FLEAS OF FOX SQUIRRELS IN SOUTHERN MICHIGAN

Thesis for the Degree of M. S.
MICHIGAN STATE UNIVERSITY
JOHN C. ARNSMAN
1970

ABSTRACT

FLEAS OF FOX SQUIRRELS IN SOUTHERN MICHIGAN

By

John C. Arnsman

During 1967, 1968 and 1969 samples of flea populations were removed from 197 fox squirrels in Southern Michigan. Orchopeas howardii (Baker) was found to be the major flea of the fox squirrel. It made up 99 per cent or 556 of the 559 fleas examined.

The annual cycle of this flea on the fox squirrel was delineated. The population peaks every year in March, and may peak again in August and September. The population cycle of this flea closely follows the squirrel breeding cycle and may possibly be associated with it.

The age and sex of a host squirrel are determining factors in its susceptibility to parasitism by fleas. Adult females have significantly fewer fleas per animal (1.6) than the immature females (2.7), the immature males (3.2) or the adult males (3.0). The low number of fleas parasitizing the adult females was not a factor of the number of squirrels in this host class that were parasitized.

A "mangy condition" frequently observed in squirrels is apparently not related to flea parasitism. Although, it does occur at the same time as the flea population peak in March, it is perhaps more related to population densities and climatological factors.

FLEAS OF FOX SQUIRRELS IN SOUTHERN MICHIGAN

By

John C. Arnsman

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Entomology

1970

ACKNOWLEDGEMENTS

I would like to thank Dr. R. L. Fischer for his encouragement, and his material and editorial help in conducting and writing of this study. Dr. G. E. Guyer and Dr. R. H. Baker also contributed by giving encouragement and in helping to develop ideas. Dr. L. W. Gysel very kindly made a number of his traps available to me and helped in selecting the study site for this study. The Michigan Department of Natural Resources made certain unpublished records available as well as offering the help of their personnel with technical problems. Last, I would like to thank my wife for complaining long enough about my graduate student status that I had to finish this degree to get a little peace and quiet.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

As a major game animal the fox squirrel, Sciurus niger Linn., has been the subject of much biological investigation. Allen (1943), for example, published a monograph on the biology and management of the fox squirrel in Michigan. Brown and Yeager (1945) and Baumgartner (1940) published on the fox squirrel in Illinois and Ohio respectively. All three authors mention finding fleas on the squirrels; the latter two record the fleas, Orchopeas howardii (Baker) and Orchopeas nepos (Baker). Both authors give numbers in terms of "common", "very common", "occurs regularly" and "in very large numbers in over-wintering nests", but no other numerical data.

Fox (1940) lists Orchopeas wickhami (Baker) as the flea of the fox squirrel. Ellis (1955), in a small sample, found an average of 8.3 chicken fleas, Echidnophaga gallinaceae (Westwood), per fox squirrel in Oklahoma. Mathewson and Hyland (1964) found Cediopsylla simplex (Baker), Ctenocephalides felis (Bouche), Orchopeas howardii (Baker) and Megabothris asio (Baker) on S. niger in Rhode Island. Mathewson and Hyland do not mention how many fleas per squirrel were present.

Orchopeas howardii is a species closely associated with tree squirrels in North America. Its range extends from the Atlantic seaboard (Fuller 1943, Tindall and Dorsie 1961, and Mathewson and Hyland 1964) to the Rocky Mountains (Dunn and Parker 1923), from the Gulf

coast (Baker 1944, and Fox 1940) north at least to Vermont (Osgood 1964) in the east and Montana (Dunn and Parker 1923) in the west.

The present study was designed to determine the composition and numbers of the flea species on fox squirrels occurring in Southern Michigan.

METHODS

The areas in which this study was carried out were three small woodlots on the property of Michigan State University. One is an unnamed woodlot of approximately 40 acres located in section 6 of T. 3 N., R. 1 W. of Ingham Co. Collections of fleas were made from squirrels found in this woodlot from August to October of 1967. Hudson woodlot, approximately 15 acres in size, was trapped from October 1967 to August 1968; and Minnis woodlot was studied from August 1968 to September 1969. Both of the latter are located in section 30 of T. 4 N., R. 1 W. of Ingham Co.

