* (Saussure)

By

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*Tadarida brasiliensis mexicana* (Saussure)

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# CHAPTER I

## INTRODUCTION

The literature reveals very little work on the ecology of parasites infecting bats that annually migrate to Oklahoma, although the taxonomy and morphology of gastro-intestinal helminths have been treated extensively. Several species of helminths have been described from the Mexican freetail bats, *Tadarida brasiliensis mexicana*, in Mexico (Caballero, 1940, 1942). Eads, et al. (1957), Gilford (1952), and Caballero (1940, 1942) have been instrumental in determining the species of helminths which infect the freetail bat. In a study on bat parasites from Texas, Jameson (1959) determined that 58% of the 21 freetails he examined were infected with *Dicrocoelium rileyi* and 28.6% with *Ochoterenatrema labda*. Macy (1931) reported 70% of the 81 Florida freetails examined were infected with *D. rileyi*. These reports were based on only one sample of bats and the frequency of infections, during migration, was not given. The purpose of the present study was to determine the frequency of helminth infections in bat populations of four caves in western Oklahoma from the time of arrival in April to the time of southward migration in late October, and to compare frequency of infection in terms of age and sex of *Tadarida*. In addition, these infection frequencies were compared to the number of parasites per bat for the same period.

## Description of Host

The Mexican freetailed bat, Tadarida brasiliensis mexicana (Saussure), is a gregarious species abundant in the southwestern United States. It is migratory, moving into Mexico each fall and returning to the Southwest each spring (Villa, 1956; Glass, 1959). The exact region where these animals winter is not known; banding returns for the fall of 1963 (Glass, personal records) include the southernmost band recovery for this species, i.e., from the vicinity of Tuxpan, Veracruz, Mexico. Stunkard (1938) and Chitwood (1938) did not include Tadarida spp. as being among bats examined for helminths in Yucatan caves.

The family Molossidae includes Tadarida, which is characterized as follows: tail extending well beyond the tail membrane, length of head and body 46.6-65.2 mm (Hall and Kelson, 1959) and the dark brown dorsum and paler venter covered with short, velvety fur. The diet consists exclusively of insects; Hall and Kelson (1959) state that moths comprise the bulk of this species' food.

## Description of Study Area

During this study four Tadarida nursery caves located in northwestern Oklahoma were sampled. These were Selman's Cave in Woodward County, Merrihew Cave in Woods County, and Vickery Cave and Connor's Cave in Major County. A fifth nursery cave is located west of Reed in Greer County, southwestern Oklahoma. The latter is the largest of the five caves in terms of bat populations, but is located approximately 150 miles south of the southernmost study cave, which made a weekly sampling schedule inconvenient. Legal descriptions of the cave locations were given by Glass and Ward (1959).

The caves are located in areas with overcrusts of gypsum, and each is located at the head of a ravine which serves as a drain for water from the cave. All caves are proximal to water sources such as farm ponds, streams, or stock watering tanks. Heavy rains periodically wash out large deposits of guano which have accumulated on the floors of the caves. These periodic flushings of guano serve to distribute parasite eggs to adjacent surface waters and provide opportunities for infection of intermediate hosts.

Crude estimates of freetail populations for the four caves were obtained by a combination of factors, such as, size of clusters within the caves, and density and duration of the evening flight. These estimates (Table I) were needed to give an idea of the relative populations of *Tadarida* in the caves sampled. During the period of this study (1963 and 1964) 40,000 neonatal (young of the year) bats were banded in Selman's and Connor's caves. The frequent occurrence of these banded bats in all four caves indicated a free interchange of freetails between the caves and it was assumed that freetails of the four caves constituted a single population.

Selman's Cave apparently contained only Mexican freetails, as no other species of bat was seen during the study period. Connor's Cave had a small colony of *Myotis velifer* in a different area of the cave than the *Tadarida* colony, although *M. velifer* babies have been noted in clusters of *Tadarida* babies. Vickery Cave was mainly a freetail cave, although *M. velifer* were occasionally collected in *Tadarida* samples during both years. The *Myotis* evidently were from an adjacent cave containing several thousand bats of this species. Also present in small numbers were *Eptesicus fuscus* and *Plecotus townsendi*. Merrihew Cave harbored five species of bats, *T. b. mexicana*, *M. velifer*, *Eptesicus fuscus*, *Plecotus townsendi*, and *Antrozous pallidus*. These species do not ordinarily intermingle, but have been reported to cluster in different areas of this cave (Twente, 1955). This cave contained the smallest freetail population of the four study caves, although it is comparable in size to Selman's or Vickery caves.

TABLE I

POPULATION ESTIMATES FOR THE STUDY CAVES

| MONTH | SELMAN'S | MERRIHEW'S | VICKERY | CONNOR'S |
|---|---|---|---|---|
| 1963 | | | | |
| June | 300,000 | 15,000 | 500,000 | 300,000 |
| July | 600,000 | 17,000 | 400,000 | 700,000 |
| August | 750,000 | 50,000 | 1,000,000 | 500,000 |
| September | 200,000 | -- | 800,000 | -- |
| October | -- | -- | 100,000 | -- |
| 1964 | | | | |
| April | 80,000 | 10,000 | 100,000 | 2,000 |
| May | 20,000 | 2,000 | 80,000 | 10,000 |
| June | 150,000 | 15,000 | 600,000 | 200,000 |
| July | 400,000 | 60,000 | 600,000 | 700,000 |
| August | 300,000 | 15,000 | 1,000,000 | 200,000 |
| September | -- | -- | -- | -- |
| October | -- | -- | -- | -- |

## CHAPTER II

## MATERIALS AND METHODS

### Collection of Bats

Bats were collected from June to October in 1963 and from April through October in 1964. Samples were collected from the evening emergence flight from the caves by means of a modified Constantine harp trap (Constantine, 1958). All 1964 samples were collected with a net, either from evening flights or from circling bats inside the caves. This method of collection was less time-consuming than the Constantine harp trap procedure and allowed visits to more than one cave per day.

Four samples (one per cave) were collected every other week from June through August, 1963. From 15 September until the last 1963 collection in mid-October weekly samples were collected from either Selman's or Vickery cave, the other two caves being completely or nearly vacated of Tadarida by mid-September. These collections were made on weekend trips from Stillwater, with samples taken inside the caves with a 3/4" mesh fish net. Flying bats were netted from three different locations in each cave. Samples in April and May of 1964 were made every weekend when possible. This period of time had not been studied the previous year and it was felt advisable to compile as much data as possible during the spring months while the bats were arriving from Mexico. Vickery Cave filled first and was sampled exclusively during early April. By mid-April populations were of sufficient size to permit collecting from all caves. From the first week in June through the last week of August bats were collected every other week. Two caves per week were sampled in September; population decreases restricted October samples to Vickery and Selman's caves, the last two caves to be abandoned.

Because of a high rate of mortality in pregnant female *Tadarida* during June of 1964, a styrofoam ice chest containing approximately 12 pounds of ice was used to transport bats from the caves to Stillwater. Collected samples were placed in two-gallon polypropylene buckets to prevent direct contact of bats with the ice. Mortality, apparently due to heat and suffocation, dropped sharply after use of the ice chest was begun. At night or in cool weather, bats were transported in open polypropylene buckets without significant mortality rates.

Samples collected in 1963 were processed immediately after collection at facilities near the caves, and sample sizes consisted of as many bats as could be collected in one night. Initial samples were small while examination techniques were being perfected. Due to large sizes of samples collected on 3 October and 10 October 1963, examination of all bats in a sample required up to 72 hours. This delay possibly resulted in migration and/or loss of helminths in those bats that were examined last. During 1964, 10 to 20 bats collected from each of two caves visited weekly were processed in Stillwater within 48 hours of collection.

## Examination of Bats for Helminths

The bats to be examined were sacrificed individually, as deterioration of the stomach and small intestines made examination difficult within two hours of death. Sex, date of collection, state of pregnancy, and age class (adult or young of year) of the bats were noted and recorded. From July through August adults could be distinguished from young of the year by the greyer pelage of the young. After pelage molts in late August this character could not be used in separating the two age classes of bats as pelage color was identical in both. Tooth wear is an inaccurate indicator of age because banded bats one and two years old showed no more appreciable tooth wear than did banded young. After the August molt no attempt was made to separate adults from young, except in banded specimens.

The skin was removed from the abdomen and a T-shaped incision was made into the peritoneal cavity from a point above the genitalia to the level of the lowest rib. The stomach and intestines were removed, stripped of mesenteries, and rinsed in a container of cold physiological saline solution to remove blood. The stomach and intestines were immediately separated and placed in individual containers of saline to prevent post-mortem migration of helminths between sections of the digestive tract. The containers were then placed under a Bausch and Lomb dissecting microscope, and the organs held with forceps and opened. Tearing the organs with a flattened dissecting needle rather than cutting them with scissors minimized damage done to the parasites. Small intestines were examined from the colic to the pyloric ends to expose cestodes without damaging their scolices. The saline solution caused the organs to evert as they were opened and facilitated location of the parasites. Both the organs and containers were re-examined for helminths which might have been overlooked in the initial examination.

## Preparation of Helminths for Study

Nematodes were mounted on slides and cleared with lactol-phenol. Selected slides were ringed with clear fingernail polish to prevent drying while in storage.

Alum Cochineal, Borax Carmine, and Semichon's Acetic Carmine were used to stain trematodes and cestodes. Alum Cochineal gave the poorest contrast of organs in the smaller trematodes and was seldom used. Semichon's Carmine gave the best results in organ contrast and in staining ducts and glands, and was used extensively for trematodes. Both Semichon's Carmine and Borax Carmine gave good results on cestodes. Specimens stained in Borax Carmine, an alcohol-based stain, were transferred directly from the alcohol preservative to that stain. Helminths stained in Semichon's Carmine, a water-based stain, were transferred through 50 percent and 20 percent isopropyl alcohol to demineralized water before being placed in the stain. Specimens were stained for 24 hours and destained with a solution of one part concentrated hydrochloric acid to 99 parts 70 percent alcohol. The destaining action was neutralized by transferring the specimens through two changes of 70 percent isopropyl alcohol. After dehydration in 90 percent and absolute isopropyl alcohol the parasites were cleared in methyl salicylate and mounted on slides in synthetic balsam.

# CHAPTER III

# RESULTS

Data were collected from June through October, 1963, and from April through October, 1964 (Table II). During these periods 898 specimens of _Tadarida_ _b_. _mexicana_ were collected and examined for gastric and intestinal helminths. Graphic results in the following discussion are given in monthly intervals and are averages of all data for each month. The subdivision of data into biweekly classes would have resulted in samples of such a small size as to be invalid. Data concerning parasites recovered from bats shown in both charts and graphs are based on general types of parasites (i.e., nematodes, trematodes, and cestodes) rather than on taxonomic identification of the various helminths. The lines connecting points on the graphs are for convenience in following monthly changes in the data and are not meant to indicate straight-line regression changes between monthly plottings of data.

## General Frequencies and Rates of Infections

Table III includes data concerning the collection period, number of bats examined, and kinds and numbers of helminths collected.

