Fall 1984

Seasonal changes and overwintering of endoparasites in the bat (Myotis lucifugus) in a Southeastern Wisconsin hibernaculum

James R. Coggins
University of Wisconsin - Milwaukee

SEASONAL CHANGES AND OVERWINTERING OF ENDOPARASITES IN THE BAT, *MYOTIS LUCIFUGUS* IN A SOUTHEASTERN WISCONSIN HIBERNACULUM

JAMES R. COGGINS

Department of Biological Sciences, University of Wisconsin–Milwaukee

Milwaukee, Wisconsin 53201

ABSTRACT

Eight digenetic trematode species (Phylum Platyhelminthes, Subclass Digena), one cestode species (Phylum Platyhelminthes, Class Cestoidea) and three nematode species (Phylum Nematoda) were recovered from the little brown bat, Myotis lucifugus, at the Neda Mine hibernaculum in southeastern Wisconsin. Bats displayed a rich and diverse helminth fauna throughout the year. Statistically significant seasonal variation was observed for two digenetic trematodes. Mean intensities and prevalence of parasites were highest in autumn and spring and lowest in summer. Highest species diversity occurred in autumn. Greater intensity and prevalence in autumn and spring were correlated with bat swarming and emergence patterns, behavioral phenomena which would also produce a more heterogeneous assemblage of parasites during these times of year. Myotis lucifugus retained a large and varied population of parasites throughout eight months of hibernation.

INTRODUCTION

This paper summarizes ecological studies that began in 1979 and are continuing through the present time on population ecology of the parasite fauna in the little brown bat, Myotis lucifugus, at Neda Mines. The little brown bat is the most common bat in the United States from the standpoint of distribution and abundance (Barbour and Davis 1969). Although endoparasites of M. lucifugus have been recorded from other midwestern states including Kansas, Nebraska and Oklahoma (Nickel and Hansen 1967) and Iowa (Blankespoor and Ulmer 1970; 1972), little is known of the helminth fauna of Wisconsin bats (Coggins, in press).

Since previous reports concerning the parasite fauna of Wisconsin bats were only species descriptions (Macy 1935; Rausch 1975; Font 1978) or new host/locality records (Coggins et al. 1981), the present study was undertaken to determine the nature of seasonal parasite population changes in M. lucifugus and to assess the effect of extended host hibernation on overwintering parasites.

All the parasites recovered are endoparasites. Digenetic trematodes are parasites that have two hosts. The adult lives within a vertebrate while juvenile or larval stages reside within one or more invertebrates. All digenea reported herein use arthropods as the intermediate (invertebrate) host. Most cestodes also use two hosts in their life cycle. Although few of the life histories of both digenea and the cestode reported in the present study are known, the one cestode found is thought to use coleopterans as its intermediate

host. Nematodes vary widely in their life histories. They may have an invertebrate host or direct life cycle.

MATERIALS AND METHODS

Bats were collected from the Neda Iron Mine located in Dodge County, Wisconsin. Although this mine produced iron ore in the late 1800's it has been abandoned for almost 70 years. There are over 4.8 km of subterranean tunnels and approximately 28 openings. This mine is surrounded by extensive cultivated fields and lowland marsh; entrances are located amid isolated patches of woody and old field vegetation. A heavy snow cover is normally found from December through March. The property is owned and administered by the UWM Field Station. This site is the largest known bat hibernaculum in Wisconsin and also serves as a summer roost for a smaller number of bats. In addition to *M. lucifugus*, by far the most abundant species, three other bat species utilize the mine: the long-eared bat, *M. keeni*; the big brown bat, *Eptesicus fuscus*; and the eastern pipistrelle, *Pipistrellus subflavus*.

Relative insect abundance near the trapping site was determined by sampling with a total of four plastic cylinders, coated with a sticky substance, placed along a transect. Traps were situated at ground level, 1, 2, and 3 m in height. Insects were identified to order when possible and counted. The most common insects at the time of this study were, in order of decreasing biomass, dipterans, coleopterans and lepidopterans (Rupprecht 1980).