All woodlots botanically consisted primarily of sugar maple-beech forests, Acer saccharum Marsh and Fagus grandifolia Ehrh. respectively. Other trees in common, but nondominant numbers, included: basswood, Tilia americana Linn.; elms, Ulmus spp.; white oak, Quercus alba Linn.; black oak, Quercus velutina Lam. and black cherry, Prunus serotina Ehrh. The woodlots were surrounded by agricultural areas which varied from pasture and hay to row crops.

The traps used were all box traps, of various designs, but with a minimum size of 5 X 7 X 20 inches inside dimensions and a maximum size of 8 X 10 X 30 inches. The traps included both enclosed, wood-sided traps, and traps made of hardware cloth over a wire frame. Data on the efficiency of the different kinds of traps were not kept, but

no difference in either efficiency of capture or of mortality of trapped squirrels were noted. Ear corn was used for bait.

Trapping began in August 1967 and ended in September 1969. The traps were set in every month of the year for a minimum of 10 days except from May through August of 1968.

When a squirrel was trapped it was released into a nylon mesh cone and forced into the small end of the cone. Either chloroform or ether were applied to a clean rag and held over the head of the squirrel while it was immobilized in the cone. When the squirrel began to relax it was withdrawn from the cone in a gloved hand by holding the back of its neck between the thumb and first finger and supporting the thorax with the other three fingers of the gloved hand. Additional anesthesia was applied until the animal was completely relaxed whereupon the animal was examined for fleas.

To remove the fleas, the squirrel was held over a white piece of new flannel cloth (15 X 24 inches) and the breath blown through the fur against the natural lay of the hair. The fleas, easily seen moving through the fur, were picked out by hand and placed on the white flannel cloth. After examining the squirrel once in this manner the animal was reexamined by rubbing the fur against the grain and searching for additional fleas.

When all visible fleas were removed to the white flannel cloth the squirrel usually had become quite active and was released. The fleas were removed from the cloth and placed in 95 per cent alcohol where they were stored until they could be cleared and permanently mounted.

Twelve squirrels which were accidently killed during handling were examined for fleas in the same manner as for the live squirrels, then placed in polyethylene bags and brought to the laboratory for thorough inspection by washing in a white enamel pan. This provided a check of the efficiency of the field techniques for flea removal. These 12 squirrels had 93 fleas when examined in the field, and no additional fleas were recovered when they were examined in the laboratory.

The fleas were cleared in 10 per cent potassium hydroxide and mounted on slides in diaphane. The host specimen of each flea, the age, sex and general health of each host were recorded.

RESULTS

In the 25 months of the study 197 fox squirrels were examined. A total of 559 fleas were removed of which 556 or 99 per cent were Orchopeas howardii (Baker). A single female Nosophilis fasciatus (Bosc), one male Opisodasys pseudarctomys (Baker), and a female Ctenophthalmus pseudoagyrtes Baker were also recovered. Since O. howardii was the preponderant species, all the population calculations were based on this species.

There were 2.8 fleas per squirrel over the entire study period. Figure 1 shows the incidence of fleas per squirrel on a monthly basis. A major cycle in numbers of fleas per squirrel occurred, beginning with a low in November or December and reaching a peak in March of both years. Numbers of fleas were also high in September of 1967 but data are insufficient to determine whether this is a peek or the downgrade of a prior peak. Since the flea population did not peak again in September 1968, special effort was made to check this period in 1969. However, the flea population was again low. Fifteen squirrels killed and examined from areas outside of the study area during September and October of 1969 harbored a total of only five fleas.