Data illustrated in Fig. 1 represent a summary of frequencies of infection for all freetail bats examined and are not affected by the

TABLE II

COLLECTION DATES AND SAMPLE SIZES

| DATE 1963 | SELMAN'S Sample Size | MERRIHEW'S Sample Size | VICKERY Sample Size | CONNOR'S Sample Size | Total Sample |
|---|---|---|---|---|---|
| 16-17 June | 2 | 0 | 3 | 6 | 11 |
| 20 June-1 July | 4 | 0 | 6 | 2 | 12 |
| 10-15 July | 5 | 6 | 6 | 6 | 23 |
| 25-30 July | 8 | 7 | 7 | 8 | 30 |
| 7-13 August | 3 | 0 | 10 | 10 | 23 |
| 20-27 August | 10 | 10 | 10 | 12 | 42 |
| 15-22 September | 15 | 0 | 10 | 0 | 25 |
| 3 October | 0 | 0 | 39 | 0 | 30 |
| 12 October | 0 | 0 | 35 | 0 | 35 |
| 1964 | | | | | |
| 4-10 April | 0 | 0 | 29 | 0 | 29 |
| 19-24 April | 12 | 0 | 15 | 14 | 41 |
| 3-8 May | 10 | 10 | 20 | 0 | 40 |
| 22-29 May | 20 | 20 | 20 | 0 | 60 |
| 8 June | 0 | 16 | 11 | 0 | 27 |
| 23 June | 17 | 0 | 0 | 0 | 17 |
| 3-9 July | 20 | 20 | 9 | 14 | 63 |
| 16-22 July | 20 | 0 | 20 | 10 | 50 |
| 30 July | 0 | 10 | 0 | 10 | 20 |
| 7-11 August | 10 | 20 | 30 | 0 | 60 |
| 21-29 August | 20 | 0 | 10 | 10 | 40 |
| 5 September | 0 | 20 | 0 | 20 | 40 |
| 13-19 September | 20 | 8 | 40 | 0 | 68 |
| 25 September-3 October | 40 | 20 | 0 | 20 | 80 |
| 11 October | 0 | 0 | 20 | 0 | 20 |
| 31 October | 0 | 0 | 16 | 0 | 16 |

TABLE III

INFECTION FREQUENCIES AND NUMBERS OF PARASITES FOR BATS REGARDLESS OF AGE OR SEX

| MONTH | YEAR | BATS INSPECTED | BATS INFECTED | NEMATODES | TREMATODES | CESTODES |
|---|---|---|---|---|---|---|
| June | 1963 | 21 | 13 | 21 | 19 | 1 |
| July | 1963 | 55 | 35 | 251 | 6 | 6 |
| August | 1963 | 65 | 30 | 254 | 39 | 8 |
| September | 1963 | 25 | 10 | 58 | 0 | 0 |
| October | 1963 | 74 | 22 | 108 | 18 | 8 |
| April | 1964 | 70 | 52 | 465 | 204 | 2 |
| May | 1964 | 100 | 37 | 106 | 24 | 7 |
| June | 1964 | 44 | 31 | 206 | 121 | 12 |
| July | 1964 | 123 | 79 | 478 | 40 | 24 |
| August | 1964 | 100 | 30 | 265 | 5 | 1 |
| September | 1964 | 145 | 48 | 456 | 9 | 44 |
| October | 1964 | 76 | 30 | 214 | 65 | 4 |

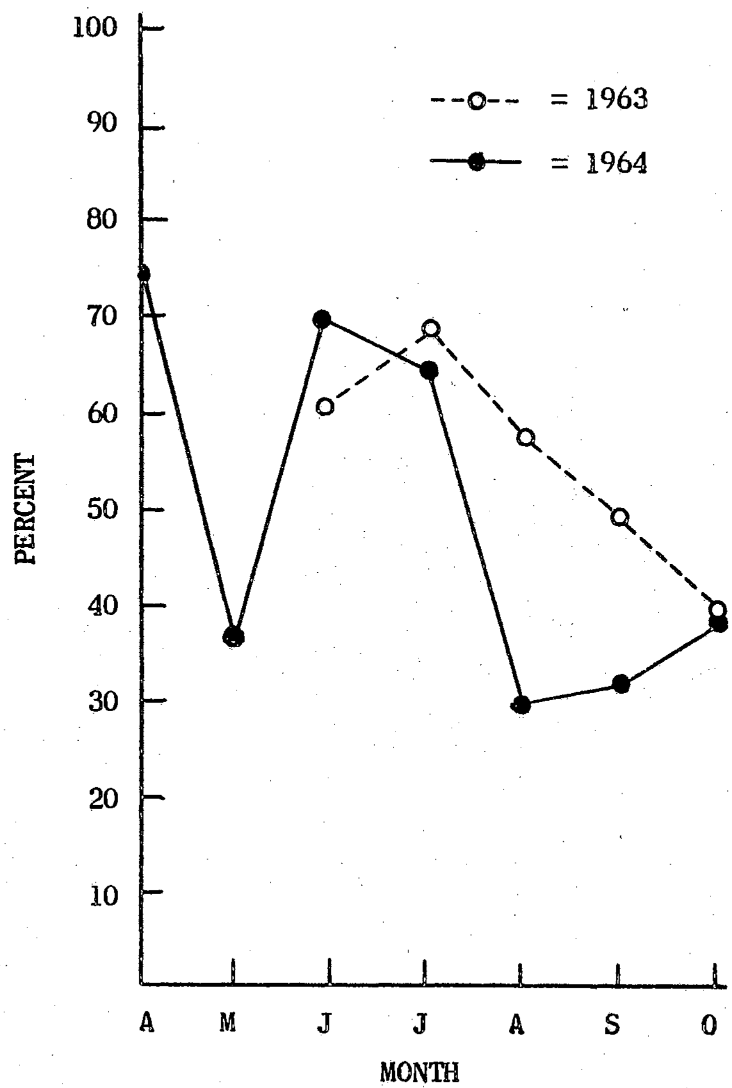


Fig. 1. Comparison of 1963 and 1964 frequencies of infection for all bats.

age or sex of the bats. Monthly plottings (expressed in percent form) represent the number of bats infected with helminths compared to the number examined. Lack of data for spring, 1963 precluded comparison with 1964 data for the same period.

During the spring months, following the arrival of *Tadarida* in the study area during April and May of 1964, the frequencies of infection dropped from 74% during April to 37% in May. This decline was followed by a sharp rise in the frequency of infection to a level of approximately 70% in June. The initial decline in frequency of infection, followed by a rise in June to a level comparable to the April figures, was attributed to an adjustment in conditions necessary for reinfection of the host; i.e. development of successive stages of parasites not found in the study area when the bats arrived in the spring. Apparently, helminths were being lost from the definitive host through the intestinal tract, and no infective larvae were being acquired. The net result was a drop in both frequency of infection and in infection rates. Under the conditions in which these bats persist in the study caves, it was possible that after a period of time, eggs voided with the feces developed into infective larval stages that were capable of reinfecting the definitive host, *Tadarida*. With this reinfection, the frequency of infection returned to levels similar to those found when the bats arrived in the study area.

Frequencies of infection for June and July of the two years showed similarities in the ratio of bats infected to bats inspected. A sharp decline in the frequency of infection was evident after July of both years. This decline was much more abrupt in 1964, when infection frequencies dropped from 64% in July to 30% in August, while the 1963 decline for this same period amounted to only 12%. During 1963, it is evident that a gradual decline in frequency of infection occurred to the time of the bats' departure in October, but in 1964, frequencies of infection showed a gradual increase from August through October. The differences that are shown in the declination of the infection frequency for July and August of 1963 and 1964 can be attributed to variations in infection frequencies among adults and young of the year for the two years. This factor will be discussed in the section on frequencies of infection for these two age classes. October frequencies of infection were approximately 40%.

Data for April and May, 1964 (Table III) illustrate the effect of a change in locality on nematodes and trematodes. These helminths underwent a decline in numbers from April to May, followed by an increase in June. Cestodes were not adversely affected by the change in locality which the host, Tadarida, underwent. This is possible because of the continual maturing of a cestode with several stages of reproductive development present in one parasite. Also, the number of cestodes collected increased from April through July, indicating the presence of these helminths in the study area prior to the arrival of Tadarida, and their subsequent infection of this host.

Monthly infection rates for the bats were calculated by dividing the total number of helminths collected during each month by the total number of infected bats for the same month. These calculations indicated the average number of parasites per infected bat for each month, and do not indicate changes in the infection rate during the month.

Infection rates determined from the 1963 collection (Fig. 2) generally followed the pattern of frequencies of infections for the same year, with a rise in the rate of infection from June through July. However, the peak rate of infection occurred during August, at which time the frequency of infection in bats was on the decline. The frequency of infection in bats underwent a steady decline from July to the last collection in October, while the infection rate declined from August through September, then rose slightly through October.

Data obtained concerning infection rates (Fig. 2) for Spring of 1964 indicated a definite correlation with the corresponding frequency of infection in bats. The April to June pattern was similar for both sets of figures. However, July-October data on infection rates showed an inverse relationship, in that while frequency of infected bats was declining the rate of infection was rising. This inverse relationship also was evident when the August-October infection rates during the two years were compared.

Fig. 3 shows the relative occurrence of nematodes, principally _Molinostrongylus_ sp., in _Tadarida_ collected throughout the study period. These results are represented in terms of percentages as determined by the numbers of nematodes collected from all bats in one month compared to the total number of helminths collected from these bats during the same period. Data obtained during the two years are well correlated, and indicate the importance of _Molinostrongylus_ sp. (and to some extent _Physaloptera_ sp.) as a parasite of _Tadarida_. Throughout the study period nematodes were found to constitute the majority of helminths which infected _Tadarida_. During the late summer, however, the parasitic infection consisted primarily of nematodes. Spring and fall data

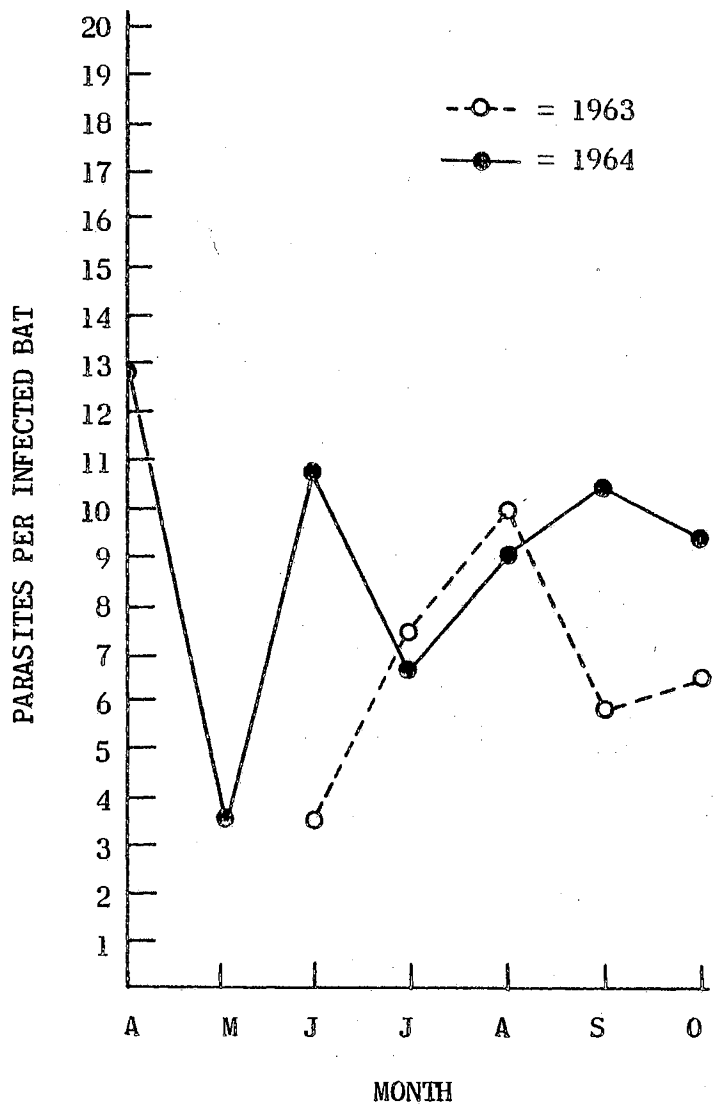


Fig. 2. Comparison of 1963 and 1964 infection rates for all bats.