During 1979 and 1980 four to five active bats were collected monthly by either mist net or harp trap (Tuttle 1974). Hibernating bats were removed from the mine in November, 1979 and February, 1980. Since the initial two-year collection period I have continued to collect smaller numbers of bats during the summer months only. Animals were transported live to the laboratory and necropsied for internal helminth parasites. Digenetic trematodes and cestodes were relaxed in hot water, fixed in A.F.A. and stained in Semichon's acetocarmine for species identification. Nematodes were identified as temporary mounts in lactophenol and stored in 70% alcohol with glycerine. Parasite counts were $\log_{10} Y+1$ transformed before analysis by a Model II ANOVA (Sokal and Rohlf 1969).

Voucher specimens of all trematode and cestode species have been deposited in the University of Nebraska State Museum, Division of Parasitology, No. 21250-21258.

RESULTS

Eight species of digenetic trematode, one species of cestode and three species of nematodes were recovered from 59 *M. lucifugus* during this study (Table 1). Prevalence (percentage of hosts infected with one or more helminths) was greatest during spring and autumn while lowest in summer (Fig. 1).

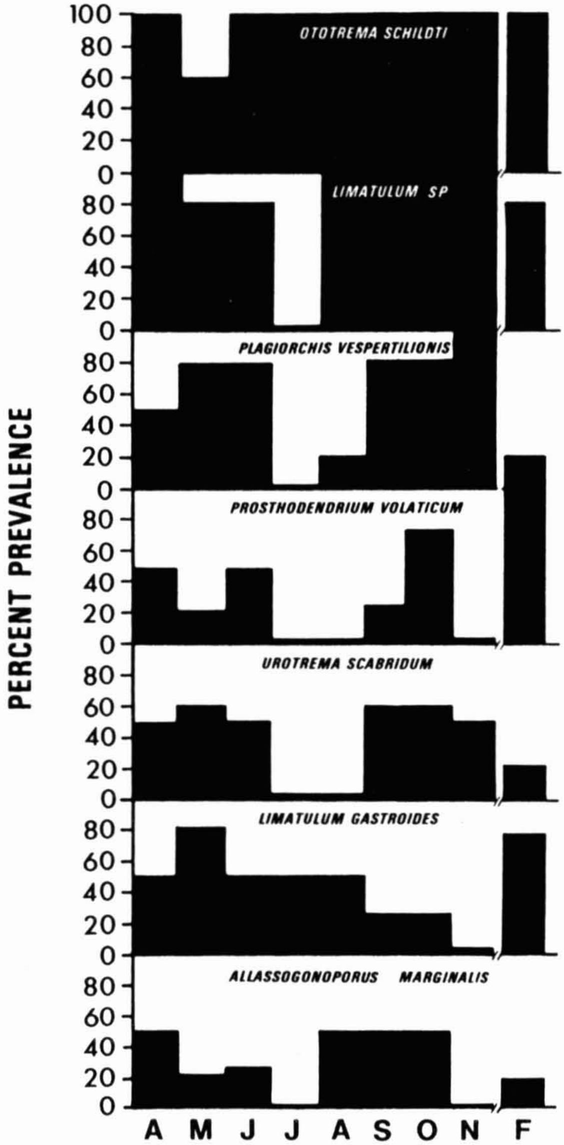

Figure 1. Seasonal prevalence of helminth parasites of Myotis lucifugus.

Table 1. Mean intensity, standard error of the mean and range (in parenthesis) for helminth parasites of *Myotis lucifugus*.