The host squirrels were broken into four classes: first year male, first year female, adult male, and adult female, as shown in

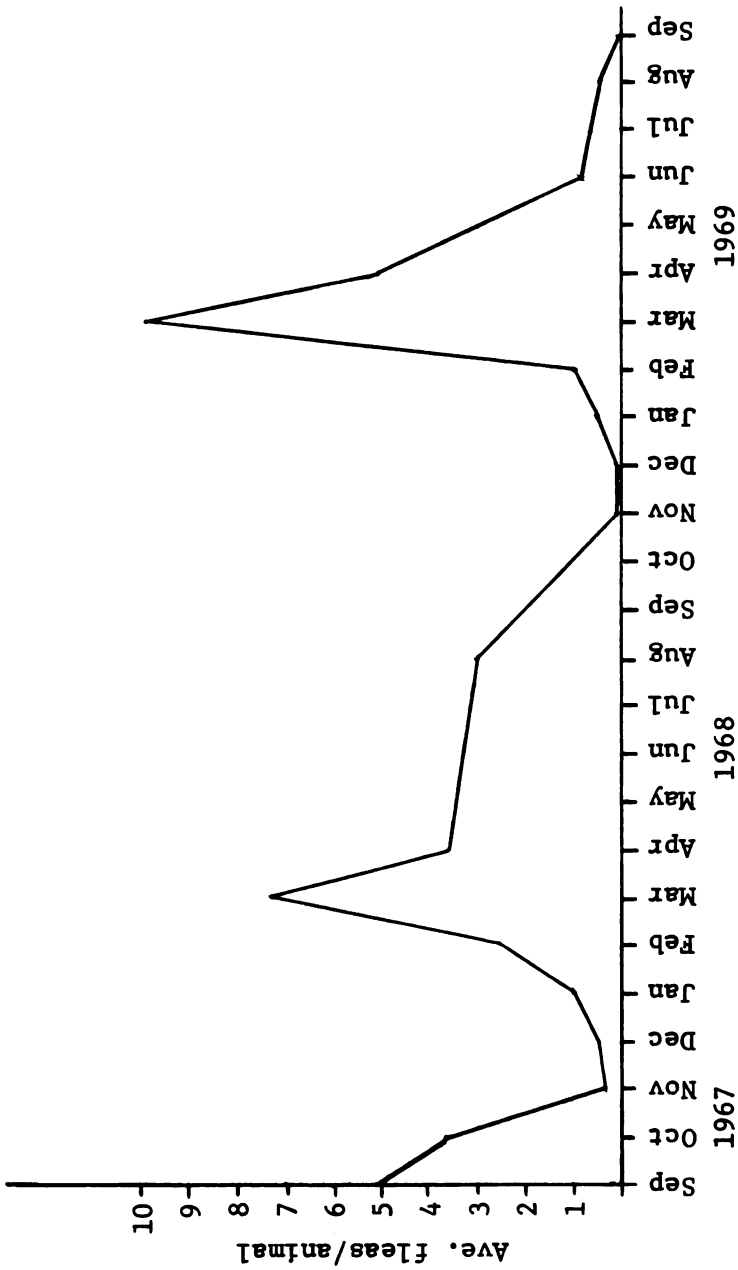

Figure 1.--The average number of fleas per squirrel on a time basis.

Table I. The average number of fleas per host, within these classes was compared (Table I) using a Chi^2 test. The summation of the Chi^2 values for the four segments of the population equalled 22.8794. Adult females were found to have significantly fewer fleas per animal (1.6) than any other class. First year females had 2.7 per animal, first year males 3.2, and adult males 3.0.

TABLE I.--Number of fleas per host in four host classes; 1st year female, 1st year male, Adult female, and Adult male

Host Class	No. of Squirrels	No. of fleas	Chi^2 values
1st Year Female	75	204	0.2470
1st Year Male	34	108	1.5661
Adult Female	36	56	20.3179*
Adult Male	51	154	0.7485
Summation Chi^2			22.8794*

*Significant at the 1 per cent level.

No significant differences were found in the fleas per squirrel for the adults versus first year animals or for the males versus females (Tables II & III).

To determine whether the low number of fleas per adult female was a reflection of fewer animals with fleas or fewer actual fleas per animal, the data were compared in a different manner. The number of hosts with fleas was compared to the total number of squirrels examined. The four host classes were not significantly different in the number of hosts with fleas as shown in Table IV.