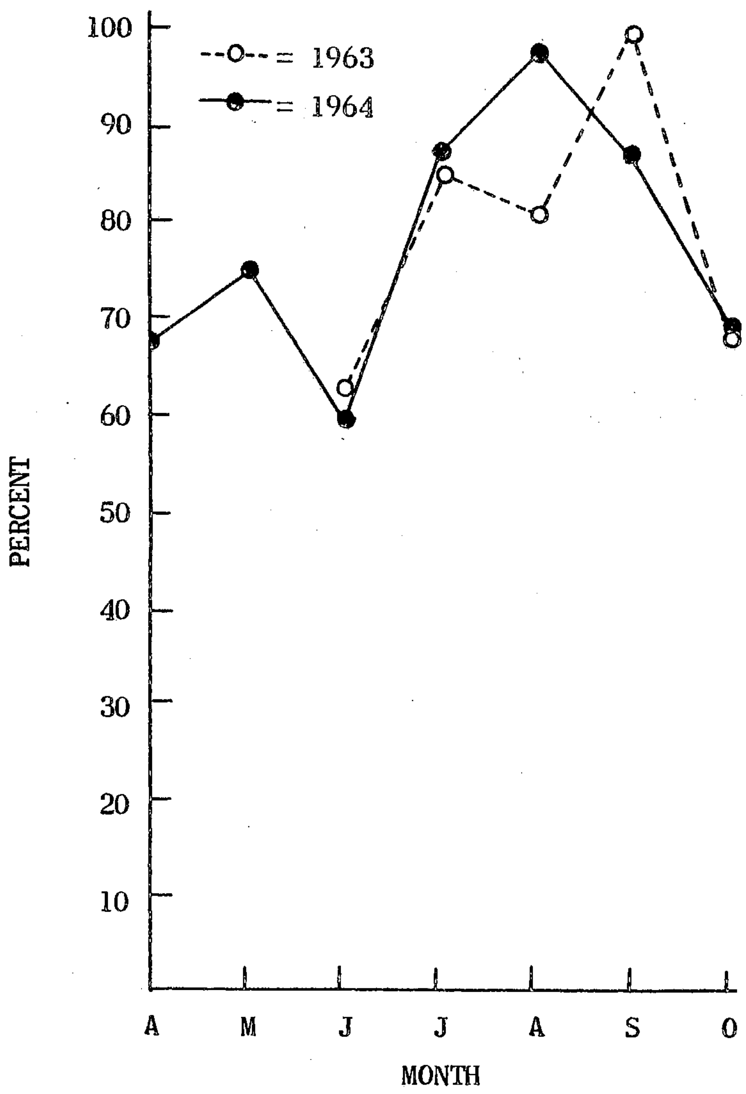


Fig. 3. Relative abundance of nematodes in monthly parasite collections.

indicate the presence of significant numbers of trematodes which were either brought to the study area by the migrating Tadarida or acquired while the bats were in this area. The May 1964 data show a rise in the relative abundance of nematodes, contrasting to the drop in both frequency of infected bats and total infection rates of helminths during the same month. Although nematodes did show a drop in numbers, as indicated by data in Table III, the drop was not as severe as the drop in trematodes. The percentages of nematodes infecting Tadarida are nearly identical (approximately 69%) for October of both years (Fig. 3).

## Infection Frequencies and Infection Rates for Adult and Neonatal Bats

Table IV concerns the infection frequencies and numbers of helminths recovered from parasitized bats for adult and young bats.

Data summarized in Fig. 4 are incomplete due to the lack of information concerning frequencies of infection which occurred during the spring months, but the overall data indicate an inverse relationship in monthly frequencies for adult and neonatal bats during 1963. Adult infection frequencies rose from June (62%) to July (77%), then declined sharply to a low of 30% for an August infection frequency. During this period of decline in frequencies among adults, data for young born during late June and July indicated a rise in infection frequency from 44% during July to 63% in August. By September the bats could not be aged effectively, necessitating a combination of data into infection frequencies for bats regardless of age class. For this period,

TABLE IV

INFECTION FREQUENCIES AND NUMBERS OF PARASITES FOR AGE CLASSES OF BATS

| MONTH | YEAR | AGE | BATS INSPECTED | BATS INFECTED | NEMATODES | TREMATODES | CESTODES |
|---|---|---|---|---|---|---|---|
| June | 1963 | Adult | 21 | 13 | 27 | 19 | 1 |
| June | 1963 | YOY | 0 | 0 | 0 | 0 | 0 |
| July | 1963 | Adult | 35 | 27 | 158 | 6 | 6 |
| July | 1963 | YOY | 18 | 8 | 93 | 0 | 0 |
| August | 1963 | Adult | 33 | 10 | 49 | 39 | 8 |
| August | 1963 | YOY | 32 | 20 | 205 | 0 | 0 |
| September | 1963 | Adult | 0 | 0 | 0 | 0 | 0 |
| September | 1963 | YOY | 1 | 1 | 26 | 0 | 0 |
| September | 1963 | Unknown | 24 | 9 | 32 | 0 | 0 |
| October | 1963 | Adult | 0 | 0 | 0 | 0 | 0 |
| October | 1963 | YOY | 0 | 0 | 0 | 0 | 0 |
| October | 1963 | Unknown | 74 | 22 | 108 | 18 | 8 |
| April | 1964 | Adult | 70 | 52 | 465 | 204 | 2 |
| April | 1964 | YOY | 0 | 0 | 0 | 0 | 0 |
| May | 1964 | Adult | 100 | 37 | 106 | 24 | 7 |
| May | 1964 | YOY | 0 | 0 | 0 | 0 | 0 |
| June | 1964 | Adult | 44 | 31 | 206 | 121 | 12 |
| June | 1964 | YOY | 0 | 0 | 0 | 0 | 0 |
| July | 1964 | Adult | 89 | 66 | 336 | 40 | 24 |
| July | 1964 | YOY | 34 | 13 | 142 | 0 | 0 |
| August | 1964 | Adult | 38 | 7 | 39 | 5 | 1 |
| August | 1964 | YOY | 62 | 23 | 226 | 0 | 0 |
| September | 1964 | Adult | 20 | 0 | 0 | 0 | 0 |
| September | 1964 | YOY | 14 | 9 | 94 | 0 | 1 |
| September | 1964 | Unknown | 111 | 39 | 362 | 9 | 43 |
| October | 1964 | Adult | 11 | 4 | 9 | 2 | 0 |
| October | 1964 | YOY | 8 | 8 | 113 | 23 | 2 |
| October | 1964 | Unknown | 57 | 18 | 92 | 40 | 2 |

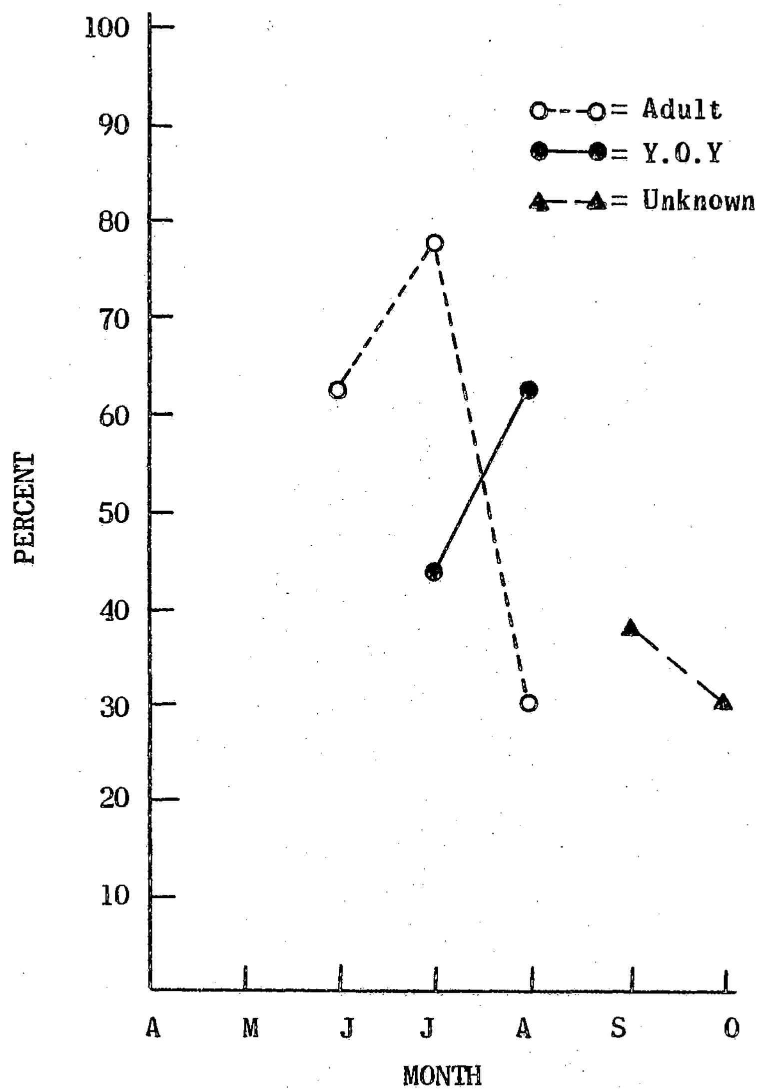


Fig. 4. Comparison of infection frequencies for age classes of bats, 1963

September-October frequencies showed a decline, from 38% in September to 30% in October. No attempt was made to connect the adult and neonatal frequencies with the infection frequencies obtained after September.

Data concerning frequencies of infection in adult bats, April to June 1964 (Fig. 5) are the same data used in Fig. 1 on general infection frequencies, previously discussed. Since young are not born until July, information on adult infection frequencies prior to this time is the same as that for general frequencies. A slight rise in frequencies of infection among adults from June (71%) to July (74%) was followed by a sharp decrease to 18% in August. Twenty banded adult *Tadarida* examined in September contained no helminths; however, the infection frequency for banded adults rose to 36% in October. Infection frequencies among young remained about the same from July (38%) to August (37%) but showed a sharp rise through September (64%) and October (100%). The September-October changes were the same for both adults and young of the year; both age classes showed a 36% increase in infection frequency. Data for frequencies of infection in adults and young during September and October were from banded *Tadarida*. Frequencies for unbanded bats were plotted separately, and showed a decline from 37% in September to 32% in October. This decline was evident in 1963, and involved comparable frequency of infection values.