PARASITE	MONTH								
	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	FEBRUARY
HOST SAMPLE	10	9	8	8	8	9	8	10	8
DIGENEA									
Lecithodendriidae									
Allassogonoporus marginalis[2] (Oliver 1938)	2.0±3.4 (1-7)	1.2±2.7 (0-6)	0.3±0.5 (0-1)	0	5.8±7.2 (0-15)	0.5±0.6 (0-1)	1.5±1.9 (0-4)	0	0.8±1.8 (0-4)
Limatulum gastroides (Macy 1935)	0.8±1.0 (0-2)	3.0±3.4 (0-8)	1.8±2.1 (0-4)	7.5±14.3 (0-29)	1.8±2.9 (0-6)	0.5±1.0 (0-2)	0.3±0.5 (0-1)	0	2.0±1.6 (0-4)
*Limatulum mcdanieli**	8.3±6.4 (1-15)	26.6±2.4 (0-85)	2.5±35.3 (0-5)	0	17.0±15.6 (1-34)	3.8±3.6 (1-9)	19.3±32.6 (1-68)	5.4±2.1 (3-6)	7.8±11.1 (0-27)
Ototrema schildti (Font 1978)	31.5±31.2 (4-75)	32.8±46.4 (0-106)	29.3±10.0 (23-44)	13.8±24.1 (1-50)	13.5±20.0 (1-43)	141.3±111.9 (29-239)	163.3±306.6 (1-623)	65.5±70.0 (16-115)	41.8±53.1 (3-131)
Prosthodendrium swansoni[2] (Macy 1936)	0	0	0.1±0.4 (0-1)	0	0	0	0	0	0
Prosthodendrium volaticum[1,2] (Blankespoor and Ulmer 1972)	0.8±1.0	0.2±0.5	1.8±2.9	0	0	0.3±0.5	17.0±22.6	0	0
Plagiorchiidae									
Plagiorchis Vespertilionis[2] (Muller 1784)	3.5±6.4 (0-13)	13.2±11.6 (0-25)	3.3±3.3 (0-7)	0	0.3±0.5 (0-1)	14.3±23.9 (0-50)	3.3±3.3 (0-7)	8.5±2.1 (7-10	1.2±2.2 (0-5)
Urotrematidae									
Urotrema scabridum[2] (Braun 1900)	0.5±0.6 (0-1)	5.2±7.7 (0-18)	1.0±1.4 (0-3)	0	0	2.5±2.7 (0-6)	7.8±11.2 (0-24)	1.5±2.1 (0-3)	0.4±0.9 (0-2)

CESTODA									
Hymenolepididae									
Hymenolepis christensoni (Macy 1931)	0	0	0	0.3±0.5 (0-1)	0	0	0	0	0.4±0.5 (0-1)
NEMATODA									
Rictulariidae									
Rictularia lucifugus[2] (Douvres 1956)	0	0	0	0.3±0.5 (0-1)	0	0	0.5±1.0 (0-2)	0	0
Trichostrongylidae									
Allintoshius sp.	0.3±0.5	0	0	0	0	0	0	0	0
Trichuridae									
Capillaria palmata[2] (Chandler 1938)	0.5±1.0 (0-2)	0	0.1±0.4 (0-1)	0	0	4.3±7.2 (0-15)	0	0	0

[1]New host record

[2]New locality record

*New species

Digenetic trematodes constituted the bulk of the helminth community. At least one species of digenean was recovered from each individual host. Ototrema schildti was recovered from 57 of 59 bats examined (97%) and was the most common parasite found in this study. Intensity (defined as the mean number of parasites per infected host) of O. schildti was highest in autumn (September-October), but a substantial number of worms was present throughout the year (Table 1). The highest number of O. schildti recovered was 623 from a bat captured in October. No significant seasonal variation was observed in monthly mean intensity of O. schildti ($F=1.57$, $P>0.05$). Ototrema schildti was found in 100% of the hosts examined throughout the year, except in May when 60% of hosts were infected (Fig. 1).

Two species of Limatulum were recovered from the stomach of M. lucifugus. A newly described species, L. mcdanieli (Brooks and Coggins 1983), was the second most abundant parasite present, being found in 90% of hosts (Table 1). Limatulum mcdanieli was present in all months but July, with prevalence high in autumn and spring but low in summer. No statistically significant seasonal variation was observed ($F=1.87$, $P>0.05$). Limatulum gastroides was recovered less frequently (71%) and in lower densities. However, intensity of this parasite did vary statistically throughout the collection period ($F=3.21$, $P<0.05$). The highest percentage of bats infected with L. gastroides occurred in spring and winter.