TABLE II.--Number of fleas per host for adult versus 1st year

Host Class	No. of Squirrels	No. of fleas	Chi^2 values
Adults	87	210	4.994
1st Year	110	312	0.016
Summation of Chi^2			5.010

TABLE III.--Number of fleas per host for male versus female squirrels

Host Class	No. of Squirrels	No. of fleas	Chi^2 values
Males	86	262	1.615
Females	111	260	7.254
Summation of Chi^2			8.869

TABLE IV.--Number of fleas per host in four host classes using only hosts that had at least one flea

Host Class	No. of Squirrels	No. with fleas	Chi^2 values
1st Year Female	34	13	0.026
1st Year Male	51	21	0.076
Adult Female	75	32	0.292
Adult Male	36	10	1.124
Summation of Chi^2			1.517

The sex distribution of fleas was also checked. Female fleas significantly outnumber males in every collection, as shown in Figure 2. The females never made up less than 57 per cent of the population and averaged 72 per cent.

Records on the reinfestation of individual host animals are shown in Table V. Five squirrels were captured twice, and four were captured 3 times. Two squirrels which were caught twice and one squirrel which was caught 3 times were never found to have fleas. The other three squirrels which were caught twice had fleas the second time they were captured. The time interval between any of these recaptures did not exceed three days. The other three squirrels which were caught 3 times had fleas at least two times out of the three. The interval between captures with fleas for these three animals was between one and 23 days. Therefore, six of the nine recaptured squirrels became infested with fleas between captures. The time interval between captures when an individual squirrel became reinfested with fleas ranged from one to 23 days. On three occasions squirrels were captured one day after a previous capture and were reinfested. A squirrel, without fleas at its first capture, appeared to remain free of fleas for 46 days, during which time it was caught, examined, and released two additional times.

In the present study eight squirrels were caught (March and April of 1968) which had a "mangy condition". Three, or 37.5 per cent were infested with fleas and 38.6 per cent of the total squirrel population were infested during this same time interval. However, the eight squirrels with a "mangy condition" had fewer fleas (3.3 per animal) than did the total trapped population (5.3 fleas per animal).