Differential decreases in frequencies of infection for 1963 and 1964 among bats regardless of age or sex can be explained by the comparison of changes of frequencies for age classes after July of 1963 and 1964. The July-October changes for 1963 involved a simultaneous

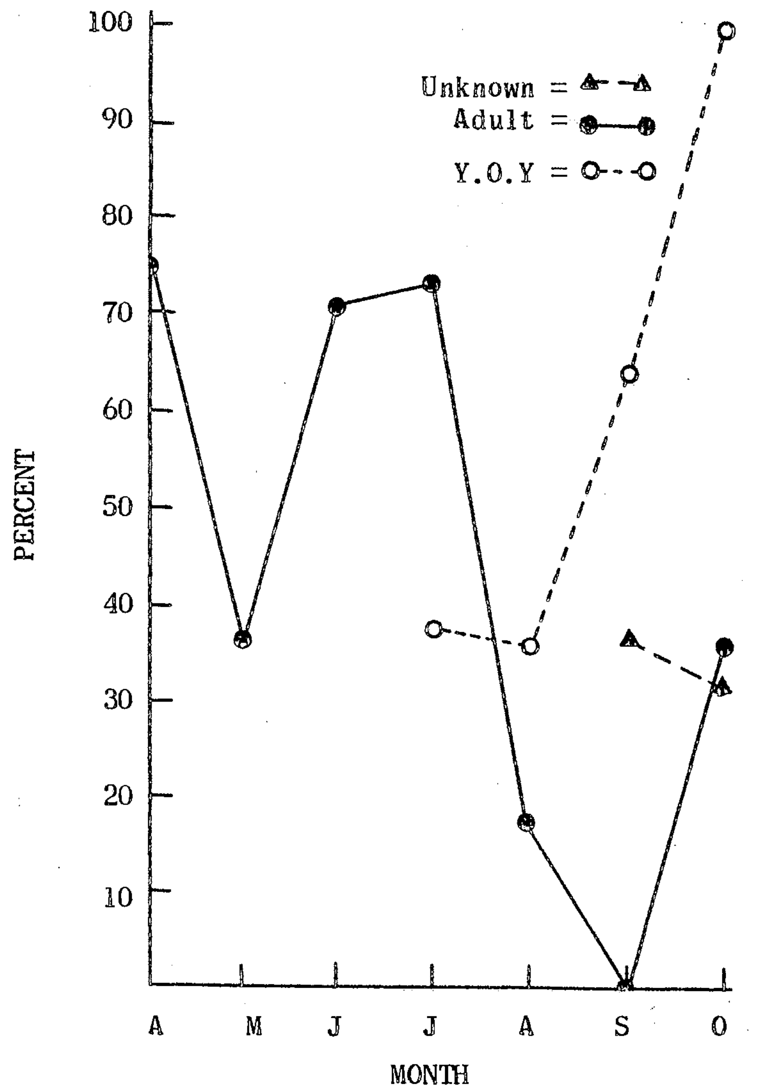


Fig. 5. Comparison of infection freq-uencies for age classes of bats, 1964

decline of frequencies for adults and rise of frequencies for young of the year. The net effect was a gradual decline in frequencies for all bats (Fig. 1). However, young of the year showed no marked change in infection frequencies from July to August, 1964, while data on adults indicated a sharp decline in infection frequencies. The net effect was a sudden drop in frequencies for all bats from July to August. A further drop in adult infection frequencies from August to September was counterbalanced by a sharp increase in infection frequencies among young. The rise in frequencies for young in this period more than offset the decline in frequencies of infection among adults; the net effect was an overall increase in frequencies of bat infections from August (30%) to September (33%). This increase was more evident from September (33%) to October (39%) when frequencies among both adults and young were rising.

Rates of infection of adults and young in 1963 (Fig. 6) showed an inverse relationship to the frequencies of infection of these age classes (Fig. 4) from June through August. While frequencies of infection in adults declined during this period, rates rose from 3.6 parasites per infected adult in June to 9.6 parasites per infected adult in August. The number of parasites per infected young of the year dropped from 11.6 in July to 10.3 in August, while frequencies of infected young increased during these months. Infection rates in unknown-age bats increased from a low of 3.5 in September to 6.1 in October.

Data for 1964 infection rates showed little correlation with 1963 infection rates for adult and young bats, but changes that were

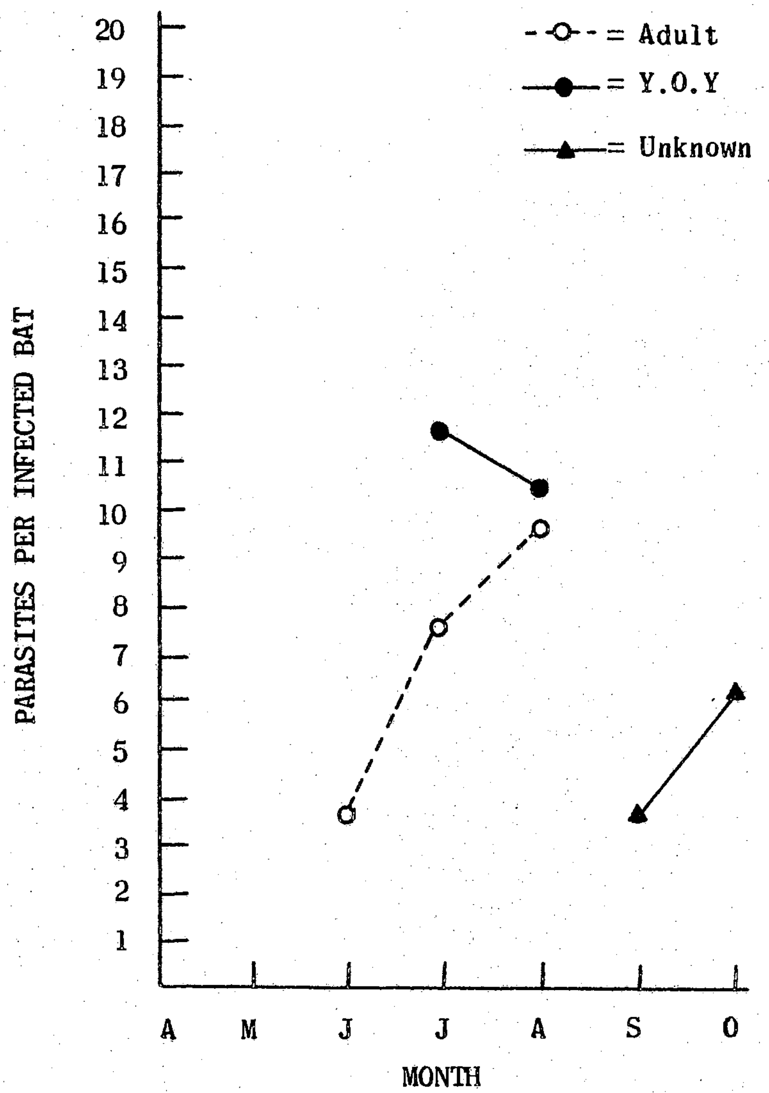


Fig. 6. Comparison of infection rates for age classes of bats, 1963

apparent in the 1964 infection rates were similar to data on frequencies of infection in adults and young during 1964. Adult infection rates, 1964, (Fig. 7) were high in April, dropped sharply during May, and rose again in June. From June through September infection rates decreased, except for a slight increase from July through August. As with frequencies of infection among adults, infection rates increased from September through October. Infection rate data for young showed an increase from July through August, followed by a decrease in September, and then an increase through October. Data for bats of unknown age indicated a drop in infection rates from September through October, unlike the increase for this period in 1963. Reasons for the dissimilarity in data obtained from bats of unknown age during 1963 and 1964 were not determined.

## Frequency of Infection and Rate of Infection in Male and Female *Tadarida*

The sex ratios of freetails in the four study caves from June through October, 1963 and 1964 are summarized in Table V. These data, taken from the results of a study on the population dynamics of Oklahoma freetails (Perry, 1965), indicate the greater abundance of females in the *Tadarida* populations that persisted in the study area. Females constituted the majority of freetails in three of the four study caves (Selman's, Vickery, and Connor's). This unequal sex ratio was especially evident until birth of the young in July. Male young of the year decreased the difference in sex ratios, although females continued to predominate. Davis, et al. (1962), in a study

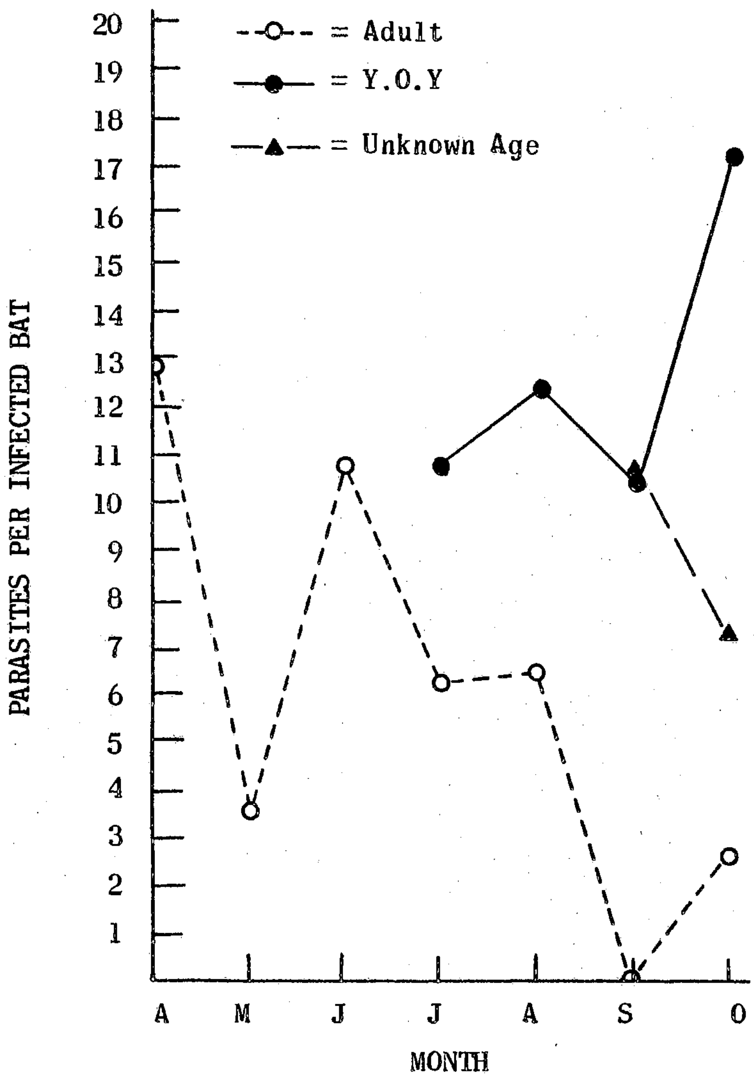


Fig. 7. Comparison of infection rates for age classes of bats, 1964.

of freetails in Texas, suggested that most male freetails do not return to North America in the spring. Because of the unequal sex ratios in the caves, male samples were considerably smaller than female samples for both years. Data obtained from June collections of both years were limited; only three males were collected in 1963, while the 1964 samples consisted entirely of females. No attempt was made to deliberately collect a set number of males, as it was felt that this would bias the random sampling technique employed.