Plagiorchis vespertilionis was recovered from 46 (78%) of the hosts examined (Table 1). The highest percentage of infected hosts occurred in autumn and spring, with the lowest prevalence in summer. This parasite was recovered in all months except July, with intensity highest in autumn and spring. However, the intensity of this parasite did not display statistically significant variations ($F=1.85$, $P>0.05$).

Prevalence of Prosthodendrium volaticum was highest in spring and autumn (Fig. 1). Mean intensity, although low, followed a similar seasonal pattern (Table 1) and was statistically significant ($F=6.13$, $P<0.05$). Prosthodendrium swansoni was recovered only once during this study. Urotrema scabridum and Allassogonoporus marginalis were found in low numbers throughout the year (Table 1). The percentage of bats infected was highest in autumn.

The cestode Hymenolepis christensoni was rarely recovered during this study; one specimen was obtained in July and two in February. Although found incidentally in M. lucifugus, several big brown bats taken from the same locality were heavily infected with this cestode.

The nematodes Capillaria palmata, Rictularia lucifugus, and Allintoshius sp. were recovered infrequently. Prevalence of all nematodes was highest in autumn.

The mean number of parasite species per host for each collection period is shown in Figure 2. The observations for 1979-1980 displayed a seasonal fluctuation with the higher mean number of species in autumn (5.3 in September and October) and spring (4.3 in April). The number of parasite species collected during summer dropped precipitously (1.8 in July).

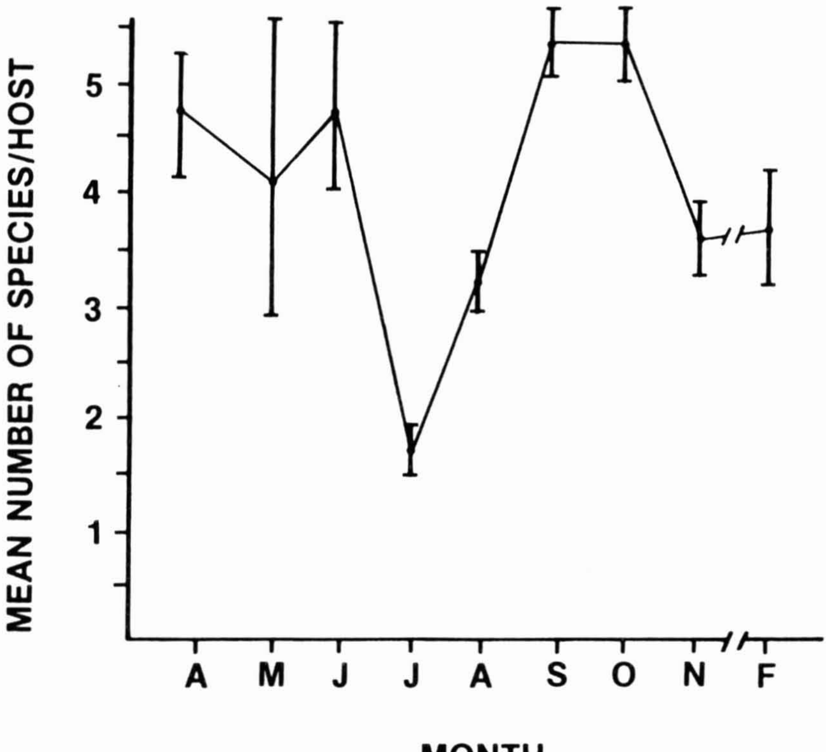

Figure 2. Mean number of parasite species ($\pm$ 1 SE) infecting Myotis lucifugus.

DISCUSSION

Little information exists on the seasonal periodicity of bat parasites. Nickel and Hansen (1967) indicated that the helminth intensities in Myotis grisescens were low following hibernation, increased during spring and summer and peaked in autumn. Blankespoor and Ulmer (1972) reported that the highest percentage of bats infected with Prosthodendrium volaticum, the only parasite for which seasonal periodicity was considered, also occurred in summer and autumn. However, they failed to state whether these differences were statistically significant. Since digenetic trematodes were the only commonly occurring parasites recovered from M. lucifugus in the present study, this is the only group for which seasonal changes were considered. Only two digeneans, Limatulum gastroides and P. volaticum, displayed statistically significant monthly variation.