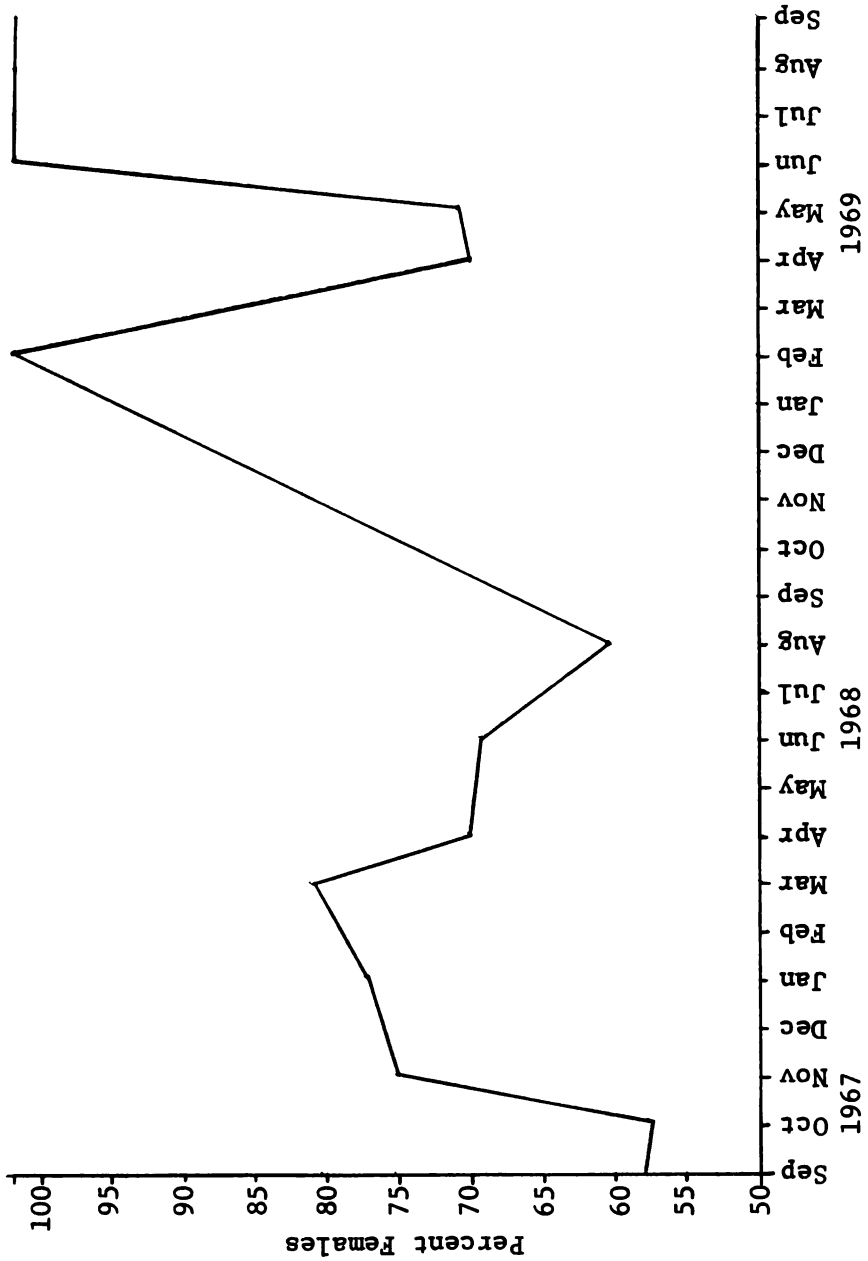

Figure 2.--The per cent of fleas examined which were females.

TABLE V.--Summation of data on squirrels captured more than once

Host	Recapture	Number of fleas present	Days between captures	Total days between 1st & last captures
C-1	1	0	31	31
	2	0		
C-19	1	0	2	2
	2	7		
C-23	1	0	2	2
	2	8		
C-26	1	0	3	3
	2	4		
B-122	1	0	1	1
	2	0		
B-28	1	0	1	2
	2	6	1	
	3	5		
B-47	1	0	3	46
	2	0	43	
	3	0		
C-21	1	21	17	23
	2	0	6	
	3	5		
D-23	1	2	7	8
	2	0	1	
	3	1		

DISCUSSION

The annual adult population of O. howardii has at least one well defined peak in fox squirrels in southern Michigan. This occurs in March. A single annual peak population of fleas has also been noted for Spilopsyllus cuniculi (Dale) on the European rabbit, Oryctolagus cuniculus (Linn.) by Allan (1956). Parker (1958) had two fleas, Hoplopsyllus anomalus (Baker) and Rhadinopsylla heiseri (McCoy), on the antelope ground squirrel, Citellus leucurus leucurus (Merriam), with one population cycle per year; and Ryckman et al. (1954) had three fleas, Echidnophaga gallinacea (Westwood), Damanus montanus (Baker) and H. anomalus on the California ground squirrel, Citellus beecheyi beecheyi (Richardson), with one population cycle per year.

During 1967, however, a high population level was also found in September (Figure 1). While the March population peak appears to initiate from a low level in November and December and to increase continously until March when numbers begin to decrease. This peak population of fleas follows the mating season of the fox squirrel in southern Michigan (Allen, 1940) by approximately a month.

Mead-Briggs and Rudge (1960) have described the necessity for a "factor" from pregnant rabbits for ovarian maturation in the rabbit flea, Spilopsyllus cuniculi (Dale). While data are scanty, circumstantial evidence would lend support to Mead-Briggs and Rudge's work

in the present study with O. howardii. The primary mating season of the fox squirrel begins in mid-winter and lasts until early spring (Allen, 1940). A second mating season may occur in Michigan but only when the habitat can support more squirrels, and its extent appears to be dependent on the condition of the habitat (Allen, 1940). Therefore, if O. howardii does require a "factor" from a pregnant female host to breed successfully it would have a yearly population peak in the late winter or early spring, following the squirrel mating season which peaks in January and February. Another population peak could occur during August and September in occasional years. This second peak would occur only during the years that the squirrels had an extensive summer mating season and might account for the high numbers of fleas found in late summer of 1967.