TABLE V

SEX RATIOS OF FREETAILS FOR THE STUDY CAVES, IN TERMS OF PERCENT FEMALES

| MONTH | SELMAN'S | | MERRIHEW'S | | VICKERY | | CONNOR'S | |
|---|---|---|---|---|---|---|---|---|
| | 1963 | 1964 | 1963 | 1964 | 1963 | 1964 | 1963 | 1964 |
| April | -- | 77% | -- | 71% | -- | 82% | -- | 33% |
| May | -- | 85 | -- | 70 | -- | 82 | -- | 33 |
| June | 97% | 95 | 83% | 64 | 91% | 81 | 99% | 99 |
| July | 80 | 90 | 30 | 50 | 75 | 72 | 90 | 95 |
| August | 60 | 55 | 58 | 66 | 68 | 65 | 77 | 75 |
| September | 73 | 84 | -- | -- | 58 | 87 | -- | -- |
| October | 73 | -- | -- | 45 | 75 | 82 | -- | -- |
| Averages | 73% | 82% | 50% | 65% | 72% | 82% | 86% | 84% |

Data for frequencies of infection in males and females (Table VI) indicated an inverse relationship throughout the summer of both years. Frequencies of infection during 1963 (Fig. 8) exhibited a high degree of fluctuation for both sexes, with frequencies in males increasing while frequencies in females decreased, and vice versa.

The monthly changes in female frequencies of infection appeared more stable than changes in male frequencies, as a peak was reached

TABLE VI

INFECTION FREQUENCIES AND NUMBERS OF PARASITES FOR MALE AND FEMALE BATS

| MONTH | YEAR | SEX | BATS INSPECTED | BATS INFECTED | NEMATODES | TREMATODES | CESTODES |
|---|---|---|---|---|---|---|---|
| June | 1963 | Males | 3 | 2 | 1 | 1 | 0 |
| June | 1963 | Females | 18 | 11 | 26 | 18 | 1 |
| July | 1963 | Males | 15 | 3 | 17 | 0 | 0 |
| July | 1963 | Females | 40 | 32 | 23 | 6 | 6 |
| August | 1963 | Males | 10 | 6 | 66 | 0 | 0 |
| August | 1963 | Females | 55 | 24 | 188 | 39 | 8 |
| September | 1963 | Males | 9 | 2 | 4 | 0 | 0 |
| September | 1963 | Females | 16 | 8 | 54 | 0 | 0 |
| October | 1963 | Males | 19 | 10 | 72 | 2 | 6 |
| October | 1963 | Females | 55 | 12 | 36 | 18 | 2 |
| April | 1964 | Males | 20 | 18 | 276 | 121 | 0 |
| April | 1964 | Females | 50 | 34 | 189 | 83 | 2 |
| May | 1964 | Males | 24 | 13 | 53 | 3 | 3 |
| May | 1964 | Females | 76 | 24 | 53 | 21 | 4 |
| June | 1964 | Males | 0 | 0 | 0 | 0 | 0 |
| June | 1964 | Females | 44 | 31 | 206 | 121 | 12 |
| July | 1964 | Males | 30 | 10 | 27 | 3 | 0 |
| July | 1964 | Females | 93 | 69 | 451 | 13 | 24 |
| August | 1964 | Males | 39 | 12 | 147 | 0 | 0 |
| August | 1964 | Females | 61 | 18 | 118 | 5 | 1 |
| September | 1964 | Males | 51 | 29 | 323 | 2 | 34 |
| September | 1964 | Females | 94 | 19 | 133 | 7 | 10 |
| October | 1964 | Males | 16 | 10 | 76 | 0 | 1 |
| October | 1964 | Females | 60 | 20 | 138 | 65 | 3 |

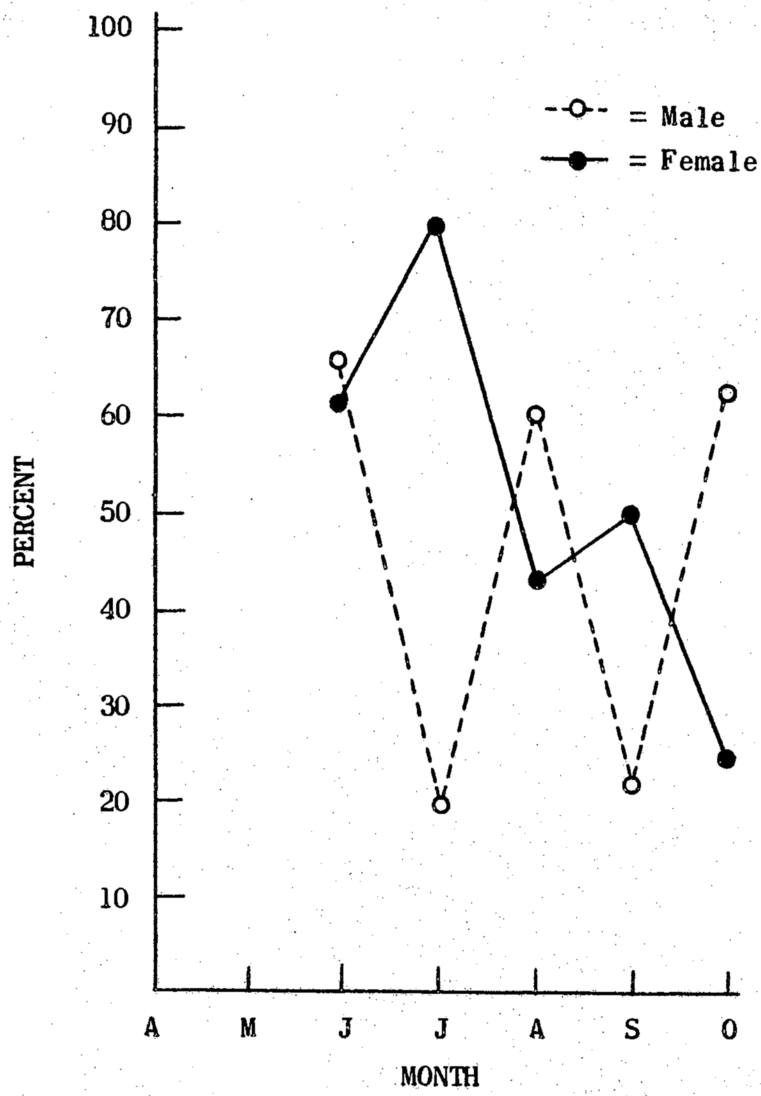


Fig. 8. Comparison of infection frequencies for males and females, 1963.

during July, after which time monthly frequencies generally declined through October. No overall pattern of change was evident from data concerning male frequencies of infection.

Data for 1964 frequencies of infections (Fig. 9) indicate a more marked pattern of infection frequency changes for both males and females. There was a decline in frequencies of infection for both sexes of 36% from April to May. However, the decline continued through August for males, while infection frequencies in females rose from May through July before declining sharply in August and September. Frequencies of infection were about 30% for both sexes in August, but the frequencies of infection continued to drop until September for males, while female infection frequencies increased during this same period of time. Both sexes showed a rise in frequency of infection from September to October.

Data for female frequencies of infection during 1964 were well correlated with data for general frequencies of infection (Fig. 1). This correlation, especially evident from April to August, indicated the importance of females in the total population structure, as data obtained on male frequency for this period had little effect on the data that was obtained on general frequencies of infection. With the introduction of a large number of young males into the population in July, the subsequent rise in infection frequencies for males apparently offset the decline in frequencies for females, with the net result that general frequencies of infection showed a gradual increase from August to September. The rise of the male infection frequencies was assumed to involve principally young-of-the-year males, as the August-September increase for males was about 26%, the same figure as the

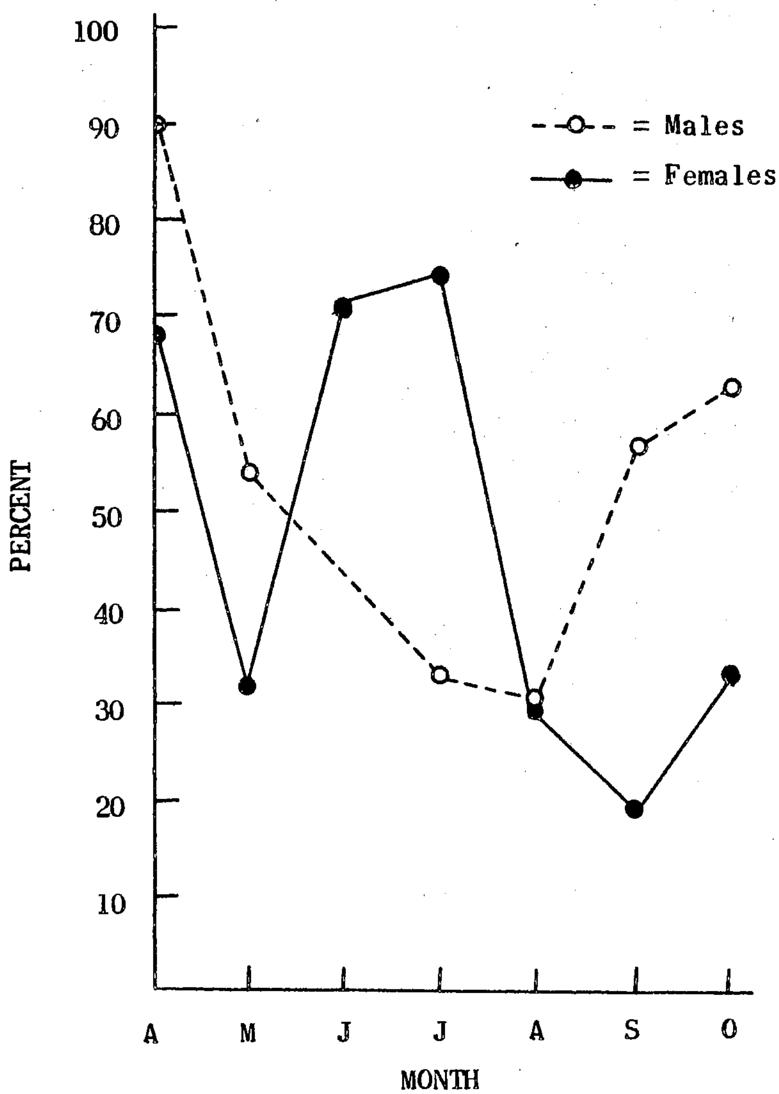


Fig. 9. Comparison of infection freq-
uencies for males and females, 1964.

August-September increase for all young-of-the-year bats (Fig. 5). The young-of-the-year females did not exert so marked an influence on the infection frequencies of all young-of-the-year, as the decline in infection frequencies of adult females offset the rise in the infection frequencies of young females. Frequencies of infection for both males and females, from September to October, rose during the period. Similar changes were observed to occur in the age class and general frequencies of infection.

Data for 1963 rates of infection in males and females (Fig. 10) indicated comparable rates and changes of rates from June to August. In September infection rates for males dropped sharply, compared with a gradual decline for females. While the infection rate for females continued to decline to a low of 4.7 parasites per infected female in October, the infection rate for males rose from a level of 2.0 parasites per bat in September to 7.8 parasites per bat in October.