Since host hibernation was cited as the probably cause of low parasite intensity and low prevalence following winter in the studies above, it is significant to note the high prevalence and intensity found during spring in the present study. I believe that this discrepancy may be due to differing hibernation habits of Myotis lucifugus in Wisconsin. In Iowa, bats hibernated from January to May and a similar pattern probably occurs in Kansas. In both studies prevalence and intensity of parasites were low in spring and increased toward autumn. Since, presumably, no parasite recruitment occurs during winter hibernation, low intensities in spring as observed by previous workers suggest that parasites are lost during hibernation.

In contrast, Myotis lucifugus in Wisconsin begin swarming behavior in September, enter hibernation during October and do not emerge until late May, a period of nearly 8 months. Thus, hibernation is considerably longer than the activity period for these animals. In the present study, active bats were collected in both April and October, the period just before and after hibernation. This was made possible because of the variation of when individuals enter and emerge from hibernation. Additionally, the insects upon which these bats feed also emerge later in spring than in the more southern locations. At the Neda hibernaculum, parasite intensity, prevalence and species diversity were highest in autumn and spring and lowest in summer. Life cycles of most parasites collected appear to be shifted toward autumn, i.e., greatest recruitment of parasites appears to take place during late summer when the largest numbers of immature trematodes were observed. The late summer recruitment then leads to high intensities in autumn. The large numbers of parasites observed during spring in the present study was surprising. I feel that this indicates that the bulk of parasites are retained throughout the long period of hibernation. No information exists on the life span of any of the parasites recovered but since numbers decreased in summer, most species probably survive for less than 12 months. Thus, greatest parasite recruitment occurs in late summer. These parasites are retained during hibernation and bats emerge with a rich helminth fauna. These parasites

are then lost in early summer. This parasite adaptation may be important because of the short activity period of the bats.

Although not unexpected, considerable variation in parasite intensity was observed between individual hosts. This clumping of parasites is inconsistent with previous work on parasite populations and has been incorporated into at least one definition of parasitism (Crofton 1971). In the present study, an explanation for the extreme variance lies in the choice of collection site. The Neda Mine is the largest known hibernaculum in Wisconsin, with an estimated winter population of 75,000 Myotis lucifugus (Rupprecht 1980). Autumn swarming, hibernation and spring emergence probably involve bats from several different locations (Fenton 1969). Also, migration distances for M. lucifugus are known to range up to 445 km (Humphrey and Cope 1976). Thus, collections in spring and autumn most likely represented quite a heterogeneous assemblage, consisting of many populations originating from different geographical locations. Bats from differing habitats may display widely different helminth fauna.

The feeding strategy of bats is important in determining the types of parasites present. There is widespread disagreement as to the feeding strategies of insectivorous bats. Myotis lucifugus has been described as both a highly selective (Buchler 1976) and selectively opportunistic (Anthony and Kunz 1977) feeder. Belwood and Fenton (1976) showed a different feeding strategy between males and females and between adults and subadults. However, I found no significant differences in the burden of parasites between sexes or by age.

Foraging habits appear to be important in interspecific differences in endoparasitic prevalence and intensity. Belwood and Fenton (1976) described M. lucifugus as preying heavily on chironomid Diptera but with the ability to efficiently harvest swarms of emerging aquatic insects as their abundance changes. Whitaker (1972) found M. lucifugus to prey heavily on lepidopterans and dipterans while Eptesicus fuscus has been described as primarily a coleopteran predator (Black 1972).