Adult female squirrels were found to have fewer fleas per animal than first year females, adult males or first year males. This difference in numbers of fleas per host was not a factor of age or sex alone but was a factor of both combined, adults not having more fleas than first year animals and males not having more than females. It was also shown that this was not a factor of the number of animals parasitized. So it can be deduced that it is an actual difference in the number of fleas per host. The most obvious reason for this difference is in differing behavior patterns of the host classes. Allen has shown that adult males have a significantly larger range than females and that immature squirrels move frequently during their first year. By moving frequently from one nest to another these three classes would be more susceptible to infestation. Once infested they

would spread the fleas to other nests within their present and future home ranges. The adult female, on the other hand, has both a close association with her home range as well as a smaller home range. This could be responsible for the smaller number of fleas per animal.

Unfortunately, if O. howardii does need a "factor" from a pregnant female host, the fleas would have to feed on a female. The distribution of fleas within the host population found in this study does not indicate that many fleas have this opportunity. The distribution of fleas among the host age classes might change at different times of the year. If additional collections could be made it might be possible to show whether or not the fleas changed their preference for host-age classes at a time of the year that allowed them to feed on females immediately after breeding.

The data from this study indicate that the flea population on the host is composed of 72 per cent females and 28 per cent males. Many other studies, including Evans and Freeman (1950) and Stannard and Pietsch (1958), have observed similar ratios of male to female fleas on the host. They have postulated that the females might live longer than the males or that the females might spend more time on the host and less in the nest compared to the males. This study cannot elucidate further on this phenomenon, but widens the range of species in which it is known to occur.

Fleas are known to vary widely in their requirements for the presence of a host. Some species spend nearly all their adult lives attached to a single host while others spend the majority of their time in the nest with only short periods on the host for feeding. However,

most species fall between the two extremes in the amount of time spent on the host. The data given in Table V were collected to help determine where O. howardii fits on this host requirement gradation. However, the low number of squirrels examined, plus the variability in time taken for repopulation of different individual hosts by fleas, made this impossible. One squirrel (B-28) was repopulated by fleas within one day, while another (C-21) was not repopulated in 17 days. Squirrel C-1 apparently spent 31 days without becoming infested while B-47 apparently spent 46 days without any fleas. Some squirrels, such as B-28 and D-23, became repopulated readily, while others, such as C-1 and B-47, seemed never to acquire fleas. This phenomenon seems best explained by saying that the nest is the primary focus of the infestation. Those animals whose nests are not infested do not have fleas while those animals whose nests are infested become repopulated rapidly.

Allen (1940) and Brown and Yeager (1947) suggest a possible relationship between fleas and a "mangy condition" of the squirrel's pelage. The time when squirrels are most susceptible to mange in late winter. The only "mangy" squirrels observed were seen during March and April of 1968. This coincides with the peak of the flea population cycle. Of the eight squirrels handled with a "mangy condition" three (37.5 per cent) had fleas, which was no different from that found in the total population at this time (38.6 per cent). However, the eight squirrels with a "mangy condition" had 3.3 fleas per animal while the total population at this time had 5.3 fleas per animal. The sample size does not allow statistical comparison, but the difference in the

numbers of fleas per animal in "mangy" and "non-mangy" squirrels indicates that the "mangy" condition may not be attractive to fleas.

Sarcoptic mange is usually associated with period of stress due to either weather or food conditions. If the flea population cycle is dependent on the breeding cycle of the squirrels, then the occurrence of large numbers of fleas and mange would appear at the same time in late winter but for different reasons. Since a "mangy condition" was not noted during the fall of 1967, or during late winter of 1967 and 1969 when large numbers of fleas were present, it appears that the two phenomena are caused by different factors.

SUMMARY

During 1967, 1968 and 1969 samples of flea populations were removed from 197 fox squirrels in Southern Michigan. Orchopeas howardii (Baker) was found to be the major flea of the fox squirrel. It made up 99 per cent or 556 of the 559 fleas examined.

The annual cycle of this flea on the fox squirrel was delineated. The population peaks every year in March, and may peak again in August and September. The population cycle of this flea closely follows the squirrel breeding cycle and may possibly be associated with it.

The age and sex of a host squirrel are determining factors in its susceptibility to parasitism by fleas. Adult females have significantly fewer fleas per animal (1.6) than the immature females (2.7), the immature males (3.2) or the adult males (3.0). The low number of fleas parasitizing the adult females was not a factor of the number of squirrels in this host class that were parasitized.