Data for 1964 rates of infection (Fig. 11) did not indicate similar patterns of changes in infection rates for the two sexes. Infection rates were widely separated for April, but became similar by May. June data for males were lacking. The male infection rate in July was low (3.0 parasites per infected male) but rose sharply to an August rate of 12.3 parasites per infected male. The September rate for males (12.4) was almost identical to the August rate. Unlike 1963, the male infection rate decreased from September to October. Females showed a sharp increase in June, followed by a decline in infection rates for July. The female infection rate in 1964 remained fairly level from July to September, then rose in October.

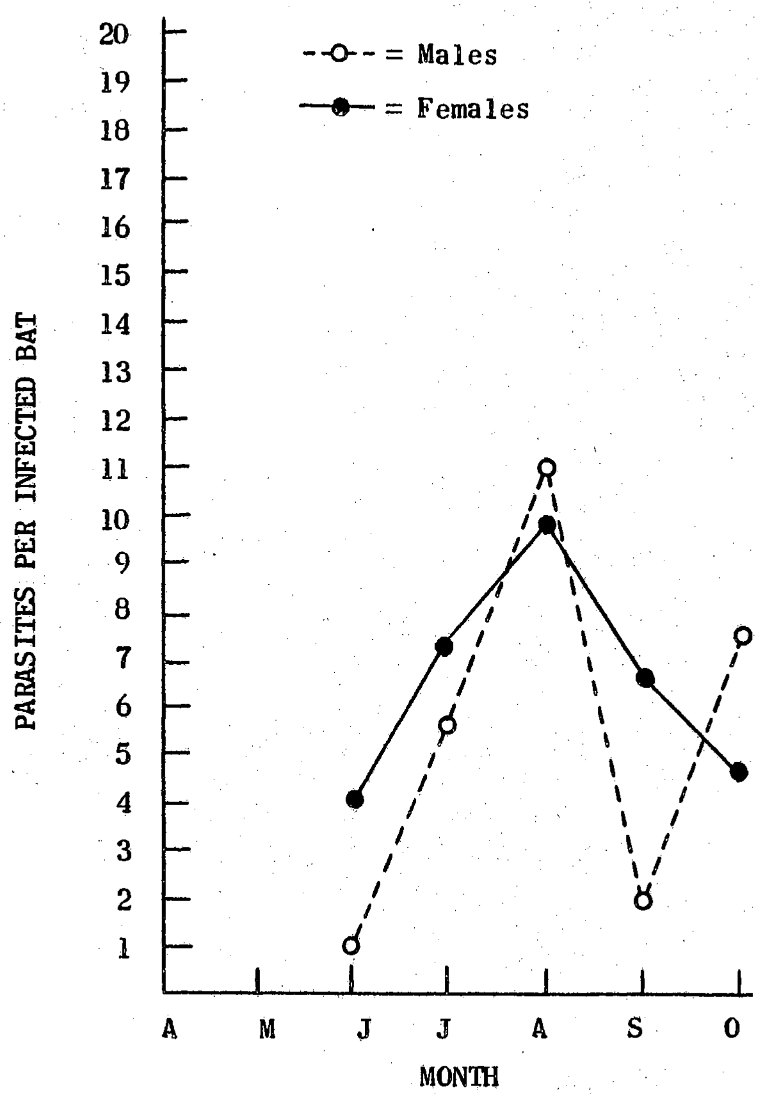


Fig. 10. Comparison of infection rates for males and females, 1963

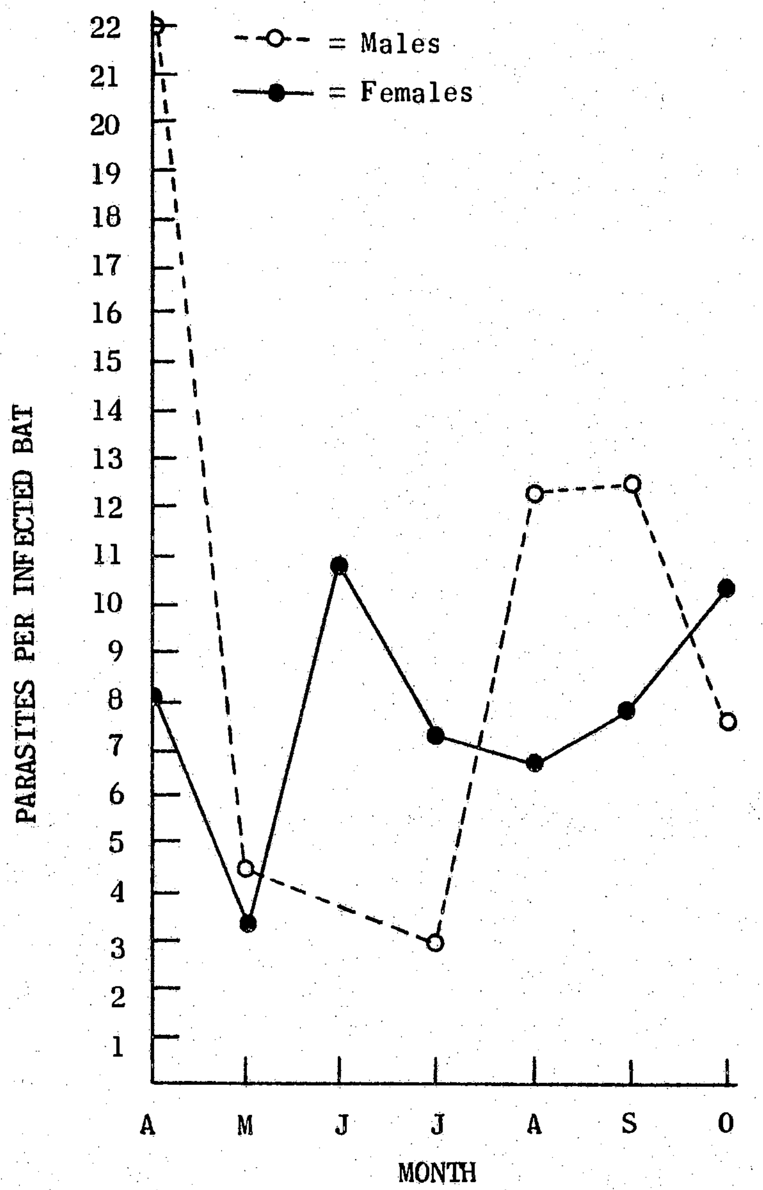


Fig. 11. Comparison of infection rates for males and females, 1964

Infection rates for males and females, 1963 (Fig. 10) showed little correlation with infection frequencies for males and females, 1963 (Fig. 8). Infection rates for males rose steadily from a low of 1.0 parasite per infected male in June (based on only three males) to 11.0 parasites per male in August. The female infection rate rose from 4.1 in June to 9.8 in August. However, after August, infection rates for both sexes were generally correlated with infection frequencies. Females showed a general decline in both infection rates and frequencies from August to October. Males exhibited a decrease in infection rates and frequencies from August to September, but a later increase became evident in October.

A similarity in the general pattern of infection rates and frequencies existed for males and females during 1964. The infection rate (Fig. 11) and the infection frequency (Fig. 9) declined for both sexes from April to May. Males exhibited decreases for both infection frequencies and rates through July, but July-August infection rates increased sharply while frequencies of infection gradually decreased. Frequencies of infection in males rose during September, while infection rates remained fairly constant. September-October frequencies of infection increased while infection rates decreased.

Female infection frequencies and infection rates generally correlated through June, but after this month showed little similarity to each other. Infection rates declined from 10.9 parasites per infected female in June to 6.9 parasites per infected female in August, then rose gradually to an October figure of 10.3 parasites per infected bat. Infection frequencies rose slightly from June (71%) to July (74%), and declined sharply to September (20%) before rising to 31% during October. In both frequencies and rates of infection there were peaks during the summer, followed by decreases in late summer and final rises in October.

Rates and Frequencies of Infection
for Bats in the Study Caves

Table VII represents data which summarize monthly infection frequencies for bats in the four caves sampled. Samples from Merrihew's Cave were taken only in July and August in 1963. No samples were collected from Connor's Cave in September or October of that year, for the population of freetails was drastically reduced by September of 1963. Connor's Cave was not sampled during May, June, and October, 1964.

No definite pattern of changes in infection frequencies for bats in each of the study caves was evident during 1963. Bats in Selman's and Connor's caves had identical frequencies (approximately 83%) for June; the June frequency for Vickery Cave was much lower (33%). July frequencies of infection in freetails rose for Vickery Cave (69%) and Connor's Cave (94%) but dropped for Selman's Cave (53%). With the exception of the bat population in Merrihew's Cave, all caves showed a decline in frequency of infected freetails from July to August. After August, information was collected only from Selman's and Vickery caves. The August-September frequency rose in Selman's Cave, but dropped in Vickery Cave. The October frequency was higher in Vickery Cave, but lower in Selman's Cave. Information on all caves throughout

TABLE VII

FREQUENCIES OF INFECTED BATS IN EACH OF THE STUDY CAVES

| MONTH | YEAR | SELMAN'S | | | MERRIHEW'S | | | VICKERY | | | CONNOR'S | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | INFECTED | INSPECTED | % | INFECTED | INSPECTED | % | INFECTED | INSPECTED | % | INFECTED | INSPECTED | % |
| June | 1963 | 6 | 5 | 83 | 0 | 0 | 0 | 9 | 3 | 33 | 6 | 5 | 83 |
| July | 1963 | 13 | 7 | 53 | 13 | 4 | 30 | 13 | 9 | 69 | 16 | 15 | 94 |
| Aug. | 1963 | 13 | 2 | 15 | 10 | 7 | 70 | 20 | 11 | 55 | 22 | 10 | 45 |
| Sept. | 1963 | 15 | 7 | 46 | 0 | 0 | 0 | 10 | 3 | 30 | 0 | 0 | 0 |
| Oct. | 1963 | 35 | 9 | 26 | 0 | 0 | 0 | 39 | 13 | 33 | 0 | 0 | 0 |
| April | 1964 | 12 | 12 | 100 | 0 | 0 | 0 | 44 | 30 | 68 | 14 | 10 | 71 |
| May | 1964 | 30 | 15 | 50 | 30 | 12 | 40 | 40 | 10 | 25 | 0 | 0 | 0 |
| June | 1964 | 17 | 13 | 77 | 16 | 12 | 75 | 11 | 6 | 55 | 0 | 0 | 0 |
| July | 1964 | 30 | 19 | 63 | 30 | 15 | 50 | 29 | 20 | 69 | 34 | 25 | 73 |
| Aug. | 1964 | 30 | 12 | 40 | 20 | 4 | 20 | 40 | 12 | 30 | 10 | 2 | 20 |
| Sept. | 1964 | 40 | 5 | 13 | 25 | 13 | 52 | 40 | 18 | 45 | 40 | 12 | 30 |
| Oct. | 1964 | 20 | 9 | 45 | 20 | 8 | 40 | 36 | 13 | 36 | 0 | 0 | 0 |

the 1963 collection period showed that changes in infection frequencies for bats in the four caves were correlated with changes in general infection frequencies for freetails (Fig. 1), in that high infection frequencies in early summer were followed by lower frequencies in September and October.