In the present study the highest number of parasite species was recovered in spring (9 in April) and autumn (8 in October). After spring emergence, a much smaller number of M. lucifugus use the hibernaculum as a summer roost. Most summer colonies of M. lucifugus roost adjacent to a pond or stream or forage in trees or other nearby vegetation. These bats do not range far from the roost in daily feeding. These hosts probably have a more homogeneous diet which, in turn, produces a smaller and less diverse helminth fauna. During July and August only four and five species of parasites, respectively, were recovered from the hosts examined.

While there are numerous hypotheses to explain variation in species number, the mechanisms for effecting changes in these patterns remain unknown (Esch et al. 1979). In the present study, Ototrema schildti was by far the dominant species. The distribution of species is shown in Figure 2 as a plot of the mean number of species per host. The results obtained are consistent with the view that the bat

community emerging from hibernation is composed of several populations from different geographical locations. These populations congregate during autumn swarming, use a common hibernaculum and emerge in spring to disperse throughout a wide area in the Midwest. The low number of parasite species observed in summer indicates a more homogeneous bat community at the summer roost. The greatest number of parasite species was recovered in autumn (8 in October). During this period, however, the bulk of the parasite intensity was composed of one species. In the present study, the number of helminth parasite species in *Myotis lucifugus* appears to be strongly influenced by behavioral phenomena of the hosts (swarming, hibernation, spring emergence). Pianka (1978) indicated that increased competition may result in smaller niches and, consequently, greater species diversity. In the present investigation, higher numbers of parasite species occurred during periods when the host community varied (habitat variation).

Little is known of the ability of helminth parasites to overwinter in hibernating animals. Chute (1960) demonstrated that the woochuck, *Marmota monax*, retained its nematode fauna during a five-month hibernation. Ford and Lang (1967) concluded that adult *Fasciola hepatica* could not be maintained in hibernating thirteen-lined ground squirrels, *Spermophilus (Citellus) tridecemlineatus*. Chute (1961) reported that hibernation may retard development of *Trichinella spiralis* in golden hamsters. Chute and Covalt (1960) demonstrated that *T. spiralis* developed in bats held at 30^{o}C, but at 26^{o}C no development was observed although worms were not killed. These workers concluded that lowered host body temperature may inhibit parasite development without resulting in elimination from the host. Although much of the work dealing with parasite overwintering has consisted of abnormal host-parasite associations, it has been assumed that low parasite numbers occur in naturally infected hibernating bats. Nevertheless, in the present study, all bats collected during hibernation had 4-7 species of helminths. Furthermore, the observed numbers of most species in winter approximated autumn values. Torpid *Myotis lucifugus* in the hibernaculum have a mean winter body temperature of approximately 5^{o}C (Rupprecht 1980), a temperature well below that reported to prevent development of *T. spiralis* and *F. hepatica*. Clearly, *M. lucifugus* in southeastern Wisconsin retain a large and varied helminth fauna despite relatively long periods of sustained low body temperature. This finding represents a unique adaptation by the endoparasite.

ACKNOWLEDGMENT

I wish to thank John Tedesco and Chuck Rupprecht who participated in this study and Jason Coggins who helped with host collecting. This study was supported, in part, by funds from the UWM Graduate School.

LITERATURE CITED

Anthony, E. L. and Kunz, T. H. 1977. Feeding strategies of the little brown bat, *Myotis lucifugus*, in southern New Hampshire. Ecology 58: 775-786.

Barbour, R. W. and Davis, W. H. 1969. Bats of America. University Press of Kentucky, Lexington, Kentucky. 286 p.

Black, H. L. 1972. Differential exploitation of moths by the bats Eptesicus fuscus and Lasiurus cinereus. J. Mammal. 53: 598-601.

Black, H. L. 1974. A north temperate bat community: structure and prey populations. J. Mammal. 55: 138-157.

Blankespoor, H. D. and Ulmer, M. J. 1970. Helminths from six species of Iowa bats. Iowa Acad. Sci. 77: 200-206.

Blankespoor, H. D. and Ulmer, M. J. 1972. Prosthodendrium volaticum sp. n. (Trematoda: Lecithodendriidae) from two species of Iowa bats. Proc. Helminthol. Soc. Wash. 39: 224-226.