A "mangy condition" frequently observed in squirrels is apparently not related to flea parasitism. Although, it does occur at the same time as the flea population peak in March, it is perhaps more related to population densities and climatological factors.

LITERATURE CITED

Allan, R. M. 1956. A Study of the Populations of the Rabbit flea Spilopsyllus cuniculi (Dale) on the Wild Rabbit Oryctolagus cuniculus in Northern Scotland. Proc. R. Ent. Soc., London. 31: 145-152.

Allen, D. L. 1943. Michigan Fox Squirrel Management. Game Division Pub. 100. Michigan Dept. of Cons. 404 pp.

Baker, R. H. 1944. An Ecological Study of Tree Squirrels in Eastern Texas. Jour. Mamm. 25: 8-24.

Brown, L. G. and L. E. Yeager. 1945. Fox Squirrels and Gray Squirrels in Illinois. Bull. Ill. Nat. Hist. Survey. 23: 5: 1-95.

Dunn, L. H. and R. R. Parker. 1923. Fleas Found on Wild Animals in the Bitterroot Valley, Montana. U. S. Pub. Health Rpts. 38: 2763-2775.

Ellis, L. L. 1955. A Survey of the Ectoparasites of Certain Mammals in Oklahoma. Ecology 36: 12-18.

Evans, F. C. and R. B. Freeman. 1950. On the Relationship of Some Mammal Fleas to Their Hosts. Ann. Ent. Soc. Amer. 43: 320-333.

Fox, I. 1940. Fleas of the Eastern United States. The Iowa State College Press. Ames, Iowa. 191 pp.

Fuller, H. S. 1943. Fleas of New England. Jour. N. Y. Ent. Soc. 51: 1-12.

Holland, G. P. and A. H. Benton. 1968. Siphonaptera from Pennsylvania Mammals. Amer. Midl. Nat. 80: 252-251.

Hopkins, G. H. E. and M. Rothschild. 1953-1956. An Illustrated Catalogue of the Rothschild Collection of Fleas in the British Museum of Natural History. Brit. Mus. (Nat. Hist.) London. Vol. 1-4.

Hopkins, G. H. E. 1954. Nomenclatural Notes on the Flea of the Gray Squirrel. Entomologist. 87: 197-198.

Knipping, P. A., Morgan, B. B. and R. J. Dicke. 1950. Preliminary List of Some Fleas From Wisconsin. Wis. Acad. Sci., Arts and Letters. 40: 199-206.

Layne, J. N. 1954. The Biology of the Red Squirrel, Tamiasciurus hudsonicus loquax (Bangs), in Central New York. Ecol. Monog. 24: 326-267.

Mathewson, J. A. and K. E. Hyland. 1964. The Ectoparasites of Rhode Island Mammals. Jour. Kans. Ent. Soc. 37: 157-163.

Mead-Briggs, A. R. and A. J. B. Rudge. 1960. Breeding of the Rabbit Flea, Spilopsyllus cuniculi (Dale). Nature, London. 187: 1136-1137.

Osgood, F. L. 1964. Fleas of Vermont. Jour. N. Y. Ent. Soc. 72: 29-33.

Parker, D. D. 1958. Seasonal Occurrence of Fleas on the Antelope Ground Squirrel in the Great Salt Lake Desert. Jour. Econ. Ent. 51: 32-36.

Poorbaugh, J. H. and H. T. Gier. 1961. Fleas (Siphonaptera) of Small Mammals in Kansas. Jour. Kansas Ent. Soc. 34: 198-204.

Rapp, W. F. and D. B. Gates. 1957. A Distributional Check-List of the Fleas of Nebraska. Jour. Kansas Ent. Soc. 30: 50-53.

Ryckman, R. E., Lindt, C. C., Ames, C. T. and R. D. Lee. 1954. Seasonal Incidence of Fleas on the California Ground Squirrel in Orange County, California. Jour. Econ. Ent. 47: 1070-1079.

Tindall, E. E. and R. F. Dorsie. 1961. New Delaware Records for Mammalian Ectoparasites, Including Siphonaptera Host List. Bull. Brooklyn Ent. Soc. 56: 89-99.