Fig. 12 illustrates data that depict infection frequencies of bats in the four caves during 1964. Changes in infection frequencies for all bats (Fig. 1) were similar to changes in frequencies for bats from each of the four caves. With the exception of Connor's Cave bats, frequencies were high in April, followed by lower May and higher June frequencies. The high infection frequencies persisted through July, but were followed by lower frequencies in August. Data were lacking concerning May and June infection frequencies in Connor's Cave. With the exception of infection frequencies for bats in Selman's Cave, frequencies of infection for bats from all caves rose from August to September, then decreased in October. Bats in Selman's Cave exhibited a decrease in infection frequencies from August to September, followed by a rise in October.

An analysis of monthly infection rates for bats in each cave showed that the changes of infection rates followed no particular pattern. Plottings of these changes as graphs resulted in a figure which was difficult to interpret; for this reason these graphs are not included in this study. Infection rates for 1963 were about 3.0 parasites per infected bat for caves sampled (Selman's, Vickery and Connor's). These rates increased in July and August to the level of 7.3 to 10.5 parasites per infected bat. Data collected during the

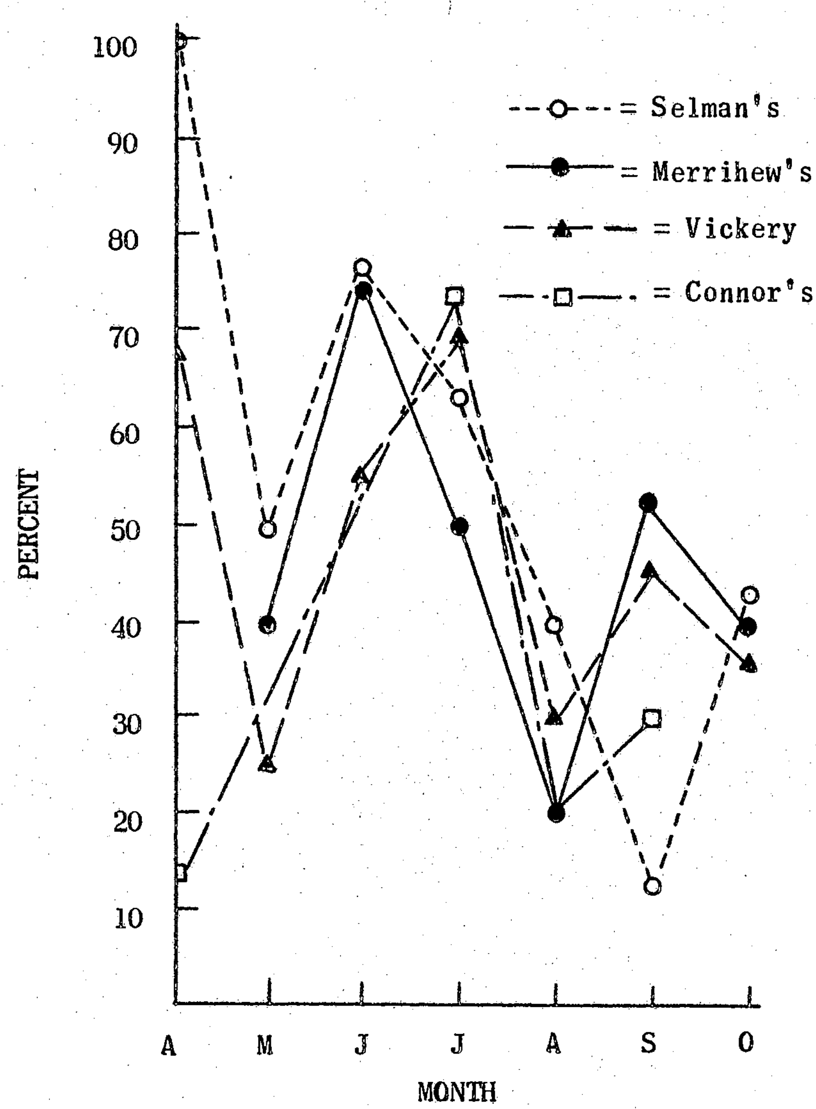


Fig. 12. Frequencies of infected bats for cave populations, 1964

examination of bats from Selman's and Vickery caves, the only caves sampled in September and October, showed a decrease in infection rates during these months to approximately 6.0 parasites per bat by October.

Infection rates for all bats collected from each cave during 1964, were similar through June. Variations in the infection rates of bats are apparent after this period and it is evident that there is little correlation with frequencies of infection. Fluctuations in monthly infection rates for each cave did not parallel fluctuations for other caves. October infection rates ranged from 4.8 parasites per infected bat in Selman's Cave to 13.9 parasites per infected bat in Vickery Cave. Unlike data reported for 1963, no general increase in infection rates was apparent during July and August.

## Helminth Parasites Collected from the Gastrointestinal Tract of *Tadarida b. mexicana*

Of the 898 bats examined for helminths, 417 (approximately 46%) were found to be infected with helminth parasites. These parasites were collected from the stomach and/or the small intestines. The large intestine of *Tadarida* is extremely short, and no helminth parasites were found in this section of the intestinal tract in any of the bats examined.

An intestinal nematode of the genus *Molinostrongylus* was the most abundant helminth collected from the freetails. Identification was made with the aid of keys from Chitwood (1938) and Yamaguti (1958). Voge (1956) reported finding *Molinostrongylus delicatus* in Mexican freetails from California, while Jameson (1959) reported infections of freetails with Anoplostrongylus delicatus. Chitwood (1938) placed both of the above genera in the subfamily Ollulaninae, family Trichostrongylidae. Yamaguti (1958) classified Anoplostrongylus and Molinostrongylus as members of the subfamily Strongylicanthinae, family Trichostrongylidae. He reported Anoplostrongylus paradoxus in Tadarida brasiliensis in Brazil, and Molinostrongylus delicatus from freetails examined in Texas.

The only nematode I found in the stomach of bats examined from Oklahoma was identified as a larval stage of the genus Physaloptera.

Two young freetails examined on 16 July 1964 contained a total of 24 nematodes tentatively identified as Tricholeiperia sp. These specimens were the only nematodes of this genus collected during this study. These bats were still suckling, and unable to fly. This is possibly an instance of accidental infection from another species of bat. Nematodes collected from Myotis velifer, a bat found in association with freetails in the study caves, were not of this genus. No other bat species inhabiting these caves (see introduction) were examined for parasites. Tricholeiperia carnegiensis was collected by Chitwood (1938) from the stomach of Natalus mexicanus in a cave in Yucatan, Mexico.

A single species of cestode, Hymenolepis decipiens, was identified with the aid of keys by Macy (1931) and Hughes (1941). The rostellum of specimens of this tapeworm contained 38-39 rostellar hooks approximately 23 microns in length. The specimens usually were found in the anterior part of the small intestine, although specimens were occasionally collected in the small intestine adjacent to the colon.

Three specimens of trematodes, collected from the stomach or small intestine of freetail bats, were verified as to their taxonomic identification by R. W. Macy, Department of Biology, Portland State College, Portland, Oregon. These species were *Urotrema scabridum* Braun, 1900; *Acanthatrium eptesici* Alicata, 1932; and *Limatulum oklahomensis* Macy, 1931. Other trematodes collected and identified, but not verified, were *Dicrocoelium rileyi*, *Plagiorchis vespertilionis*, and *Prosthodendrium* sp.

Macy (personal communication) listed the species of *Urotrema* collected from the small intestine as *U. schillingeri* Price, 1931, but indicated this as a synonym of *U. scabridum*. Although Gilford (1952) considered *U. scabridum* and *U. schillingeri* as separate species in his taxonomic keys, Yamaguti (1958) listed *U. schillingeri* as a synonym of *U. scabridum*, the name used in this discussion. This species was collected by Eads, et al. (1957) from freetail bats in Texas.

The genus *Acanthatrium* is considered by Yamaguti (1958) to be a subgenus of *Prosthodendrium*. *Acanthatrium alicatai* was collected by Eads, et al. (1957) from *T. b. mexicana* in Texas. The species collected from freetails in Oklahoma caves during this study was determined as *A. eptesici*. Both species were reported by Yamaguti (1958) as infecting *Eptesicus fuscus* in the United States. He designated these helminths as *Prosthodendrium alicatai* and *P. eptesici*.

The trematodes found in the stomach of Oklahoma freetails examined were identified as *Limatulum oklahomensis*. This trematode is typically a stomach trematode (Macy, personal communication), but was collected from both the stomach and small intestine of Oklahoma freetails. Gilford (1952) and Yamaguti (1958) reported the host for this trematode as *Tadarida cynocephala*, and the type locality as Aetna, Kansas. *T. cynocephala* is considered a subspecies of *Tadarida brasiliensis*, with a range covering the southeastern part of the United States (Hall and Kelson, 1959). Aetna, Kansas lies in the range of *T. b. mexicana.*

A trematode found in the small intestine of the freetail bat during this investigation was tentatively identified as belonging to the genus *Prosthodendrium*. Macy (personal communication) stated that he did not possess enough material to determine the species of this trematode. Three species of *Prosthodendrium* have been collected from Mexican freetails: Gilford (1952) reported the collection of *Prosthodendrium scabrum* Caballero, 1943, from the intestine of *Tadarida brasiliensis* in the region of Mexico City; Eads, et al. (1957) collected *P. naviculum* from freetails in Texas; and Jameson (1959) identified some trematodes of Texas bats as *Ochoterenatrema labda*. Yamaguti (1958) considered *Ochoterenatrema* as a synonym of *Prosthodendrium*.

A single specimen of a trematode tentatively identified as *Plagiorchis vespertilionis* was collected from a male *Tadarida* during May, 1964. This species was recovered from *Tadarida brasiliensis* by Caballero (1940) in the Mexico City area during December, 1939 and January, 1940. *T. b. mexicana* is not found in the Oklahoma caves during these months, but has migrated into Mexico and possibly further south.

Several specimens of *Dicrocoelium rileyi* Macy, 1931 were recovered from containers used to hold the small intestine of bats during the examination of this organ. This trematode is commonly a parasite of the liver and gall bladder of *Tadarida* and other bats. Specimens recovered in the examination containers were assumed to have been forced from the biliary ducts and other portions of the liver during removal of the liver and mesenteries from the stomach and intestines.

## Monthly Occurrences of Species of Helminths

Table VIII summarizes data of helminths collected from *T. b. mexicana* in Oklahoma caves during 1964. Data concerning the monthly occurrences of these parasites are reported for only this year, because samples collected in 1964 were more complete and more representative for the period of *Tadarida's* stay in the study caves. Data collected on bat parasites for 1963 were not summarized. The recording of data did not begin until June, and no information was available for April and May, the months of *Tadarida's* arrival in the study caves.

The nematodes collected during 1964 were found in both adults and young of the year (Table VI), indicating the ability of both *Molinostrongylus* and *Physaloptera* to complete their life cycle in the study area. This is true also for the cestode, *Hymenolepis decipiens*, which also was collected from adult and young bats throughout the sampling period (Table VIII). These species of helminths were persistent in *T. b. mexicana* from April through October, the period of this bat's occupancy of the study caves. Although the nematodes were relatively abundant in the bats throughout the sampling period, the number of cestodes collected in April was low, and rose throughout the summer months. This indicated that these parasites were acquired after the bats arrived in the study area, while the nematodes were brought into the area by the migrating freetails.