Brooks, D. R. and Coggins, J. R. 1983. Limatulum mcdanieli n. sp. (Digenea: Lecithodendriidae) from Myotis lucifugus (Mammalia: Chiroptera) in Wisconsin. Transactions of the Amer. Micros. Soc. 102: 81-83.

Buchler, E. 1976. Prey selection by Myotis lucifugus (Chiroptera: Vespertilionidae). Amer. Natur. 110: 619-623.

Chute, R. M. 1960. Overwintering of helminths in hibernating animals. J. Parasitol. 48: 539.

Chute, R. M. 1961. Infections of Trichinella spiralis in hibernating hamsters. J. Parasitol. 47: 25-29.

Chute, R. M. and Covalt, D. B. 1960. The effect of body temperature on the development of Trichinella spiralis in bats. J. Parasitol. 48: 855-858.

Coggins, J. R. In press. Methods for the study of bat endoparasites. Pp. 1-34. In Kunz, T. H. (ed.). Behavioral and Ecological Methods for the Study of Bats. Smithsonian Institution Press.

Coggins, J. R., Tedesco, J. L. and Rupprecht, C. E. 1981. Intestinal helminths of the bat, Myotis keeni (Merriam), from southeastern Wisconsin. Proc. Helminthol. Soc. Wash. 48: 93-96.

Coggins, J. R., Tedesco, J. L. and Rupprecht, C. E. 1982. Seasonal changes and overwintering of parasites in the bat, Myotis lucifugus (Le Conte), in a Wisconsin hibernaculum. Amer. Midl. Natur. 107: 305-315.

Crofton, H. D. 1971. A quantitative approach to parasitism. Parasitology 62: 179-193.

Esch, G. W., Gibbons, J. W. and Bourque, J. E. 1979. Species diversity of helminth parasites in Chrysemys s. scripta from a variety of habitats in South Carolina. J. Parasitol. 65: 633-638.

Fenton, M. B. 1969. Summer activity of Myotis lucifugus (Chiroptera: Vespertilionidae) at hibernacula in Ontario and Quebec. Can. J. Zool. 47: 597-602.

Fenton, M. B., Boyle, N. G. H., Harrison, T. M. and Oxley, D. J. 1977. Activity patterns, habitat use, and prey selection by some African insectivorous bats. Biotropica 9: 73-85.

Font, W. F. 1978. Ototrema schildti gen. et sp. n. (Trematoda: Lecithodendriidae) from the little brown bat, Myotis lucifugus, in Wisconsin. J. Parasitol. 64: 391-392.

Ford, B. R. and Lang, B. Z. 1967. Fasciola hepatica in hibernating Citellus tridecemlineatus (Mitchell). J. Parasitol. 53: 1073.

Humphrey, S. R. and Cope, J. B. 1976. Population ecology of the little brown bat, Myotis lucifugus, in Indiana and north-central Kentucky. Spec. Publ. 4, Amer. Soc. Mammal. 81 p.

Macy, R. W. 1935. A new trematode, Limatulum gastroides (Lecithodendriidae), from the little brown bat, Myotis lucifugus. Proc. Helminthol. Soc. Wash. 2: 74-75.

Nickel, P. A. and Hansen, M. F. 1967. Helminths of bats collected in Kansas, Nebraska and Oklahoma. Amer. Midl. Natur. 78: 481-486.

Pianka, E. R. 1978. Evolutionary Ecology. Harper and Row, New York. 397 p.

Rausch, R. L. 1975. Cestodes of the genus Hymenolepis Weinland, 1858 (sensu lato) from bats in North America and Hawaii. Can. J. Zool. 53: 1537-1551.

Rupprecht, C. E. 1980. Annual activity cycles and hibernation strategies in a north temperate bat community. M. S. Thesis, Univ. Wis.-Milw. 84 p.

Sokal, R. R. and Rohlf, F. J. 1969. Biometry. W. H. Freeman, San Francisco. 859 p.

Tuttle, M. D. 1974. An improved trap for bats. J. Mammal. 55: 475-477.