Six species of trematodes were recovered from the Mexican freetail bats examined during this study. Of these species, *Plagiorchis vespertilionis* and *Urotrema scabridum* were found only in April and May. *Limatulum oklahomensis* was collected throughout the study period,

TABLE VIII

MONTHLY INCIDENCES OF TYPES OF PARASITES COLLECTED IN THE STUDY AREA

| PARASITE | APRIL | MAY | JUNE | JULY | AUGUST | SEPTEMBER | OCTOBER |
|---|---|---|---|---|---|---|---|
| *Limatulum oklahomensis* | 20 | 5 | 3 | 4 | 0 | 0 | 1 |
| *Plagiorchis vespertilionis* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Urotrema scabridum* | 34 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Prosthodendrium* sp. | 43 | 8 | 53 | 16 | 3 | 3 | 10 |
| *Acanthatrium eptesici* | 69 | 10 | 58 | 1 | 1 | 4 | 44 |
| *Dicrocoelium rileyi* | 1 | 1 | 0 | 1 | 1 | 0 | 3 |
| *Hymenolepis decipiens* | 2 | 7 | 12 | 24 | 1 | 44 | 4 |
| *Molinostrongylus* sp. | 455 | 103 | 205 | 476 | 265 | 446 | 194 |
| *Physaloptera* sp. | 10 | 3 | 1 | 2 | 0 | 10 | 20 |

with the exception of August and September. Specimens of Dicrocoelium rileyi were recovered sporadically from April through October. Both Prosthodendrium sp. and Acanthatrium eptesici were identified in relatively large numbers throughout the study period. The incidence of infection of Tadarida by the latter two species was high in April, lower throughout late spring and summer, and high again in October.

During both years, Limatulum oklahomensis was the only trematode collected from bats known to be young of the year. Twenty-three specimens of this helminth were recovered from banded young of the year on 31 October, 1964. All other trematodes were recovered from adults or bats of unknown age.

Results of data concerning monthly incidence of each type of helminth indicate the species of parasites present in the freetails during their migration to the study area and species which were acquired after the bats arrived in the Oklahoma caves which were studied. The presence of species of Molinostrongylus and Physaloptera collected throughout the summer indicate that these nematodes were brought to the study area by the migrating freetails and that bats were capable of being infected while in Oklahoma. The initial scarcity of specimens of Hymenolepis decipiens in freetails during April, followed by an increase in the number of specimens collected throughout the summer, indicated that this cestode was acquired in Texas or Oklahoma after Tadarida had migrated northward from Mexico.

The occurrence of Urotrema scabridum and Plagiorchis vespertilionis only during April and May indicates that these species were introduced into the study area by the migrating freetails. Absence of biological and ecological conditions possibly precludes completion of the life cycle of these parasites in Oklahoma. Information concerning hosts and distribution of representative trematodes species (Table IX) was obtained from Yamaguti (1958). From this information it is apparent that U. scabridum and P. vespertilionis occur in Mexico and South America, although U. scabridum has been collected in the United States.

Limatulum oklahomensis and Acanthatrium eptesici were collected from freetails throughout the study period. It is evident that the life cycles of these trematodes may be completed while Tadarida is in the Oklahoma caves. This infection capability was confirmed for L. oklahomensis by the collection of specimens of this trematode from bats known to be young of the year. No attempt was made to determine the life cycle of this parasite nor to determine whether the intermediate host species were present in the study area. Information concerning the distribution of L. oklahomensis and A. eptesici (Table IX) verifies the presence of these parasites in Mexican freetails in the United States.

TABLE IX

HOSTS AND GEOGRAPHIC DISTRIBUTION OF TREMATODES COLLECTED IN THE STUDY AREA

| TREMATODE | HOSTS | DISTRIBUTION |
|---|---|---|
| Urotrema schillingeri (synonym of U. scabridum) | Ondatra zibethica, Nycticeius humeralis, Noctilio macropis, Molossus nigricans, Phyllostoma, Promops centralis | USA<br>Mexico<br>Brazil |
| Acanthatrium eptesici (subgenus of Prosthodendrium) | Eptesicus fuscus | USA |
| Limatulum oklahomensis | Tadarida cynocephala | Kansas |
| Dicrocoelium rileyi | Tadarida cynocephala<br>Nycticeius humeralis | USA |
| Plagiorchis vespertilionis | Vespertilio auritus, Myotis, Pipistrellus, Eptesicus, Leuconoe, Plecotus, Nyctalus, Nyctimonus, Rhinolophus, Tadorida (sic), Miniopterus | Europe<br>Canada<br>Mexico<br>Egypt |
| Prosthodendrium sp. | | |
| P. labda | Tadarida brasiliensis, Natalus mexicanus | Mexico |
| P. naviculum | Eptesicus fuscus, Dasypterus floridanus | USA |
| P. scabrum | Tadarida brasiliensis, Lasiurus cinereus | Mexico |

## CHAPTER IV

## SUMMARY AND CONCLUSIONS

During 1963 and 1964, 898 specimens of *Tadarida brasiliensis mexicana* were examined for gastric and intestinal helminth parasites. Monthly changes in frequencies and rates of infection were recorded, and the incidence of helminth species throughout the 1964 study period was traced.

Frequencies of infection for all bats during both years were high during June and July, and were reduced until the freetails migrated in the fall. The variation in decline of general infection frequencies after July for the two years was attributed to the influence of variations in infection frequencies for young of the year on general frequencies.

Infection frequencies for all bats during late spring and early summer, 1964, were high during April, followed by a decline in May and a rise during June to a frequency level comparable to that of April. The May decrease in infection rates was attributed to the effects of a lack of infective larvae in the study area when the freetails arrived from Mexico. Upon reinfection of the definitive host the frequency of infected bats increased during June.

Infection rates for all bats generally reflected the 1963 pattern of infection frequencies. During 1964, the similarity between infection rates and frequencies was evident only through July. After this month an inverse relationship existed between rates and frequencies of infection.

Nematodes were the most abundant helminths in the stomach and intestines. Spring and fall collections contained significant numbers of trematodes and cestodes, while summer collections consisted mainly of nematodes.

The relationship between infection frequencies for adult and young bats during 1963 and 1964 was similar, with frequencies of infected adults decreasing while frequencies of infected young increased. An inverse relationship was apparent between rates and frequencies of infection for the two age classes during the summer of 1963. Little correlation was evident between infection rates for 1963 and 1964. However, changes that were apparent in the 1964 infection rates were similar to data on 1964 infection frequencies for adults and young.

Data for frequencies of infection in males and females indicated an inverse relationship throughout the summer of both years. The importance of females in the total population structure was indicated by the correlation between frequencies of infected female bats and frequencies for all bats regardless of sex or age.

Infection rates for males and females showed little correlation with infection frequencies for the sexes during 1963, but were similar in general patterns during 1964.

Little similarity in pattern was evident in infection rates for the two years.

Little similarity in infection rates and infection frequencies for bats in the study caves was evident from the 1963 data. Similar changes in frequencies of infected bats for the caves were indicated during 1964, although there was no definite correlation in infection rates for the four caves.

The nematodes Molinostrongylus sp. and Physaloptera sp. were present in all bats throughout the study periods. These results indicated that they were brought into the study area by the migrating freetails. Apparently, bats were capable of being infected with these nematodes in the study area. Specimens of Tricholeiperia sp. were collected from two baby freetails during July. This was assumed to be an accidental infection from an unidentified species of bat.

The presence of Hymenolepis decipiens in both adult and young bats indicated that this cestode was acquired in the study area.

Six specimens of trematodes were recovered from T. b. mexicana in the study area. Plagiorchis vespertilionis and Urotrema scabridum were collected only during April and May, indicating that these trematodes were introduced into the study area by the freetails, and that biological and ecological conditions prevented the completion of their life cycle in Oklahoma. Limatulum oklahomensis, Acanthatrium eptesici, Prosthodendrium sp., and Dicrocoelium rileyi were collected throughout the study period, and it is assumed that they were acquired in either Texas or Oklahoma, and that the life cycles of these trematodes may be completed while the freetails are in Oklahoma. This infection capability was confirmed for L. oklahomensis by the collection of specimens of this trematode from freetails known to be young of the year.

## LITERATURE CITED

Caballero y C., E. 1940. Algunos trematodos intestinales des los murcielagos de Mexico. An. Inst. Biol. Univ. Mex. 11: 215-223.

_______. 1942. Descripcion de Parallintoshius tadaridae n. sp. (Nematoda: Trichostrongylidae) de los murcielagos de Mexico. An. Inst. Biol. Univ. Mex. 13: 105-109.

Chitwood, B. G. 1938. Some nematodes from the caves of Yucatan. Carnegie Inst. of Wash. Publ. 491: 51-66.

Constantine, D. G. 1958. An automatic bat-collecting device. J. Wildl. Manag. 22(1): 17-22.

Davis, Richard B., Clyde F. Herreid II, and Henry L. Short. 1962. Mexican free-tailed bats in Texas. Ecol. Monogr. 32(4): 311-346.

Eads, R. B., J. S. Wiseman, and G. C. Menzies. 1957. Observations concerning the Mexican free-tailed bat, Tadarida mexicana, in Texas. Texas J. Sci. 9(2): 227-242.

Gilford, James H. 1952. Studies of the trematodes from certain midwestern bats. Master's thesis, Univ. Illinois. 210 p. Microfilm.

Glass, B. P. 1958. Returns of Mexican freetail bats banded in Oklahoma. J. Mamm. 39(3): 435-437.

_______. 1959. Additional returns from freetail bats banded in Oklahoma. J. Mamm. 40(4): 542-545.

_______, and Claude M. Ward. 1959. Bats of the genus Myotis from Oklahoma. J. Mamm. 40(2): 194-201.

Hall, E. R. and K. R. Kelson. 1959. The mammals of North America. The Ronald Press, New York. 2 vol.

Hughes, R. Chester. 1941. A key to the species of tapeworms in Hymenolepis. Amer. Micr. Soc., Trans. 60: 378-414.

Jameson, D. K. 1959. A survey of the parasites of five species of bats. Southwest. Nat. 4(2): 61-65.

Macy, R. W. 1931a. New bat trematodes of the genera Plagiorchis, Limatulum, and Dicrocoelium. J. Parasit. 18: 28-33.

Macy, R. W. 1931b. A key to the species of Hymenolepis found in bats and the description of a new species, Hymenolepis christensoni, from Myotis lucifugus. Amer. Micr. Soc., Trans. 50: 344-347.

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

Stunkard, H. W. 1938. Parasitic flatworms from Yucatan. Carnegie Inst. Publ. 491: 33-50

Twente, John W., Jr. 1955. Some aspects of the habitat selection and other behavior of cavern-dwelling bats. Ecology 36(4): 706-732.

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

Voge, Marietta. 1956. A list of nematode parasites from California mammals. Amer. Midl. Nat. 56(2): 423-429.

Yamaguti, Satyu. 1958. Systema Helminthum. Interscience Publishers, Inc., New York. 5 vol.

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